THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY—VOL. XXVI.

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

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AND NOW OF

JOHN MURRAY, LL.D., Ph.D., &c.

ONE OF THE NATURALISTS OF THE EXPEDITION

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EDITORIAL NOTES.

This Volume contains Parts LX., LXVII., and LXXIII. of the Zoological Series of Reports on the Scientific Results of the Expedition.

Part LX.—This Part comprises the second portion of the Report on the Crinoidea, by Dr. P. H. Carpenter, F.R.S., and deals with the Comatulæ. The First Part of the Report, dealing with the Stalked Crinoids, forms Part XXXII. of the Zoological Series of Reports, and was published in 1884 in Volume XI., Zoology.

In the present Memoir Dr. Carpenter gives the results of his investigations, which have extended over thirteen years, and the Report may be regarded as practically a complete Monograph of the living species of Comatulæ.

The Report consists of 401 pages of letterpress, 70 lithographic plates, and other illustrations.

Part LXVIII.—This Report on the Seals, by Professor Sir William Turner, F.R.S., completes the Reports on Marine Mammals, the First Part of which, on the Bones of the Cetacea, formed Part IV. of the Zoological Series of Reports, and was published in Volume I., Zoology, in 1880.

The present Part consists of a description of the skeletons of the Seals collected by the Expedition; of a revised classification of the Pinnipedia; of a description of the brains of the Elephant Seal and Walrus, and a comparison with the brains of the Carnivora generally and of Apes and Man; also some observations on the viscera of the Elephant Seal. It is accompanied by an Appendix on the MYOLOGY of the PINNIPEDIA, by Dr. W. C. Strettell Miller.

The Report consists of 240 pages of letterpress, illustrated by 10 lithographic plates and several woodcuts.

Part LXXIII.—The Report on the ACTINIARIA, by Professor Richard Hertwig, was published in 1882, forming Part XV. of the Zoological Series of Reports, in Volume VI., Zoology.

The present Memoir forms the Supplementary Report promised at that time on a number of forms which reached Professor Hertwig too late for the descriptions to be included in the original Report. It consists of 56 pages of letterpress and 4 lithographic plates.

The Memoir was translated from the German by G. Herbert Fowler, Esq., Ph.D., of University College, London.

JOHN MURRAY.

CHALLENGER OFFICE, 32 QUEEN STREET,
EDINBURGH, 21*st June* 1888.

ERRATA FOR PART LX.

Page 34, line 22, for "*setosa*," read "*multispina*."
Page 60, line 6 from bottom, for "*Actinometra conjungens*," read "*Antedon conjungens*."
Page 90, line 15, for "*Antedon fluctuans*," read "*Antedon elegans*."
Page 90, line 23, *for* "the late Mr. Spedding," *read* "the Rev. T. R. R. Stebbing."
Page 93, line 11, delete the words "of *Actinometra difficilis* (Pl. LII. fig. 2)."
Page 94, line 5, for "*costatus*" read "*costata*."
Page 94, lines 12, 16, for "*Antedon fluctuans*, n. sp.," read "*Antedon elegans*, Bell."
Page 96, lines 1, 6, 12, 16, and page 97, line 6, for "*fluctuans*" read "*elegans*." (See p. 264.)
Page 97, line 21, for "*Antedon bidentata*" read "*Antedon variipinna*."
Page 110, line 8, for "*Antedon dubia*" read "*Antedon variipinna*."
Page 205, line 6, for "*Antedon variipenna*," read "*Antedon variipinna*."
Page 252, line 5, *for* "Bidistichate," *read* "Tridistichate."
Page 320, line 12, *for* "a.3.2br.$\frac{}{ab}$," *read* "a.3.2br.$\frac{b}{ab}$."
Page 322, line 8, *for* "figs. 1–3" *read* "figs. 1–3, 8."
Page 325, line 22, for "figs. 4–6" *read* "figs. 4–7."

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT upon the CRINOIDEA collected during the Voyage of H.M.S. Challenger during the Years 1873-76. By P. HERBERT CARPENTER, D.Sc., F.R.S., F.L.S., Assistant Master at Eton College.

PART II.—THE COMATULÆ.

PREFACE.

THE accompanying Report is the result of a study of the Comatulæ which has been carried on, with occasional breaks caused by bad health and by the pressure of other work, since the latter part of the year 1875. Early in 1878 Sir Wyville Thomson was good enough to place the Challenger collection in my hands for description; and in the following year a preliminary account of it was published in the Proceedings of the Royal Society.

The group had been singularly neglected for many years previously. Müller's classical memoir, Ueber die Gattungen und Arten der Comatulen, appeared in 1849, and laid the foundation of all future systematic work, as well as of the descriptive terminology now in use. Isolated species have been described by various authors during the last forty years, but no serious revision of the group has ever been attempted, though in 1862 Müller's classification was modified in one or two points by Dujardin and Hupé.

Thirty-five species were described by Müller in 1849, the types of which are scattered through the various museums of the Continent; and by the kindness of Sir Wyville Thomson I was enabled to make a personal examination of almost all of these in the autumn of 1880. Twenty of them belong to *Antedon* and fifteen to *Actinometra*, as these genera are now understood. Four at least of Müller's species (1 of *Antedon*, 3 of *Actinometra*) appear to me to have no real value; while 168 species belonging to these two genera are considered in the present Report, viz., 120 of *Antedon* and 48 of *Actinometra*. Of these there are only two which I have not personally examined, the type of one having disappeared, while I have not as yet been able to visit the museum which contains the other.

Of these 168 species 79 were discovered by the explorations of the Challenger (*Antedon* 64, *Actinometra* 15), which also added two new genera, represented by 4 species, to the family Comatulidæ. Professor Semper's dredgings in the Philippine Islands had previously made known the existence of a third generic type, and a fourth was obtained by the Gulf Stream explorations of the U.S. Coast Survey, though the fact was not recognised at the time. Other species of each of these two genera were obtained by the Challenger, making in all 180 species of this family, 88 of which were new to science.

These numbers are considerably lower than those mentioned in the Preliminary Report. At the time when that was published I had only seen three large *Comatula*-collections besides that of the Challenger, viz., those of the British and Paris Museums, and that made by Professor Semper in the Philippines. Since then, however, I have examined many hundred Comatulæ, including in many cases large numbers of individuals belonging to the same specific type, and the experience thus gained has been of the utmost value, by enabling me to unite under one specific name forms which at first had seemed distinct to the less trained eye. In one or two cases the result has been that the specific names appended to some of the plates which were first printed off have since required alteration; and the same is true of some of the earlier sheets of the text.

The preparation of this Report has been considerably delayed by the pressure of other work and by interruptions of various kinds. The first four years after the collection came into my hands were occupied pretty continuously by the framing of specific diagnoses. These were nearly all completed when Sir Wyville Thomson died, in March 1882; and my leisure time for the next three years was almost entirely devoted to the completion of the Report on the Stalked Crinoids which he had left unfinished. I hoped then that another year's work would enable me to revise my descriptions of the Comatulæ and suffice for the completion of this Report. But this object has been seriously interfered with by a continual increase of professional duties, together with the necessity of completing some long-delayed palæontological work for the Trustees of the British Museum. I have also been much hindered by a troublesome affection of the eyes, which has frequently entailed a prolonged cessation from work.

These, and other causes for delay which I need not mention, have not, however, been altogether disadvantageous; for various small and more or less local collections of Comatulæ have come into my hands during the past five years, and the experience gained by their examination has been of great value in causing me to modify some of my earlier judgments respecting specific characters.

The seventy plates accompanying this Report have been drawn by the following artists—Messrs. Berjeau and Highley, Parker and Coward, George West and Sons, and Mr. W. S. Evans; and I desire to express my thanks to all these gentlemen for the care with which they have always endeavoured to carry out my wishes. I am also greatly indebted to my friend Professor F. J. Bell, F.Z.S., of the British Museum, for the ready way in which he has always given me the utmost facilities for examining the collection of Comatulæ under his care.

I have likewise to acknowledge the courteous kindness of Professor S. Lovén at Stockholm, Professor A. Schneider of Breslau, Dr. E. von Marenzeller of Vienna, Dr. Otto Hamann of Göttingen, and Dr. F. Nansen of Bergen, who have been good enough to send selected Comatulæ to me for examination from the collections in their charge. It is proper also that I should record my indebtedness to the authorities of the numerous Continental Museums which I visited in 1880, for the uniform courtesy with which their collections were placed at my disposal.

It only remains, in conclusion, for me to express my sincere thanks to Mr. John Murray for the kind patience with which he has borne the numerous delays in the completion of this Report, to which I have referred above; and also to Mr. W. E. Hoyle, M.A., of the Challenger office, for the careful manner in which he has supervised its passage through the press.

ETON COLLEGE, *April* 1888.

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MORPHOLOGY.

I.—GENERAL INTRODUCTION.

The Comatulæ constitute a group of Neocrinoids, which is so extensive, and differs so much from the remaining members of the order, that a subordinal rank may not improbably come to be assigned to it. The great variety and extensive distribution of the species of *Antedon* and *Actinometra* at the present time recall similar facts about *Pentacrinus* and *Millericrinus* in the Mesozoic rocks, and about *Actinocrinus* and *Platycrinus* in the Palæozoic series.

Although a few Palæocrinoids, such as *Agassizocrinus* and *Edriocrinus*, seem to have been stemless and unattached in the adult condition, the enlargement of the top joint of the larval stem into a cirrus-bearing centro-dorsal is not known to have occurred in any Palæozoic, or even in any Triassic Crinoid; while the physiological condition of the young *Edriocrinus* has been frequently reproduced in the Mesozoic Holopidæ and in the recent genus *Holopus*, which inhabits comparatively shallow water in the Caribbean Sea, side by side with the free Crinoids or true Comatulæ.

The real nature of the latter group was long misunderstood. Linck and Linnæus followed Llhuyd in regarding them as peculiar forms of the Sea-stars, to which the general name *Asterias* was assigned by the great Swede. Early in the present century, however, the free Crinoids were separated from the Asterids and Ophiurids by Lamarck. But he entirely failed to recognise their relationship to Guettard's *Pentacrinus*, which he placed among the Polypes, together with the various species of fossil Crinoids.

Five years before Lamarck wrote, the genus *Antedon* had been established by de Fréminville[1] for a Feather-star from tropical seas; while in the next year Leach[2] united all the known species of this type of the Echinodermata under the one genus *Alecto*. A similar step was taken in 1816 by Lamarck,[3] who proposed the genus *Comatula* and assigned to it eight species, six of them being new. One of these had been previously

[1] Mémoire sur un Nouveau Genre de Zoophites de l'Ordre des Radiaires, *Bull. Soc. Philom. Paris*, Bd. ii. pp. 349, 350, 1811.

[2] *The Zoological Miscellany*, London, 1815, vol. ii. p. 61.

[3] Histoire Naturelle des Animaux sans Vertèbres, éd. 2, Paris, 1816, tom. ii. p. 530.

called *Antedon* by de Fréminville, and *Alecto* by Leach; but Lamarck's authority as a zoologist, together with his description of six new species, was sufficient to make his genus more widely known than either de Fréminville's *Antedon* or Leach's *Alecto*. The very appropriate name *Comatula* was afterwards used by Miller, Goldfuss, de Blainville, Agassiz, and Müller; while d'Orbigny[1] gave it an increased importance by founding the family Comatulidæ. He referred to this family, however, not merely the various forms of Feather-star, both recent and fossil, in which the base of the calyx is closed below by the cirrus-bearing centro-dorsal piece, but also the remarkable genus *Marsupites*, which, in the adult condition at any rate, was totally devoid both of stem and of cirri. Further research has shown, however, that *Marsupites* represents a form of Crinoid which is altogether different from that of the Feather-stars; and it is now generally considered as the type of another family altogether, the Marsupitidæ.

The limits of d'Orbigny's family Comatulidæ have varied considerably at different times. *Eugeniacrinus* and its allies were referred to it by Dujardin and Hupé,[2] whose classification has not been adopted by their successors; whilst a variety of generic names have been proposed for the numerous fragments of fossil Comatulæ which occur in considerable abundance at certain horizons in the Jurassic and Cretaceous formations, viz., *Glenotremites*, *Solanocrinus*, *Decacnemos*, *Decameros*, *Comaster*, *Hertha*, and *Geocoma*. All of these, with one or two possible exceptions, find their place within de Fréminville's genus *Antedon*, as has been explained elsewhere.[3] Some twenty-five years ago this name was revived by Mr. Norman[4] in a more restricted sense than that in which it was proposed by de Fréminville; and this step has been generally followed, with the great advantage of simplifying the nomenclature considerably.

In Müller's earlier writings upon the subject of the Feather-stars, the names *Alecto* and *Comatula* seem to have been employed indifferently and as equivalent to one another; but he was subsequently led to distinguish two different types of Feather-star, one with five ambulacral grooves converging upon a generally central mouth, as in *Pentacrinus*, and the other with an excentric mouth and fewer than five disk-ambulacra. He therefore considered these as subgenera of Lamarck's original genus *Comatula*, and while distinguishing the first one by Leach's name *Alecto*, proposed to call the second type by the new designation *Actinometra*.[5] Neither of these two subgenera were ever formally defined, and Müller only described three species of *Actinometra*. A fourth was

[1] Cours élémentaire de Paléontologie et de Géologie stratigraphique, Paris, 1852, vol. ii. fasc. 1, p. 138.

[2] Histoire Naturelle des Zoophytes, Échinodermes, Paris, 1862, p. 186.

[3] See P. H. Carpenter, On the Genus Actinometra, Müller, with a Morphological Account of a new species (Actinometra polymorpha) from the Philippine Islands, *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 13, 14; and also On the Genus Solanocrinus, Goldfuss, and its relations to recent Comatulæ, *Journ. Linn. Soc. Lond.* (Zool.), 1880, vol. xv. pp. 196–201.

[4] On the Genera and Species of the British Echinodermata, pt. i, *Ann. and Mag. Nat. Hist.*, 1865, ser. 3, vol. xv. p. 98.

[5] Ueber die Gattung Comatula, Lam., und ihre Arten, *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1849, p. 246.

subsequently added by Böhlsche[1] after the type had been accorded generic rank by Dujardin and Hupé,[2] who improved considerably upon Müller's definition of it. The German zoologist had not considered the position of the mouth as a point of any systematic importance; but he referred to *Alecto* both species like *Antedon rosacea* and *Antedon eschrichti*, which have five symmetrically distributed ambulacra radiating from a central mouth, and also species with an equally symmetrical grouping of the ambulacra, but with an excentric mouth. Dujardin and Hupé, however, took no account of the number of ambulacra diverging from the peristome, to which Müller attached so much importance; but they pointed out that the distinctive character of *Actinometra* rather lay in the excentric position of the mouth, which determined the course of the ambulacra round the margin of the disk, instead of towards its centre. Nevertheless, they did not transfer to *Actinometra* the various species of *Alecto* described by Müller with an excentric mouth and symmetrically grouped ambulacra; so that they did not make any real addition to the genus, although they recognised its characters better than Müller had previously done. Single species were subsequently added to it by various writers, but it was never properly defined.

Having assigned a generic value to *Actinometra*, Dujardin and Hupé did the same for Müller's type *Alecto*, for which, however, they preferred Lamarck's name *Comatula*. But three years later Mr. Norman replaced this by *Antedon*, a name which was originally proposed earlier than either *Alecto* or *Comatula;* and at the same time he restricted it to those species only in which the mouth is central or subcentral and the anus lateral. Very nearly all subsequent writers have accepted this definition of *Antedon;* but no attempt was ever made to modify the Müllerian descriptions of *Comatula* in accordance with it.

Towards the end of 1875, ten years after the publication of Mr. Norman's precise definition of *Antedon*, I had the opportunity of studying a large collection of tropical Comatulæ which had been obtained by Professor Semper in the Philippine Islands; and it soon became evident that the number of ambulacra diverging from the peristome is so variable as to be useless for the purposes of generic discrimination. At the same time other characters seemed to be correlated with the central or excentric positions of the mouth respectively; and I came to the conclusion that the real distinction between *Antedon* and *Actinometra* respectively is based upon this feature of their organisation, the number of groove trunks connected with the peristome being a character of very minor importance.[3] I soon learnt that Professor Lütken had held this opinion for some time past; and he also pointed out to me certain characters of the oral pinnules which are always associated with the excentric position of the mouth. Since that time I have

[1] Ueber Actinometra Bennettii und eine neue Comatula Art (Antedon Dubenii), *Archiv f. Naturgesch.*, 1866, Jahrg. xxxii. Bd. i. p. 90.

[2] *Op. cit.*, p. 208.

[3] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 17, 18.

examined a very large number of Comatulæ; and I have almost always found a terminal comb on the oral pinnules of those species which have an excentric mouth; while a variety of other characters are more or less constantly associated with these, as will be explained in detail further on.

In the year 1866 a new Comatulid genus, *Phanogenia*, was established by Lovén[1] for a remarkable tropical species with a stellate centro-dorsal bearing a few rudimentary cirrus-stumps. The dredgings of the Challenger, however, have shown that this condition is common to several species of *Actinometra*, with which the genus *Phanogenia* corresponds in all essential respects. A third new genus of Comatulæ was established in 1868 by Semper[2] for a little five-armed type which he had discovered in the Philippines. He called it *Ophiocrinus*, and for some years it was regarded merely as a subgenus of *Antedon*. Eventually, however, after examination of the three species obtained by the Challenger in the Pacific, together with Semper's original specimen, I satisfied myself of its claim to generic rank, and I proposed to call it *Eudiocrinus*,[3] instead of by Semper's name *Ophiocrinus* which had been preoccupied by Salter. But about the same time that this new generic name was proposed on account of all the known species being limited to the Pacific Ocean, another specific type was discovered by the "Travailleur" in European seas, and it was subsequently described by Perrier[4] as *Eudiocrinus atlanticus*.

One other genus of recent Crinoids, has been described, besides those just mentioned (*Antedon*, *Actinometra*, *Phanogenia* and *Eudiocrinus*), viz., *Comaster*, Agassiz.[5] The leading character of this genus, according to its proposer, depended upon the number of divisions in the arms, and was rightly disregarded by Goldfuss[6] who thought more of the presence of basals on the exterior of the calyx as a generic distinction. Müller[7] adopted the genus in the sense in which it was understood by Goldfuss; but he seems eventually to have abandoned it altogether.[8] This will doubtless prove to be its ultimate fate, as it has not been seen by any naturalist since the time of Goldfuss, whose original specimen of it was dissected and has since disappeared. If his account of it is correct, *Comaster* must be a very remarkable type, differing in many respects from all other recent Comatulæ, as I have explained elsewhere;[9] but I am strongly inclined to believe that its apparent peculiarities are merely due to the want of knowledge respecting the internal structure of

[1] Phanogenia, et hittills okändt slägte af fria Crinoideer, *Öfversigt. k. Vetensk. Akad. Förhandl.*, 1866, p. 231.

[2] Ophiocrinus, eine neue Comatuliden Gattung, *Archiv f. Naturgesch.*, 1868, Jahrg. xxxiv., Bd. i. p. 68.

[3] Descriptions of new or little known Comatulæ. I. On the species of Atelecrinus and Eudiocrinus, *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 493.

[4] Sur des Eudiocrinus de l'Atlantique et sur la nature de la faune des grandes profondeurs, *Comptes rendus*, 1883, t. xcvi. pp. 725–728.

[5] Prodrome d'une Monographie des Radiaires ou Échinodermes, *Mém. Soc. Nat. Sci. Neuch.*, 1835, t. i., p. 193.

[6] Beiträge zur Petrefactenkünde, *Nova Acta Acad. Cæs. Leop.*, 1839, Bd. xix. A. p. 348.

[7] Ueber die Gattungen und Arten der Comatulen, *Monatsber. d. k. preuss. Akad. d. wiss. Berlin*, 1841, p. 180.

[8] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1849, p. 244.

[9] *Journ. Linn. Soc. Lond* (Zool.), 1877, vol. xiii. pp. 454–456.

the calyx of Comatulæ which was prevalent at the time of Goldfuss, and that *Comaster* is in reality nothing but a large *Antedon* or *Actinometra*.

Apart from *Phanogenia* and *Comaster*, therefore—one, if not both, of which are merely synonyms—no other Comatulid genera except *Eudiocrinus*, *Antedon*, and *Actinometra* were known, to science before the collections of the Challenger and of the United States Coast Survey ships came into my hands for examination. But one species of *Eudiocrinus* was known, and only about twenty each of *Antedon* and of *Actinometra* had been described, though many others were awaiting description in various museums. Now, however, the number of recent species of *Comatula* is probably nearly four hundred, and three new genera have been established, thus doubling the number known at the time the Challenger returned. One of these generic types, *Atelecrinus*, was actually obtained so long ago as 1868, during the earliest explorations of the Gulf Stream by Count Pourtalès; but the single specimen dredged was so small and mutilated that its very striking peculiarities escaped notice at the time. Equally imperfect and isolated examples of two other species were dredged by the Challenger; and it was not until several less mutilated individuals were obtained by the "Blake" in the Caribbean Sea, that I was able to realise that a new *Comatula* genus had been discovered.[1] It presents so many larval characters that I have called it *Atelecrinus*, as will be explained subsequently.

Atelecrinus can hardly be considered as a new genus discovered by the Challenger; but with *Promachocrinus* and *Thaumatocrinus* the case is altogether different. The former genus[2] differs from all other Crinoids in the composition of the calyx, which has ten primary radials instead of five only, as is normally the case; and it is represented by three distinct species, one from the North Pacific, one from Kerguelen, and one from a depth of 1800 fathoms at Station 158 in the Southern Sea. At this Station too, there was obtained a single specimen of another *Comatula* which I have no hesitation in regarding as by far the most remarkable of all the Crinoids that have been dredged of late years, viz., the extraordinarily archaic form *Thaumatocrinus*, which presents certain characters only to be found in some of the Palæocrinoids. Its peculiarities were fully described in the Report on the Stalked Crinoids,[3] and I do not propose therefore to say much about it here.

[1] Report on the Results of Dredging under the Supervision of Alexander Agassiz, in the Gulf of Mexico, and in the Caribbean Sea, 1877–79, and along the Atlantic Coast of the United States during the summer of 1880, by the United States Coast Survey steamer "Blake," Lieutenant-Commander C. D. Sigsbee, U.S.N., and Commander J. R. Bartlett, U.S.N., commanding. XVI. Preliminary Report on the Comatulæ, *Bull. Mus. Comp. Zoöl.*, 1881, vol. ix. No. 4, p. 16.

[2] Preliminary Report upon the Comatulæ of the Challenger Expedition, *Proc. Roy. Soc.*, 1879, vol. xxviii. p. 385.

[3] Zool. Chall. Exp., part xxxii., 1884, p. 370.

II.—THE CENTRO-DORSAL AND CALYX.

The principal morphological character which distinguishes the Comatulidæ from the remaining families of Crinoids is the development of cirri upon the top stem-joint, and its separation from the remaining portion of the stem as the centro-dorsal plate. This supports the ring of united radials, and, in the recent forms at any rate, closes up below the dorsal extension of the body-cavity which is contained in their central funnel, as is well shown in Pl. III. figs. *3a*, *3b*, and Pl. V. fig. *2c*.

Most recent Comatulæ are further distinguished from the Stalked Crinoids by the metamorphosis of the embryonic basals into the structure known as the "rosette," which is enclosed within the radial pentagon, and so is entirely invisible externally (Pl. I. fig. *8c*; Pl. II. figs. *3c*, *5c*; Pl. IV. fig. *3c*; Pl. V. figs. *2c*, *5d*). It will be well to discuss these two structures separately, though they are naturally in very close relation with one another.

A. The Centro-Dorsal.

The term "centro-dorsal plate" is a very old one, and was for a long time used in various ways by different authors. In fact it was not till the remarkable developmental history of the uppermost stem-joint had been made out by the late Sir Wyville Thomson and Dr. Carpenter, that the term acquired any definite signification. Both these authors used it to denote the enlarged and cirrus-bearing top stem-joint [1] which is at first in no way different from the remaining joints of the stem below it (Pl. XIV. figs. 1, 2, 8, 9). Eventually, however, it enlarges, and five cirri, which are radially situated, are developed upon it (Pl. XIV. figs. 3–6), so that it has very much the appearance of a nodal stem-joint of *Pentacrinus*. A second series of cirri, alternating in position with the first, subsequently appears (Pl. XIV. fig. 7), and others are afterwards developed in succession, so that as was well said by Wyville Thomson,[2] "the centro-dorsal plate in *Antedon* does not belong to the cup. It represents a coalesced series of the nodal stem-joints in the Stalked Crinoids."

At a certain period in the development of the young *Comatula* the centro-dorsal

[1] The centro-dorsal plate of *Comatula* must not be confused with the dorsocentral plate of other Echinoderms. This name is now generally restricted to the central plate of the abactinal system in Urchins and Stellerids. I believe this to be represented in the Comatulæ by the terminal plate at the bottom of the larval stem, as explained on p. 168 of Part I. It is shown in Pl. XIV. figs. 1, 9. Comatulæ thus have both a centro-dorsal and a dorsocentral, while the latter only is present in the remaining Echinoderms. Zittel has also given the name centro-dorsal to the enlarged uppermost stem-joint of *Apiocrinus*; but this bears no cirri, and though undoubtedly homologous with the centro-dorsal of Comatulæ, should not, I think, receive a name which is now universally understood as denoting the presence of cirri.

[2] On the Embryogeny of Antedon rosaceus (Linck, Comatula rosacea of Lamarck), *Phil. Trans.*, 1865, p. 536.

separates itself from the stem-joint below it, and the "head" of the Pentacrinoid larva becomes a free-swimming Feather-star, the rest of the larval stem being left to waste away. The precise epoch of growth at which this separation occurs varies greatly. Thus, for example, the young *Antedon tenella* retains its stem until twenty or thirty cirri have appeared on the centro-dorsal, which conceals the basals, and the pinnules are developed upon all the lower arm-joints; whereas in *Antedon rosacea* and in other species, the stem is discarded when there are only ten cirri on the centro-dorsal, the basals are still visible, and the lowest portions of the arms devoid of pinnules; while the absolute size which is reached by the mature larva before dropping off its stem varies considerably.

After the formation of the first two whorls of cirri no special regularity can be traced in the manner of their development. The young ones normally appear between those previously formed and the radial pentagon, so that their sockets are close to the margin of the centro-dorsal (Pl. I. fig. 1*a*; Pl. II. figs. 2*a*, 4*a*; Pl. IV. figs. 1*a*, 3*a*). But as the centro-dorsal grows and new cirri appear round its margin, the older cirri which are attached close to the dorsal pole drop away, and their sockets become gradually obliterated by calcareous deposit. The earlier stages of this process are seen in Pl. I. fig. 6*a*; Pl. II. figs. 1*a*, 3*a*, 5*a*; and Pl. III. figs. 6*d*, 7*a*; and the result is that the dorsal surface is usually left comparatively smooth, as seen in Pl. IV. figs. 1*a*, 1*b*, 2*a*, 3*a*, but in some species of *Antedon* the deposit of new material continues after the cirrus-sockets are obliterated, and causes the dorsal pole to become rough and irregular (Pl. III. figs. 4*b*, 5*a*; Pl. XI. fig. 3). On the other hand, the lower surface of the centro-dorsal in most species of *Actinometra* is almost flat and extremely smooth (Pl. V. figs. 1*b*, 1*d*, 2*b*, 2*d*, 2*e*, 4*b*, 5*b*, 5*c*). This is owing to the very extensive and uniform manner in which the new material is deposited, and it sometimes produces very singular results, as will be explained subsequently.

During the Pentacrinoid stage of larval existence the young *Comatula* is provided with a stem which encloses a neuro-vascular axis just as in an ordinary Stalked Crinoid. This axis contains the downward extensions of the peripheral cavities of the chambered organ within the centro-dorsal and of its central axis. When the centro-dorsal separates itself from the lower part of the larval stem, a minute five-rayed perforation remains at its dorsal pole, which corresponds to the central canal in the stem of a *Pentacrinus*, and gave passage to the neuro-vascular axis above mentioned. In recent Comatulæ this opening is closed up very soon after the entry upon the free stage of existence, by a portion of the calcareous deposit already noticed; though traces of it are sometimes visible internally upon the floor of the centro-dorsal cavity (Pl. II. figs. 2*b*, 3*b*). There are some fossil Comatulæ, however, in which it seems to have remained permanently open throughout life, so far as we can judge from the material at our disposal; while in other forms again it is extended into a large stellate impression which occupies a considerable space on the lower surface of the centro-dorsal, and in the fossil condition is more or less obliterated. But there can, I think, be no question that in *Antedon perforata*, *Antedon rugosa*, *Antedon striata*, and other species from the English Chalk, together with some foreign species like *Antedon tourtiæ*, *Antedon semiglobosa*, and *Antedon retzii*, the inferior surface of the centro-dorsal was marked during life by a large stellate opening which was considerably more than would be necessary for the simple downward passage of the neuro-vascular axis of the stem. It seems to me very probable, as I have explained elsewhere,[1] that the peripheral parts of this opening, which are radially situated, may have given passage to tubular extensions of the body-cavity into the stem, such as existed in *Barycrinus*, *Cupressocrinus*, and in other Palæocrinoids. An indirect confirmation of this view is afforded by the characters of the stem in the Bourgueticrinidæ, which resembles that of the young *Comatula* in all essential points. The stem-joints of this family contain a set of five radial spaces which communicate with one another from joint to joint, and probably also through the top of the stem with the body-cavity within the calyx. The presence of these same radial spaces in the stems of fossil Comatulæ would account for the perforation of the lower surface of the centro-dorsal, which would have effected the communication between the portions of the body-cavity derived from the right peritoneal sac, that lie in the stem and in the calyx respectively. In the ordinary species of *Antedon* the calycular portion of the cœlom is much broken up by the rosette, and by the calcareous network which rests above it and occupies the central funnel of the radial pentagon (Pl. IV. fig. 3*b*); but, as I have shown elsewhere,[2] there are five median grooves on the ventral surface of the radials which extend outwards in a similar position over the skeleton of the rays and arms, and lodge the lowest portions of their cœliac canals. They are more distinct in some species than in others, but are well shown in *Antedon carinata* (Pl. III. figs. 1*d*, 3*a*), *Antedon disciformis* (Pl. IV. fig. 2*b*), and in *Actinometra lineata* (Pl. V. figs. 2*a*, 2*c*). When these grooves pass from the ventral to the inner faces of the radials and descend into the central funnel, they become closed into canals by the union of their edges with those of the spout-like radial processes of the rosette. These canals, which I have called the axial radial canals, are therefore the proximal ends of the five cœliac canals of the arms and their extensions into the pinnules. As a general rule they become closed up by calcareous tissue, and so do not reach the dorsal surface of the radial pentagon, which presents no real openings except the central one occupied by the rosette (Pl. I. fig. 8*c*). The five radial and five interradial processes of this structure are separated by passages which lodge the paired branches of the five primary cords proceeding from the nervous envelope of the chambered organ. These ten openings are well seen in Pl. I. figs. 6*c*, 8*c*; Pl. III. figs. 4*c*, 5*b*; and also in Pl. V. figs. 1*c*, 2*c*, 2*e*, 5*d*, 5*e*, but in *Antedon quinquecostata* and *Antedon disciformis* there are five additional openings on the lower surface of the

[1] On some New Cretaceous Comatulæ, *Quart. Journ. Geol. Soc.*, 1880, vol. xxxvi. pp. 556, 557.
[2] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 77, 78.

radial pentagon, one at the inner end of each radial (Pl. III. fig. 6*b*; Pl. IV. fig. 2*c*). These are the dorsal ends of the radial axial canals, which do not become obliterated as is usually the case; and in *Antedon disciformis* there is a small pit on the upper surface of the centro-dorsal corresponding to each of these canals which terminate blindly in this position (Pl. IV. figs. 2*c*, 2*d*). Among recent Comatulæ, however, the most striking development in this respect is presented by *Antedon quinduplicava*; for the radial axial canals which pass over from the ventral to the inner faces of the radials turn outwards again at the bottom of the calyx, and expand into relatively large bilobate cavities which are formed by excavation in the apposed surfaces of the radials and the centro-dorsal respectively, as is well seen in Pl. IV. figs. 1*c*, 1*d*.

Among the fossil Comatulæ there are several species in which the ventral surface of the centro-dorsal is marked by five small radial pits of this kind, that receive the ends of the radial axial canals. But in *Antedon retzii* they appear as actual perforations in the ventral surface of the centro-dorsal which reach downward to the bottom of its internal cavity, being in fact only separated from it by a narrow septum, and this is occasionally absent, so that the centro-dorsal cavity which is naturally decagonal or pentagonal in outline becomes stellate. This condition is very common in the stem-joints of some Palæocrinoidea, such for example as *Cupressocrinus*, and I think there can be no doubt that the radial openings or the extensions of the central canal in all such cases served for the passage of canals containing water in communication with that in the cœlom above.

Messrs. Wachsmuth and Springer[1] suggested long since that the complex stem of many Palæocrinoids might have been "subservient to respiration"; and the facts mentioned above respecting the Bourgueticrinidæ and the Comatulæ certainly go far towards supporting this view.

The ventral surface of the centro-dorsal is usually flat or slightly hollowed, rarely very convex, except in species like *Actinometra paucicirra*, *Actinometra typica*, &c., in which the greater part of the centro-dorsal is enclosed within the radial pentagon, as will be explained shortly. The internal openings of the canals leading to the cirrus-sockets are frequently visible on the floor of its cavity, as is well shown in *Promachocrinus kerguelensis* and in *Antedon antarctica* (Pl. I. figs. 1*d*, 6*d*). In both these species and also in others the walls of the centro-dorsal cavity are marked by strong ribs, the lower ends of which are more or less distinctly visible through the axial opening, projecting beneath its lip, which their upper ends help to support. Five of them, those at the interradial angles, are often considerably larger than the rest, and may be the only ones visible. In other cases, however, both these and numerous smaller intermediate ribs are visible through the axial opening, as is seen in Pl. I. figs. 1*d*, 6*d*. These ribs are much more distinct in some individuals than in others of the same species. Thus, for example,

[1] Revision of the Palæocrinoidea, part i. p 15, *Proc. Acad. Nat. Sci. Philad.*, 1879.

they do not appear within the middle portion of the centro-dorsal in the specimen of *Antedon eschrichti* figured in Pl. I. fig. 8*d*, though they are comparatively large in other forms of this type, as I have noticed elsewhere.[1]

The peripheral part of the ventral surface of the centro-dorsal is divided by ridges or grooves into the five trapezoidal areas in which the radial plates are lodged, and they are occasionally marked by more or less definite pits which receive the ends of the radial axial canals, as already explained (Pl. IV. figs. 1*d*, 2*d*). In most Comatulæ every two fossæ are separated by one of the five basal grooves which lodged the rays of the basal star, to be described subsequently. They are sometimes comparatively insignificant, as in *Antedon antarctica* (Pl. I. fig. 6*d*), while in the Pacific species they are usually very strongly marked (Pl. II. figs. 1–5*b*). On the other hand, if no basal star is present, the radial fossæ on the centro-dorsal are usually separated by tolerably sharp ridges as in *Antedon eschrichti* (Pl. I. fig. 8*d*), *Antedon quinduplicava* (Pl. IV. fig. 1*d*), and *Antedon disciformis* (Pl. IV. fig. 2*d*). The last-mentioned species, however, has indications of basal grooves at the proximal ends of these ridges. The grooves are fairly distinct in both the species of *Promachocrinus* which I have examined, but though the radials are ten in number, there are only five fossæ on the centro-dorsal, the ventral surface of which is distinctly pentagonal in outline, with its angles interradial, just as in *Antedon* (Pl. I. figs. 1*c*, 1*d*, 5).

In fact, I know of no *Comatula* in which the general shape of the centro-dorsal is not more or less distinctly pentagonal with its ventral ridges and angles interradial. Wachsmuth and Springer regard this fact as indicating the probable presence of radially situated under-basals in the *Comatula*-larva. Their extensive and important investigations into the structure of the calyx in the Palæocrinoids have led them to formulate the following rule:[2]—"In species with under-basals, whenever the column is pentangular, its longitudinal angles are directed interradially, the sides and columnar cirrhi radially."

They proceed to state[3] that the centro-dorsal of Comatulæ is interradial "and rests, as in the Apiocrinidæ, against the outer face of the basals, not within the basal ring"; while they continue—"upon this mainly we base the opinion that perhaps also the Comatulæ in their early larva had rudimentary under-basals. That these plates, if present, were not observed, is not surprising, as they may have been very minute and been covered entirely by the column."

Whether this be the case or not, the statement that the centro-dorsal of Comatulæ rests against the *outer* face of the basals is a somewhat misleading one. The "outer face" can only mean that which appears on the outside of the calyx; and this, from its very nature, cannot rest against the centro-dorsal, for it would then be internal and concealed.

[1] *Quart. Journ. Geol. Soc.*, 1880, vol. xxxvi. p. 47.
[2] Revision of the Palæocrinoidea, pt. iii. sect. 1, p. 7 (229); *Proc. Acad. Nat. Sci. Philad.*, 1885.
[3] *Ibid.*, sect. 2, 1886, p. 298 (222).

The centro-dorsal is at first a simple ring, in no way different from the other stem-joints; but when the basals come to assume a definite shape and the calyx acquires the doubly conical form of the Cystid phase, the centro-dorsal becomes distinctly wider than the annular stem-joints below it and takes on a pentagonal shape. The basals rest against the sides of the pentagon, and its angles which fit in between them are therefore radial in position, as seen in Pl. XIV. figs. 1, 8. At this early stage the basals are only in contact with the centro-dorsal by their lower edges; but it soon begins to increase in diameter and extends itself over the bottom of the calyx in the manner described by Dr. Carpenter.[1] It increases at the same time in vertical depth, and the first cirri make their appearance. These are radial in position, and the portion of the centro-dorsal between every two sockets rapidly enlarges, so that it comes to project beneath each basal plate, and the angles of the centro-dorsal thus become interradial instead of radial. This change is very clearly seen in larvæ which have only one or two cirri, so that one part of the centro-dorsal shows the primitive radial symmetry, and another part the acquired interradial symmetry.

Thus then the centro-dorsal of *Comatula*, when it first assumes definite form, has a most distinct radial symmetry. Its angles occupy the same position with regard to the basals as do those of the enlarged top stem-joint in *Guettardicrinus* and *Apiocrinus*, which are also distinctly radial in situation. I desire to lay particular stress upon this fact, because Wachsmuth and Springer, in support of their assertion that Neocrinoids are built upon the plan of dicyclic Crinoids, have stated that the top stem-joint "is disposed interradially in the Apiocrinidæ, Pentacrinidæ, and Comatulæ, similar to dicyclic Palæocrinoids."[2] But the ridges and angles of the top stem-joint are radial in every species of *Apiocrinus*, as is seen with especial clearness in *Apiocrinus magnificus*.[3] Wachsmuth and Springer[4] say, however, that "the plate in *Apiocrinus magnificus* is not, as should be supposed from appearances, disposed radially, but interradially, as shown by comparison with species having a pentangular stem. It attained its radial angles accidentally by adapting its form to the basal concavity which is naturally angular." This is a form of teleological argument which is very easily employed but is very difficult to refute. Neither Wachsmuth nor Springer, nor any one else, is acquainted with the post-embryonic development of *Apiocrinus*, and the changes which may or may not have taken place in the symmetry of its top stem-joint; though from the positive way in which the American authors write one would imagine that they had watched the whole process of the "accidental" change of symmetry which they describe. If the basal concavity "naturally" has radial angles, it is surely a "natural" and not an "accidental" circumstance that the top stem-joint which occupies this cavity should also have radial angles. This is the case in every species of *Apiocrinus*, in the single species of

[1] Researches on the Structure, Physiology, and Development of Antedon rosaceus, *Phil. Trans.*, 1866, p. 742.

[2] Revision, pt. iii. p. 299.

[3] See de Loriol, Paléontologie Française, Terrain Jurassique, t. xi. pls. 46–49.

[4] Revision, pt. iii. p. 297.

Guettardicrinus, and in the majority of those of *Millericrinus*; and yet it is considered by Wachsmuth and Springer as a merely "accidental" occurrence, and the real symmetry of the top stem-joint in the Apiocrinidæ is described as interradial. It is actually and visibly so in some twenty species of *Millericrinus*. But they belong to that aberrant section of the genus which so closely approaches *Pentacrinus* in having a distinctly pentagonal stem with interradial angles, and articular faces the sculpture of which is very different from that of the typical Apiocrinidæ and somewhat closely resembles that of the joint-faces in certain Pentacrinidæ. In all of these species the top stem-joint, like those below it, has interradial angles, and the same is the case with the basal concavity into which it fits. But Wachsmuth and Springer tell us that the "natural" shape of this concavity in the Apiocrinidæ is to have radial angles, and they have not attempted to explain its interradial symmetry in these aberrant and *Pentacrinus*-like forms of *Millericrinus* by reference to any causes whatever, accidental or otherwise. Perhaps it has escaped their notice; but whether this be the case or not, it is somewhat surprising to students of the Neocrinoidea to be told that the distinctive characters of the top stem-joint in the Apiocrinidæ, presenting themselves in each of the three genera, and in by far the greater number of the species of this family, are due to "accidental" causes. Further discussion of this question, however, would be impracticable at present. I merely wish to point out that as soon as the centro-dorsal of the early larva of *Comatula* takes a definite shape its angles are distinctly radial, just as is permanently the case in the top stem-joint of *Apiocrinus*, and this is in itself an argument against the supposed change of symmetry in the latter type about which Wachsmuth and Springer write so positively. But when the cirri appear on the centro-dorsal and the basals begin to be transformed into the rosette, the outline of the centro-dorsal changes. The basals are no longer the principal plates in the calyx, but they undergo metamorphosis into the small rosette, and the centro-dorsal increases rapidly in size, more so than any other part of the skeleton, "so that it soon comes to pass beyond the circlet of basals, and to abut on the proximal edge of the first radials; and instead of stopping here it continues to increase in diameter until it conceals the whole inferior surface of the first radials, and sometimes even encroaches somewhat on the second."[1]

Here then we see the reason for the interradial angles of the centro-dorsal in the mature *Comatula*. It is an altogether secondary condition, and due to the fact that the fossæ on the ventral surface of the centro-dorsal lodge the radial plates, so that the ridges separating them are interradial, just as in *Apiocrinus* the fossæ on the top stem-joint lodge the basals and are interradial, so that the intervening ridges and the angles in which they terminate are radial. Even in fossil Comatulæ which have no rosette, but persistent basals, these plates are usually quite small and do not form a closed ring on the exterior of the calyx; so that the upper surface of the centro-dorsal is mainly occupied by the radial fossæ and has interradial angles as in recent Comatulæ (Pl. I. figs. 5, 6*a*, 8*d*; Pl. II.

[1] W. B. Carpenter, *Phil. Trans.*, 1866, p. 742.

figs. 1–5, *b*). Thus then the interradial symmetry of the centro-dorsal is an altogether secondary condition, and is due not to the possible presence of radially situated underbasals, as supposed by Wachsmuth and Springer, but to the fact that the radials themselves rest upon the plate, the primary radial symmetry of which becomes altogether obscured when it begins to increase in diameter and to develop cirri, coincidently with the retromorphosis of the basals.

The external form of the centro-dorsal varies very greatly among different species of Comatulæ. It is very distinctly conical in *Atelecrinus* (Pl. VI. figs. 5, 7). In the three chief of the remaining endocyclic genera (*Antedon*, *Eudiocrinus*, and *Promachocrinus*) it is occasionally somewhat hemispherical or subconical, with the cirrus-sockets arranged rather irregularly (Pl. I. figs. 1*a*, 6*a*, 8*a*; Pl. II. figs. 1–3, *a*; Pl. III. figs. 4*b*, 5*a*, 7*a*; Pl. XXX. figs. 1, 2, 4); but in some cases, as in *Antedon quinquecostata*, it is more distinctly pentagonal and columnar, with the sockets grouped in alternating rows (Pl. III. fig. 6*d*), while in *Antedon balanoides* it is distinctly conical (Pl. XXXIII. fig. 6). In other forms again the dorsal pole is flattened (Pl. II. fig. 4*a*), and this is especially the case in *Antedon carinata* and *Antedon macronema* (Pl. III. figs. 1*a*, 3*b*; Pl. IV. fig. 3*a*), which in this character, as in some others, exhibit a variation in the direction of *Actinometra*. On the other hand, *Antedon quinduplicara* and *Antedon disciformis*, which are still more like *Actinometra* in the small number of functional cirrus-sockets and in the discoidal shape of the centro-dorsal, belong unmistakeably to the genus *Antedon* in the relative height of the radials (Pl. IV. figs. 1*a*, 2*a*).

In most species of *Actinometra* the centro-dorsal is a thin flattened disc, often with only one row of functional cirrus-sockets (Pl. IV. fig. 4*a*; Pl. V. figs. 1*b*, 1*d*, 2*b*, 2*d*, 2*e*, 4*b*); though in *Actinometra stelligera* it is thicker and bears a comparatively large number of sockets (Pl. V. figs. 5*b*, 5*c*).

As a general rule the shape of the centro-dorsal is tolerably constant in any individual species of *Antedon*, being hemispherical in *Antedon eschrichti* (Pl. I. fig. 8*a*; Pl. XXIV. figs. 10, 11), columnar in *Antedon quinquecostata* (Pl. III. fig. 6*d*), and more discoidal in *Antedon carinata* (Pl. III. figs. 1*a*, 3*b*). But in *Antedon phalangium* it exhibits a very considerable amount of variation, being hemispherical in some forms, but greatly elongated and conical in others (Pl. XXVIII. fig. 2).

In some species of *Actinometra* the obliteration of the cirrus-sockets on the centro-dorsal is carried to a very much greater extent than in *Antedon*; and the number of functional sockets, which is at no time large, is often extremely small. In some types the changes in the centro-dorsal do not stop here, but it is reduced to the condition of a flat pentagonal plate within the ring of radials as in *Actinometra paucicirra* (Pl. LIV. figs. 1–7); while in species like *Actinometra typica* (Pl. LVII. fig. 1), the sides of this plate undergo resorption, so that clefts appear between it and the radials. This gives the base of the calyx an appearance so different from that of the ordinary Comatulæ that the genus *Phanogenia* was instituted by Lovén[1] for the reception of species presenting these characters.

It was pointed out in my preliminary report,[2] however, that the stellate appearance of the centro-dorsal in *Phanogenia* (Pl. LVII. fig. 1) "appears to be one of the concluding stages of a long series of changes in the shape and relations of the centro-dorsal, which do not commence until some time after the loss of the stem and the entry upon the free state of existence." The earlier stages of these modifications are well shown in a series of specimens of *Actinometra paucicirra*, which is very abundant at Cape York (Pl. LIV.). In the youngest individual of the series the centro-dorsal is a thin and slightly convex circular disc, about 2 mm. in diameter, which bears five pairs of cirri, one pair opposite each interradius. They reach 6 mm. in length and consist of about fifteen joints, which are tolerably mature in their general characters (Pl. LIV. fig. 10); the next stage is a slightly older individual in which all the cirri have fallen away from the centro-dorsal and the obliteration of their sockets has commenced (fig. 9). This process has been carried further in the larger and more distinctly pentagonal centro-dorsal shown in fig. 8, though it has gone on rather unequally, some of the sockets being much more obliterated than others.

Scarcely any trace of sockets can be made out in the original of fig. 5, but the centro-dorsal is a thin pentagonal disc with the appearance of processes at some of its angles, which are more probably, however, the ends of the basal rays. Its surface is much more nearly flush with that of the radials in the full-grown specimen shown in fig. 2, still, however, retaining its pentagonal shape. Fig. 1 shows another modification, each angle of the pentagon being marked by a more or less deeply impressed pit in which the basal ray is sometimes visible. The form represented in fig. 3 has a more rounded centro-dorsal, which is flush with the radials at its edges, and shows the basal rays at its angles; while there are indications of pits at the distal angles of the sutures between the first radials. The sides of the centro-dorsal in this specimen are slightly concave, and this character is much more distinct in figs. 6, 7, so that the shape becomes markedly stellate. In the former the centro-dorsal (as viewed from the dorsal side) is above the level of the radial pentagon; but in the latter it is relatively much lower, so that its surface is flush with that of the radials, the proximal edges of which are convex in correspondence with the stellate outline of the centro-dorsal. Fig. 4 shows a similar case in which the centro-dorsal is pentagonal. The effect of its complete withdrawal into the radial pentagon is to make it entirely invisible in a side view of the calyx, as seen in Pl. V. fig. 3*b*; while the dorsal surface of the united radials becomes very deeply hollowed for its reception (Pl. V. fig. 3*c*) instead of being slightly convex, as is more usually the case (Pl. V. figs. 1*c*, 5*d*).

[1] Phanogenia, ett hittils okändt slägte af fria Crinoideer, *Öfversigt k. Vetensk.-Akad. Förhandl.*, 1866, p. 231.
[2] *Proc. Roy. Soc.*, 1879, vol. xxviii. p. 390.

The stellate condition of the centro-dorsal just described in *Actinometra paucicirra* is sometimes reached by that of *Actinometra parvicirra* before the cirrus-sockets are entirely obliterated. In one specimen of this variable type which was obtained by the Challenger, the mature cirri have disappeared and are replaced by a few rudimentary stumps, while the sides of the plate are so deeply hollowed by their sockets that its outline is rather stellate than pentagonal. But it is still distinctly above the level of the radials (Pl. LXI. fig. 3).

The six examples of the large *Actinometra nobilis* which were dredged in the Philippines also exhibit a considerable amount of variation in the characters of the centro-dorsal (Pl. LXV. figs. 1–6). In the least modified form it is a rounded pentagonal plate distinctly above the level of the calyx, with traces of about ten cirrus-sockets, one of which contains a very rudimentary stump, and a well-marked process at each of its angles (fig. 2). In another specimen it is distinctly sunk below the level of the radials, with which it remains united externally by the interradial processes at its angles; but its sides are bevelled away, and most of them bear indistinct cirrus-sockets, in one of which a small stump is visible (fig. 3). In the other four examples, however, the centro-dorsal shows little or no trace of cirri, and is distinctly concave on its dorsal surface; while it is completely enclosed by the radial pentagon, united to it by the interradial processes at its angles, but separated from it by very distinct clefts along its sides. Its shape, however, is more pentagonal than stellate (Pl. LXV. figs. 1, 4–6).

These clefts are rather deeper in *Actinometra littoralis*, though the centro-dorsal retains its distinctly pentagonal form, and is about flush with the radials, with which it is in contact by its lower angles (Pl. LXVII. fig. 1). On the other hand, in *Actinometra divaricata* the centro-dorsal is very markedly stellate, and remains above the level of the radials, the surface of which falls away considerably towards the sides of the centro-dorsal, but not so much so as to give rise to definite clefts (Pl. LXIII. fig. 6).

In the Challenger specimen of *Actinometra typica*, however, in the original type of *Phanogenia*, and in others which I have seen, the centro-dorsal is both stellate and sunk below the radials, so that there are very distinct clefts between the latter and its incurved sides; and no one would think from its present appearance that it had ever been a cirrus-bearing joint (Pl. LVII. fig. 1). But in Lovén's specimen the metamorphosis was less complete, for a few cirrus-stumps are figured as still attached to the stellate centro-dorsal, which is slightly above the level of the radials. The facts stated above, however, concerning *Actinometra paucicirra*, *Actinometra nobilis*, and other forms, entitle us to assume that cirri were really present in the young *Phanogenia*, so that the genus ceases to have the extremely anomalous character which Lovén not unnaturally attributed to it.

These clefts which occur at the sides of the centro-dorsal in *Actinometra typica* and similar species must not be supposed to place the cavity of the calyx in communication with the external medium. They occur in several species of *Actinometra* in which the centro-dorsal undergoes very little modification, as for example in *Actinometra pectinata*. The small centro-dorsal of this species, as I have shown elsewhere,[1] retains its cirrus-sockets and its discoidal form, but has five minute openings round its margin; and these lead into spaces between its ventral surface and the lower surface of the radial pentagon, which are formed by the apposition of depressions in each of these surfaces respectively. But sections through the calyx of this type show that the radial spaces leading inwards from these marginal openings terminate internally against the inner portion of the ventral surface of the centro-dorsal, and are completely shut off from the radial axial canals enclosed between the rosette and the inner faces of the radials. There is, therefore, no such communication between the body-cavity and the exterior as the presence of these radial spaces might be supposed to indicate. They are precisely homologous with the interarticular pores in the stem of *Pentacrinus*, which lead inwards some little way, as described in Part I., but are in no communication with the central canal of the stem.

It is worth notice that in one fossil species, *Actinometra lovéni*,[2] from the Gault of Folkestone, the centro-dorsal approaches the *Phanogenia*-condition. It is an almost pentagonal plate, scarcely above the level of the radials, from which it is separated by narrow clefts, just as in *Actinometra typica* (Pl. LVII. fig. 1), and in *Actinometra nobilis* (Pl. LXV. figs. 3–5), and from the close resemblance of the calyx to that of these and similar species which are nearly all inhabitants of quite shallow water (20 fathoms or less), it would appear that the portion of the Gault Sea in which *Actinometra lovéni* lived cannot have reached any great depth.

B. The Chambered Organ.

Reference has been made above to the radial axial canals which are enclosed between the rosette and the radials, and sometimes reach the ventral surface of the centro-dorsal. Their character and relations were minutely described by myself in 1879, in my memoir on *Actinometra*.[3] They were shown both in longitudinal and in transverse sections, and figures were also given illustrating their openings on the under surface of the radial pentagon, together with the pits corresponding to these openings on the upper surface of the centro-dorsal in *Antedon rosacea*. They were clearly distinguished from the five cavities within the central capsule which were first discovered by Dr. Carpenter.[4] He

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 89, 90, 102, 103.

[2] See P. H. Carpenter, On some Undescribed Comatulæ from the British Secondary Rocks, *Quart. Journ. Geol. Soc.*, 1879, vol. xxxvi. p. 51.

[3] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 77, 78.

[4] *Phil. Trans.*, 1866, p. 738; and On the Structure, Physiology, and Development of Antedon rosaceus, *Proc. Roy. Soc.*, 1876, vol. xxiv. pp. 218, 219.

gave the name "five-chambered organ" or "quinquelocular organ" to the structure which had been described by Müller as a single-chambered heart. For he found it "to contain five chambers clustered like the carpels of an orange round a central axis;" and he described these chambers as being surrounded by a fibrillar envelope which he regarded as nervous in character. Marshall[1] again spoke of the cavity of the centro-dorsal as lodging "a sac divided by vertical septa into five radial compartments, and hence called the chambered organ"; and he went on to explain how this is "surrounded by a thick fibrillar investment known as the central capsule." Ludwig had previously adopted the same terminology,[2] and, in fact, he was the first to speak of the "chambered organ" without the numerical prefix, but he never used this expression to denote anything else than the five chambers with their central axis inside the central capsule; while he further described and figured the radial axial canals,[3] the relations of which to the cœliac canals of the rays and arms were subsequently pointed out by myself.[4] Their connection with the body-cavity and their distinctness from the chambers of the so-called heart were clearly recognised by Greeff,[5] both in his figures and in his descriptions; while I am not aware that Teuscher,[6] the only other recent original writer on the subject up to the time of Perrier and Jickeli, ever used the expression "chambered organ" at all, though he often referred to the "Kammern des Gefässcentrums," and he recognised the connection of the radial axial canals with the cœliac canals of the rays.

Recently, however, Messrs. Vogt and Yung have figured not only the cavities within the central capsule but also the radial axial canals, and the whole system of spaces within the calcareous network occupying the centre of the radial pentagon, together with *some accidental cavities within the solid base of the centro-dorsal piece and in the radials* as "cavités dépendantes de la cavité générale et constituant, dans leur ensemble, l'organe dit cloisonné."[7] They say "Ce sont les espaces qu'on est convenu d'appeler, fort improprement, l'organe cloisonné," and again "C'est la réunion de toutes ces excavations internes, qui sont revêtues de membranes, envoyant de cloisons transversales et dessinant ainsi un système compliqué de lacunes cloisonnées, qui composent ce que les auteurs ont appelé *l'organe cloisonné* (*Gekammertes Organ*). C'est une dénomination éminemment impropre, vu que ce n'est pas un organe, mais une suite de cavités parcourues par l'organe dorsal avec ses vaisseaux, et formant la continuation de la cavité générale du corps, du coelôme, qui entoure les intestins."[8] The statements contained in the first passage

[1] On the Nervous System of Antedon rosaceus, *Quart. Journ. Micr. Sci.*, 1884, vol. xxiv., N.S., p. 510.

[2] Beiträge zur Anatomie der Crinoideen, *Zeitschr. f. wiss. Zool.*, 1877, Bd. xxviii. pp. 315–326.

[3] *Ibid.*, p. 318.

[4] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. p. 78.

[5] Ueber das Herz der Crinoideen, *Sitzungsb. d. Gesellsch. z. Beford. d. ges. Naturwiss. zu Marburg*, 1876, No. 5, p. 93.

[6] Beitrage zur Anatomie der Echinodermen: I. Comatula mediterranea, *Jenaische Zeitschr.*, 1876, Bd. iii. pp. 244–260.

[7] Traité d'Anatomie comparée pratique, Livr. vii., 1886, p. 550, expl. of fig. 270.

[8] *Ibid.*, p. 530.

quoted and in the first paragraph of the second one are inaccurate, to say the least of it. Messrs. Vogt and Yung do not name the authors who have used the term "chambered organ" in this "very improper" sense; but it is certainly neither Dr. Carpenter, Ludwig, Greeff, Teuscher, Marshall, Jickeli, Perrier, nor myself; and I know of no other original writer on Crinoid morphology who has used the expression "chambered organ" at all. The space represented in the figures to which the Swiss authors refer[1] is the radial portion of the body-cavity within the calyx, which is clearly distinguished from the chambers within the central capsule in all the figures given by Ludwig, Greeff, and myself; and not one of us has ever regarded this space as a part of the chambered organ, nor, so far as I know, has any other writer on the subject. But from the mode of reference employed by the Swiss authors it would appear that Dr. Carpenter had made a great mistake, which had escaped notice for twenty years until it was rectified by Messrs. Vogt and Yung; whereas in reality they are themselves in error, because they give a meaning to his name which neither he nor any one else ever intended it to bear. The term "(five-) chambered organ" as employed by him and by every one of his successors until now refers exclusively to the cavities within the central capsule, which lie on the dorsal side of the rosette and radial pentagon. But Messrs. Vogt and Yung erroneously interpret it as denoting the entire system of cavities within the centro-dorsal plate and the ring of radials that rests upon it; and this is certainly not a definite organ, but a part of the general cœlom, as stated by the Swiss authors. These facts, however, were perfectly well known both to Dr. Carpenter and to his successors, and I am entirely at a loss to know who the authors can be who have used the term "chambered organ" in the "eminently improper" sense described by Vogt and Yung. The Swiss authors seem to have entirely ignored or misunderstood the writings of their predecessors, and have attributed to them a mistake which never was made. But instead of rectifying this supposed mistake they have converted it into a real one, and have perpetuated it both in their text and in the explanations of their figures. Thus in fig. 276 the cavities *within* the central capsule on the *dorsal* side of the rosette, and the portion of the body-cavity which is on the *ventral* side of this structure and is enclosed by one of its radial processes, are marked alike "*c*, *c*, cavités dépendantes de la cavité générale et constituant dans leur ensemble, l'organe dit cloisonné." No one but Vogt and Yung has used the term "chambered organ" in this sense; and as they rightly speak of it as "eminently improper," one cannot but regret that it should have been employed in a textbook of comparative anatomy for the use of students.

But Messrs. Vogt and Yung go even further than this. The space on the dorsal side of the central capsule which is marked *f′* in fig. 267 and *c* in fig. 276, and is described as one of the cavities of the chambered organ, is nothing but a rent in the organic basis of the floor of the centro-dorsal piece. These rents often appear in the skeletal tissues when very thin sections are cut, and I have been familiar with them for years. But I

[1] *Op. cit.*, *f*, fig. 264; *c*, fig. 276.

have many sections through the calyx, both of *Antedon rosacea* and of other species of Comatulæ in which there is no trace of them. Three such undamaged sections are figured in my *Actinometra*-memoir,[1] and I certainly never expected to find an accidental fracture in the skeletal tissue *outside* the central capsule described as a part of the chambered organ, the cavities of which are entirely *within* this capsule, as explained above.

If there really be such a diverticulum of the body-cavity within the calcareous substance of the centro-dorsal piece as is described by Vogt and Yung, *i.e.*, between its inner floor on which the central capsule rests and its external surface, its presence could easily be demonstrated by rubbing away the outer surface of the centro-dorsal until this cavity was reached; and I would commend this method of proving the accuracy of their anatomical descriptions to the attention of Messrs. Vogt and Yung. They have made a precisely similar error in their description of the anatomy of the arms, figuring a large rent in the skeletal tissue of an arm-joint as the "cavité de la syzygie." They will not find this cavity if they will take the trouble to rub away the syzygial surface of an arm-joint, which contains but one cavity, that of the axial canal.

Another extraordinary blunder which is committed by these authors in the explanation of fig. 276 is their description of the fibres (*b*) which unite the first radials to the centro-dorsal as the "muscles entre le premier et le second radial." Their monograph contains many other errors of a similar kind, not only in their interpretation of well-known anatomical facts, as in this last case, which they might have avoided by consulting the works of their predecessors, but also misrepresentations of passages in these writings. These, however, are more fitly dealt with elsewhere.[2]

C. The Rosette.

While the presence of a cirrus-bearing top stem-joint or centro-dorsal piece is common to all Comatulæ, even including the aberrant *Thaumatocrinus*, this genus, together with *Atelecrinus* (Pl. VI. figs. 5, 7) and many fossil species, differs from the adult condition of all other recent Comatulæ in the presence of the basals on the exterior of the calyx.

It was for a long time supposed that the basals of other Crinoids were unrepresented in recent Comatulæ; but their existence in the Pentacrinoid larva was eventually recognised by Allman, Sir Wyville Thomson, and Dr. Carpenter; and the last-mentioned observer discovered the remarkable changes which they undergo during the later part of Pentacrinoid life. These changes result in their transformation into the "rosette" which lies close to the dorsal surface of the central funnel within the radials, and covers in the upper opening of the centro-dorsal cavity that lodges the chambered organ (*sensu stricto*). It is well seen in the figures of *Antedon eschrichti*, *Antedon acœla*, *Antedon*

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pl. viii. figs. 3, 4, 7.

[2] The Morphology of Antedon rosacea, *Ann. and Mag. Nat. Hist.*, 1887, ser. 5, vol. xix. pp. 19–41.

inæqualis, and *Antedon breviradia* (Pl. I. fig. 8*c*; Pl. II. figs. 3*c*, 5*c*; Pl. III. figs. 4*c*, 5*b*), and also in those of *Actinometra maculata*, *Actinometra lineata*, and *Actinometra stelligera* (Pl. V. figs. 1*c*, 2*c*, 2*e*, 5*d*, 5*e*). Owing to its homologies with the basals of other Crinoids, and through these forms with the corresponding plates in other Echinoderms (*e.g.*, the genitals of Echini), it is a very important structure, apart altogether from its intimate relation to the great nerve centre lodged within the centro-dorsal plate and to the axial cords proceeding from it.

One would have thought therefore that some account would have been given of it in Vogt and Yung's work upon practical comparative anatomy in which *Antedon rosacea*, the form studied by Dr. Carpenter, is taken as a type of all Crinoids. It is dismissed, however, in less than half a dozen lines, and not a word is said of its morphological relations. In fact the word "basals" does not once occur in the chapter on Crinoidea in the treatise by Messrs. Vogt and Yung, who pay no attention to the comparative anatomy of anything but the soft parts as revealed by thin microscopic sections. Unfortunately, however, this too exclusive reliance upon one method of investigation has led them into a serious but at the same time a somewhat ludicrous error. In the figure given by Messrs. Vogt and Yung[1] "pour montrer la disposition du système nerveux central et des organes dorsal et cloisonné" the chambered organ (as originally described) is covered by a structure marked *o*. No explanation of this letter is given, but I learn from Professor Carl Vogt that the missing explanation should be—*o*, tissu conjonctif areolaire entourant l'organe dorsal et les cavitiés *c* de l'organe cloisonné.

Now this structure which is marked *o* in Vogt and Yung's fig. 276 is in reality nothing more or less than a part of the rosette of modified basals, which in the natural position of the animal roofs in the internal cavity of the centro-dorsal that contains the chambered organ, as is well shown in Pl. V. figs. 2*c*, 2*e*, and 5*e*. The relations of this structure to the soft parts beneath it are entirely ignored by Messrs. Vogt and Yung, though they were described at length by myself in 1879[2] and again in 1881. In the latter year I published two sectional views[3] showing the position of the rosette with respect to the chambered organ, and another similar figure and description were given later on by Marshall.[4] But these have been altogether ignored by Messrs. Vogt and Yung, who have also neglected to work out the point for themselves; and the consequence is that a structure which, though small and insignificant in Comatulæ, is nevertheless homologous with the five genital plates of Echini, is figured in a textbook of comparative anatomy as "areolar connective tissue." In the same figure, too, a portion of the centro-dorsal piece, which is in immediate contact with the central capsule, is lettered "*e*, mésentère."

There are many other points in the relations of the Crinoid skeleton which are

[1] *Op. cit.*, p. 550, fig. 276.
[2] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, p. 78.
[3] The Minute Anatomy of the Brachiate Echinoderms, *Quart. Journ. Micr. Sci.*, 1881, vol. xxi., N.S., p. 186, pl. xii. figs. 14, 15.
[4] *Loc. cit.*, pp. 508, 511, pl. xxv. fig. 1. See also Ludwig, *loc. cit.*, Taf. xix. fig. 74.

altogether misunderstood by Vogt and Yung, who have apparently attempted to work out the anatomy of the type by one method only, that of thin sections, and have almost completely ignored its osteology. Had they devoted a little more attention to the characters of a prepared skeleton of *Comatula* they would have avoided not a few errors which are calculated to give the student an altogether erroneous conception, not only of Crinoid morphology, but of that of Echinoderms in general. The basal plates are among the earliest calcareous structures which appear in the larva of any Echinoderm, and their relation to the great nerve centre of a Crinoid renders them additionally important morphologically. But no student of Messrs. Vogt and Yung would ever learn of their existence at all.

The gradual development of the rosette out of the original basal plates of the Pentacrinoid larva was fully described by Dr. Carpenter,[1] who showed that it is "essentially formed at the expense of the secondary or ventral layer of the original basals, the ends of the curved rays being the sole residue of their primary or dorsal layer." Alternating with these spout-like processes, which are radial in position, are five others of a more triangular form, which occupy a somewhat deeper situation within the radial pentagon. The apex of each of them is attached to a suture between two contiguous radials, just between the two adjacent apertures of their central canals. Each of these canals receives a branch of the primary basal cord proceeding from the central capsule, that lies on the dorsal side of the interradial process of the rosette; and when the rosette is in its natural position in the calyx, an opening for the passage of one of these secondary basal cords is visible between every two of the processes of the rosette. This is well seen in *Antedon eschrichti* (Pl. I. fig. 8*c*). The example of this species which is here represented, has a comparatively simple rosette, which is almost entirely free from any trace of the accessory structures to which I have given the general name of the "basal star," such for instance as is represented in figs. 1–5, *c* on Pl. II. In all these forms, and more especially in *Antedon angusticalyx* and *Antedon inæqualis* (figs. 4*c*, 5*c*), a larger proportion of the embryonic basal has been left unabsorbed than is usually the case in the European and Arctic Comatulæ; but the peripheral margins of each plate remain, and form, by their union with the corresponding parts of the adjacent plates, the structure which I have called the basal bridge. This is united to each radial along the inner margin of its dorsal face, and partially covers in the two secondary basal cords which are converging on its single axial canal. It is well shown in *Actinometra maculata* and *Actinometra stelligera* (Pl. V. figs. 1*c*, 5*d*) and also in the rosette of the latter species disconnected from the radials as seen in fig. 5*e*; and it appears, so far as I am aware, to be of pretty constant occurrence in this genus, though absent or at any rate undistinguishable in some species of *Antedon* (Pl. III. fig. 6*b*).

United with each angle of the pentagon formed by the five basal bridges is one of the

[1] *Phil. Trans.*, 1866, p. 745.

rays of the basal star, the relations of which are described at length in my memoir on *Actinometra*.[1] At the time this was written (1877) I had only been able to dissect the calyx in a comparatively small number of Comatulæ; but a detailed examination of the large amount of duplicate material obtained by the Challenger has shown that a basal star is nearly always present both in *Antedon* and in *Actinometra*, so that species like *Antedon tenella*, *Antedon hageni*, *Antedon phalangium*, and *Antedon rosacea*, in which it is not developed, are the exception rather than the rule; while there may be traces of it in some varieties of *Antedon eschrichti*, though not in others.

It occasionally happens that the rays of the basal star, or, more shortly, "the basal rays," appear on the exterior of the calyx between the centro-dorsal and the first radials. But there is no constancy about this character, even in individual species. Thus, for example, a basal ray is visible in the dissected calyx of *Antedon antarctica* shown on Pl. I. fig. 6*a*, but there is no trace of it in either of the three specimens figured on Pl. XXV. figs. 10–12. The basal rays sometimes appear externally beneath the alternate radials of the ten-rayed *Promachocrinus* (Pl. I. figs. 1*a*, 1*c*), but this is not always the case. I have also seen them in some individuals of *Antedon carinata*, though not in that shown on Pl. III. fig. 1*a*. They are generally to be seen in *Antedon macronema* (Pl. IV. fig. 3*a*; Pl. XXXVIII. fig. 5), in *Antedon longicirra* (Pl. XVII.), and also in *Actinometra pulchella* (Pl. IV. fig. 5*c*), and *Actinometra stelligera* (Pl. V. fig. 5*b*); while there are other species, such as *Actinometra maculata* and *Actinometra lineata*, in which they are only occasionally visible.

I have shown elsewhere that the basal rays have an entirely different origin from either the primary or the secondary portions of the rosette. They are tertiary structures formed by calcification in the synostosis between centro-dorsal and radials. Sometimes, however, they are very substantial structures, and each of them becomes so firmly united with an interradial portion of the rosette that it is often possible to get the entire complex structure thus formed to break up into five separate parts, each representing one basal plate. The results of this operation are seen in *Antedon antarctica* (Pl. I. fig. 7), *Antedon carinata* (Pl. III. figs. 1*c*, 2*a*, 2*b*, 3*a*, 3*b*), *Actinometra meridionalis*, *Actinometra pulchella*, and *Actinometra paucicirra* (Pl. IV. figs. 4*b*, 5*a*, 6*b*). Each of the compound basals so isolated is a somewhat elaborate structure. The basal ray may be long and narrow as in *Actinometra meridionalis* (Pl. IV. fig. 4*b*), or short and stout as in *Antedon antarctica* (Pl. I. fig. 7) and *Actinometra paucicirra* (Pl. IV. fig. 6*b*.)

At the proximal end of the basal ray are two openings, one on each side, which give passage to the secondary basal cords; and they are separated, when seen from the dorsal side, by the interradial process of the rosette with portions of the basal bridge (Pl. IV. figs. 4*b*, 6*b*, β). The lateral boundaries of these openings are formed by the halves of two of the radial spouts of the rosette which extend outwards from the base of the interradial

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 95–100.

process and represent the unabsorbed lateral portions of the primary layer forming the embryonic basal plate. The ventral side of the basal ray in the three species of *Actinometra* which are figured on Pl. IV. figs. 5*a*, 4*b*, 6*b*, *a*, is marked by a relatively large depression which forms the central end of the axial interradial canal. This descends into the calyx over the apposed lateral edges of two radials, as is well seen in Pl. III. figs. 1*d*, 7*c*, and Pl. V. fig. 2*c*. But in most cases it ends blindly without reaching the dorsal surface of the radial pentagon at all.

D. The Radials.

The radials of Comatulæ differ considerably from those of the Pentacrinidæ, the family of Stalked Crinoids to which the free forms are most closely allied. In *Pentacrinus*, as in the Pentacrinoid larva of *Antedon* (Pl. XIV. figs. 2–9), the first radials appear above the basals on the exterior of the calyx as relatively large convex plates. They retain this character in *Thaumatocrinus* and to a less degree in *Atelecrinus* (Pl. VI. figs. 5, 7), both of which are permanent larval forms in other respects. But in the two large genera *Antedon* and *Actinometra* there is a very considerable amount of variation in the extent to which the first radials appear externally. Some forms, such as *Antedon eschrichti*, show no indication of them at all (Pl. XXIV. fig. 11), or only traces of their angles in the interradial portions of the calyx (Pl. I. fig. 8*a*); while in other cases, such as *Antedon elegans*, *Antedon longicirra* (Pls. VIII., XVII.), and *Antedon macronema* (Pl. IV. fig. 3*a*; Pl. XXXVIII. fig. 5), they exhibit a relatively large outer surface between the edge of the centro-dorsal and the second radials. Between these two extremes every intermediate gradation may be traced. The former is due to the gradual enlargement of the centro-dorsal, which spreads itself over the base of the calyx towards the end of Pentacrinoid life and sometimes conceals the first radials altogether, as described by Dr. Carpenter[1] in *Antedon rosacea*. The second radials thus appear to spring directly from the centro-dorsal (Pl. XIII. fig. 2); and this has sometimes led to species of *Comatulæ* being described as having only two radials. In fact d'Orbigny[2] described a new genus *Comatulina*, for a fossil species in which there are no external basals and "les bras s'articulent immédiatement sans intermédiaires à la pièce centrale pourvue de ramules." The full-grown *Antedon acœla* presents this appearance, but the younger specimen figured on the same plate (Pl. XVI.) shows comparatively large first radials; while a more mature individual (Pl. II. figs. 3*a*, 3*c*) shows relatively less of them, owing to the spread of the centro-dorsal. The figures of *Antedon phalangium* on Pl. XXVIII. show similar differences of growth, though in a less degree.

The various species of *Actinometra* exhibit among themselves essentially the same

[1] *Phil. Trans.*, 1866, p. 742.

[2] Cours élémentaire de Paléontologie et de Géologie Stratigraphique, 1850–52, vol. ii. p. 139.

differences as do those of *Antedon* in the extent to which the radials appear on the outside of the calyx. In *Actinometra maculata*, *Actinometra lineata*, and *Actinometra stelligera* the centro-dorsal is so large that it actually supports the proximal ends of the second radials, and nothing but the angles of the first radials can be seen externally (Pl. V. figs. 1, 2, 5, *a*, *b*). Small portions of their sides can be seen in *Actinometra solaris* (Pl. V. figs. 4, *b*, *c*); while in *Actinometra paucicirra* and in all the *Phanogenia*-like forms the centro-dorsal only occupies a comparatively small space in the centre of the radial pentagon, a considerable portion of which appears externally as seen in Pl. V. fig. 3*c*, and in Pls. LIV., LXV.

Not only the centro-dorsal, but also the radials of *Actinometra* present very considerable differences from the corresponding parts of the *Antedon*-calyx, though these differences are less distinct in the fossil than in the recent forms of both genera. The outer or articular faces of the radials in *Antedon* are always much inclined to the vertical axis of the calyx, and are usually much wider at their dorsal than at their ventral ends, so that their outline is trapezoidal (Pl. I. figs. 6*a*, 8*a*; Pl. II. figs. 1–5, *a*; Pl. III. figs. 1*a*, 4*b*, 5*a*, 6*d*; Pl. IV. figs. 2*a*, 3*a*). *Antedon carinata* and *Antedon macronema* are, however, somewhat exceptional in this respect, the width of their articular faces being very much more uniform; and they further differ from most species of *Antedon* and resemble *Actinometra* (Pl. V. figs. 1–5, *a*) in the relatively great diameter of the central funnel of the calyx (Pl. III. fig. 1*d*; Pl. IV. fig. 3*b*). For as a general rule the opening of the central funnel which is bounded by the upper edges of the radials is very narrow, their ventral surfaces being quite small and having a steep inward slope. Hence when the calyx is viewed from above the greater part or even the whole of these inclined external faces is visible, always down to the opening of the central canal in the transverse articular ridge (Pl. II. fig. 4*d*; Pl. III. fig. 6*c*); while sometimes even the fossæ for the attachment of the dorsal ligament are visible in a superior view (Pl. I. figs. 6, 8, *b*; Pl. II. figs. 1–3, 5, *d*; Pl. III. fig. 4*a*). This last is especially the case in *Antedon macronema* (Pl. IV. fig. 3*b*), though the reverse is true of *Antedon carinata* (Pl. III. fig. 1*d*).

Most species of *Antedon* have large muscle-plates, which greatly increase the height of the distal faces of the radials (Pl. I. figs. 6, 8, *a*; Pl. II. figs. 1–5, *a*; Pl. III. figs. 4*b*, 5*a*, 6*d*). They are fairly large in *Antedon carinata* (Pl. III. fig. 1*a*), but in *Antedon macronema* they are quite small and linear and barely distinguishable in side view from the pair of fossæ immediately below them, though they are seen more clearly when viewed from above (Pl. IV. figs. 3*a*, *b*). This lower pair of fossæ was described by Dr. Carpenter[1] as serving for the attachment of the interarticular ligaments. The ridges which generally separate them from the upper fossæ mostly start from the raised rim round the opening of the central canal and run more or less obliquely outwards to meet the sides of the radials (Pl. II. figs. 2–5, *a*; Pl. III. figs. 4*b*, 5*a*, 6*d*). In *Antedon antarctica*, however,

[1] *Phil. Trans.*, 1866, p. 714.

they are almost perfectly horizontal (Pl. I. fig. 6*a*), and so give the calyx a very different appearance from that of the closely allied Arctic species *Antedon eschrichti* (Pl. I. fig. 8*a*); though *Promachocrinus kerguelensis*, another southern form, resembles *Antedon eschrichti* in this respect (Pl. I. fig. 1*a*), and the same may be said of *Eudiocrinus semperi* (Pl. III. fig. 7*a*). In some forms of *Antedon incisa* the ridges do not, as is usually the case, start from the rim of the central canal, but curve upwards slightly from the median vertical ridge of the articular face, and the upper pair of fossæ are therefore somewhat restricted (Pl. II. fig. 1*a*). In *Antedon disciformis* (Pl. IV. fig. 2*a*) the ridges run upwards from the central canal for some little distance and then curve outwards, leaving a sort of furrow between them, the bottom of which is sometimes slightly raised.[1] But in most species of *Antedon* there is a strong median ridge running down from the ventral edge of the articular face towards the opening of the central canal (Pl. I. figs. 6*a*, 8*a*; Pl. II. figs. 1–5, *a*; Pl. III. figs. 4*b*, 5*a*, 6*d*). This is hardly traceable in *Antedon carinata* (Pl. III. fig. 1*a*), which rather resembles *Antedon disciformis* in having a tendency to the intermuscular furrow that is so characteristic of *Actinometra* (Pl. V. figs. 1–5, *b*); while in *Antedon macronema* the muscular fossæ are so very slight, that the notch between them reaches down to the upper margin of the raised rim of the central canal (Pl. IV. figs. 3*a*, *b*), a character which rarely occurs in *Actinometra*.

Thus then the radials of *Antedon carinata* and *Antedon macronema* differ from those of other species of *Antedon* and approach those of *Actinometra*. There is much less difference than usual between the widths of the upper and lower ends of the distal faces, which are comparatively low, so that their long axes are horizontal and not vertical as is usually the case (Pl. I. figs. 6*a*, 8*a*). The centre of the upper surface is consequently occupied by a wide funnel, the walls of which are formed by the ventral surfaces of the radials (Pl. III. fig. 1*d*; Pl. IV. fig. 3*b*). *Antedon carinata* has fairly large muscle-plates; but they are quite small in *Antedon macronema*, and the ridges separating the muscle- and ligament-fossæ are so slightly oblique as to be almost horizontal, though their origin from the prominent and large rim of the central canal is very marked. In each case, however, the general appearance of the calyx is much more that of the *Antedon* than of the *Actinometra* type. The calyx of *Antedon macronema* further presents many resemblances to that of *Pentacrinus*, especially in the small size of the articular faces and in the large portions of the radials which appear externally (Pl. IV. fig. 3*a*). Of all recent Comatulæ it is the one which most closely approaches the general type of the Jurassic forms of *Antedon*; and as it is only known to occur on the Australian Coast, this is a point of considerable interest.

The radials of *Actinometra* differ very largely from those of the typical *Antedon*. Their distal faces are relatively low, and lie nearly or quite parallel to the vertical axis of the calyx, while there is but little difference in width between their upper and their lower

[1] This is less distinctly seen in an interradial view of the calyx than in a face view of a single radial.

ends. The vertical position of the articular faces is well seen in some forms of *Actinometra lineata*, which has an extremely "wall-sided" calyx (Pl. V. fig. 2*e*); while in *Actinometra paucicirra* their lower portions actually slope inwards as seen in Pl. V. fig. 3*c*. The ventral faces of the radials, which in *Antedon* have a steep inward slope (Pl. I. fig. 8*b*), are almost horizontal in *Actinometra*, sloping very gently inwards towards the central space. Hence the opening of the funnel becomes widely expanded, and when the radial pentagon is viewed from above little or nothing is seen besides the proper ventral faces of its component radials. All the species of *Actinometra* which I have examined have smaller muscle-plates than those of any *Antedon* except *Antedon macronema* (Pl. IV. figs. 3*a*, *b*), so that the distal faces of the radials are very low and the muscular fossæ often quite inconspicuous (Pl. IV. figs. 4*a*, 5*c*; Pl. V. figs. 1–5, *b*, 5*c*). They are separated from the lower pair of fossæ by fairly prominent ridges which are either horizontal or curved slightly upwards. These start from the sides of the radial, run inwards towards the middle line, and then turn downwards so as to leave between them a wide furrow, which gradually dies away below with the disappearance of its bounding ridges. No recent *Actinometra* has the distinct rim on the ventral side of the opening of the central canal that exists in every *Antedon*, even in *Antedon carinata* (Pl. III. fig. 1*a*) and in *Antedon macronema* (Pl. IV. fig. 3*a*), perhaps the nearest approach to it being in *Actinometra meridionalis* and *Actinometra pulchella* (Pl. IV. figs. 4*a*, 5*c*), where the lower edges of the ridges bounding the intermuscular furrow are somewhat thicker than usual.

These differences in the structure of the calyx in the two chief genera of Comatulæ are of considerable importance. For it is only by means of an acquaintance with them that the generic determination of the fossil Comatulæ becomes at all possible. Every one hitherto found in the Tertiary strata and in the Chalk, of which the entire calyx is known, is an unmistakeable *Antedon*, both in the characters of the centro-dorsal and in those of the radials. *Antedon æquimarginata* from the Gault is as clearly an *Antedon* as *Actinometra lovéni* from the same formation is an *Actinometra*. But some of the Neocomian and many of the Jurassic Comatulæ are less easily identified. The wide and low radials with marked intermuscular furrows of *Actinometra cheltonensis* from the Inferior Oolite, and of *Actinometra wurtembergica* from the Corallian of Nattheim, indicate the generic position of these types pretty clearly; while *Antedon scrobiculata* with its high articular faces, much narrower above than below, is an undoubted *Antedon*. But on the other hand, the low and wide radials and thin centro-dorsal of *Antedon picteti* and *Antedon infracretacea* are very suggestive of *Actinometra*; though in both types the articular faces of the radials have a considerable slope and are altogether much like the corresponding parts of other species which are unquestionably referred to *Antedon*. For the present, therefore, the systematic position of these and of other somewhat generalised types of early Comatulæ must remain in doubt.

E. Some Abnormal Conditions of the Rays of Comatulæ.

In the two large genera *Antedon* and *Actinometra*, just as in *Apiocrinus*, *Pentacrinus*, and *Encrinus*, there are normally five rays which divide upon the third joint above the basals, *i.e.*, the third radial is the axillary (Pls. VIII., LXVII.); and this is the general rule among the Neocrinoids. The exceptions are *Metacrinus* and *Plicatocrinus*, the former with four or six radials (primitively five or eight, as some of them are syzygial joints), and the latter with only two as in one or two fossil Comatulæ. It sometimes happens, however, that an additional radial is inserted into the normally three-jointed series, as for example in the *Pentacrinus mülleri* mentioned in Part I.,[1] and I have met with a nearly similar case in *Antedon alternata* (Pl. XXXII. fig. 5); while Wagner[2] has noticed the same monstrosity in *Encrinus gracilis*. But the two outer radials of *Antedon alternata* remain separate and are not united by syzygy, as in the *Pentacrinus mülleri* just mentioned. On the other hand, in one example of *Antedon remota* (Pl. XXIX. fig. 6) and in the only specimen of *Antedon incerta* (Pl. XVIII. fig. 4) and in one of *Actinometra parvicirra* (Pl. LXI. fig. 1) the second radial is missing in one ray and the axillary rests directly against the first radial as in *Plicatocrinus* and in many Palæocrinoids.

Another and more common variation is in the number of the rays themselves. Excepting, of course, in *Promachocrinus* there are normally five rays in all Comatulidæ; but forms with four and six rays are occasionally met with. I have a tetraradiate specimen of *Antedon rosacea*, and one of a Japanese *Antedon* in Dr. Döderlein's collection, and also one of *Actinometra paucicirra* from Cape York. In all these three individuals the anterior ray (A) is missing, so that the mouth, instead of being radial in position, is placed interradially between the rays E and B.

On the other hand the "Blake" collection contains a six-rayed form of *Actinometra pulchella*. The disc is unfortunately concealed, so that the symmetry of the ambulacra cannot be made out. But I am rather inclined to think from the appearance of the centro-dorsal that it has the usual pentamerous symmetry, one of the radials being rather larger than its fellows and also axillary, so that it bears two small rays, as sometimes happens in *Allagecrinus*.[3] Another variation characteristic of this genus occurs in *Actinometra multibrachiata* (Pl. LVI. fig. 3), one of the radials being considerably smaller than the other four.

The only other six-rayed *Comatula* that I know is a small and dry *Antedon* in the

[1] Zool. Chall. Exp., part xxxii. p. 311, pl. xv. fig. 2.

[2] Die Encriniten des unteren Wellenkalkes von Jena, *Jenaische Zeitschr.*, 1886, Bd. xx. (N.F. xiii.), p. 20, Taf. ii. fig. 13.

[3] See Carpenter and Etheridge, Contributions to the Study of the British Palæozoic Crinoids,—No. I. On Allagecrinus, the Representative of a New Family from the Carboniferous Limestone Series of Scotland, *Ann. and Mag. Nat. Hist.*, 1881, ser. 5, vol. vii. pp. 288, 292.

British Museum. But the disc is sufficiently well preserved to show that the additional ray is inserted between the two of the right side (D and E).

The facts above mentioned may be usefully compared with similar variations which have been noticed in other Echinoderms. In the only six-rayed Blastoid that I have seen[1] there are but five ambulacra, though a pseudo-radial plate without a sinus is intercalated between radials C and D, so that the dorsal surface of the calyx is very regularly hexagonal.

On the other hand Blastoids with only four ambulacra are more common; but the dorsal part of the calyx is more or less distinctly pentagonal, the fifth radial not being incised for an ambulacrum. The two postero-lateral and the right antero-lateral one (C, D, E) are the rays in which this modification has been noticed, C showing it twice and the other two once each.

Two tetraradiate examples of *Encrinus liliiformis* have recently been observed by von Koenen;[2] but it is curious that variations from the normal pentamerous symmetry are rare among the Pelmatozoa, except in the genus *Rhizocrinus*. Four- and six-rayed Urchins are not uncommon; while Ludwig[3] found half a dozen six-rayed individuals of *Cucumaria planci* in a collection of one hundred and fifty. In all cases the sixth ray was intercalated between the two forming the bivium, a fact which may be compared with the absence of the middle ray of the trivium in the three Comatulæ with abnormally interradial mouths mentioned above.

[1] See Etheridge and Carpenter, Catalogue of the Blastoidea in the Geological Department of the British Museum (Natural History), London, 1886, pp. 40, 41.

[2] Beitrag zur Kenntniss der Crinoïden des Muscheikalks, *Abhandl. d. k. Gesellsch. d. Wiss. Göttingen*, 1887, Bd. xxxiv. p. 23 (of separate copy).

[3] Ueber Sechsstrahlige Holothurien, *Zool. Anzeiger*, 1886, Jahrg. ix. p. 476.

III.—THE GEOGRAPHICAL AND BATHYMETRICAL DISTRIBUTION OF THE COMATULÆ.

Our knowledge of the existing species of the Comatulæ is at present so imperfect that it affords but a slight foundation for any generalisation respecting their geographical distribution and the origin of specific types. For they occur in the most extraordinary abundance over certain large areas, such as the Caribbean Sea, and more especially the Eastern Archipelago and Australasia. Every large collection that I have examined, and they are many, contains a number of forms from the latter district, the specific relations of which will require months of detailed work before they can be properly elucidated.

Nearly all of these are littoral species, and it is chiefly with regard to them that any generalisation would be premature at present. But the dredgings of the Challenger have accumulated a large mass of information concerning the Comatulæ of other seas than those of Australasia. This relates more especially to the *Comatula*-fauna of the continental and abyssal regions, about which we cannot expect to gain very much additional knowledge in future. The Comatulæ of the Arctic and Sub-Arctic seas are also pretty completely known; while the Strait of Magellan and the Southern Indian Ocean between Marion Island and Melbourne have yielded some dozen species for comparison with those of the northern circumpolar fauna.

The following conclusions, then, embody the condition of such knowledge of the Comatulæ as I have been able to gain from the study of the Challenger collection and preliminary work upon the material dredged by the U.S. Coast Survey steamer "Blake"; together with my notes upon the Comatulæ in the museums of London, Paris, Berlin, Vienna, Copenhagen, Lund, Stockholm, Amsterdam, Leyden, Hamburg, Dresden, Kiel, Munich, Stuttgart, and also upon the collections made by Professor Semper in the Philippines, Dr. Döderlein in Japan, Dr. Anderson in the Mergui Archipelago, and Dr. Hickson in North Celebes.

The Comatulæ range in latitude from 81° 41′ N. to 52° 5′ S., being represented in each locality by a ten-armed *Antedon*, a point which will be considered later.

Although abundant near the coasts in the Arctic Ocean and on both sides of the North Atlantic, no Comatulæ have been dredged there at a greater depth than 800 fathoms, nor were any met with in either of the Challenger's two traverses of the North Atlantic; while, though one species has been obtained at the Canaries and Madeira, there is no record of any from the Azores, Bermuda, or the Cape Verde Islands. The two Mediterranean species range as far north as Scotland, but I do not know of their passing the meridian of 20° E., either in the Mediterranean or in the Baltic. In the Florida Channel and in the Caribbean Sea, however, Comatulæ have been dredged in abundance. But none are known from the African Coast between Cape Verde (Goree) and the Cape of Good Hope, except for one species of *Antedon* at the equatorial island Rolas. The only *Actinometra* common to both sides of the Atlantic occurs at St. Paul's Rocks, and a few Caribbean species both of this genus and of *Antedon* are common along the South American coast as far south as Cape Frio (lat. 23° 1′ S.); while in mid-Atlantic *Antedon* was dredged in moderate depths near Tristan da Cunha and Ascension respectively.

Closely allied to the North Atlantic species are those occurring at Kerguelen and Heard Island, together with a couple of forms inhabiting the Strait of Magellan. This Southern Ocean has also yielded *Promachocrinus*, the unique *Thaumatocrinus*, and at 2600 fathoms a minute *Antedon* which was also found at 2900 fathoms in the North Pacific.

Various Comatulæ have been obtained at Simon's Bay, Natal, Madagascar, Zanzibar, Mauritius, St. Helena, Rodriguez, the Red Sea, the Seychelles and Ceylon, with a solitary species at Kurrachee, and in the Bay of Bengal. It is curious, however, that none were found by Mr G. C. Bourne on the coral reefs of the Chagos group. But the region in which Comatulæ are most abundant is the great Eastern Archipelago, which may be roughly described as a triangular area reaching 100° from east to west and 65° from north to south, with its angles at Ceylon, Japan, and the Kermadec Islands. Within this large area, which includes the Challenger Stations 170 to 236, Comatulæ occur in the most bewildering profusion. But, so far as I know, not one has been found on the coasts of New Zealand, although *Eudiocrinus* and a ten-armed *Antedon* were obtained by the Challenger at Station 169, within a comparatively small distance of the East Cape of the North Island. The Challenger's dredgings between the Admiralty Islands and Japan were among the deepest of the whole cruise, ranging between 1100 and 4475 fathoms, and no Comatulæ were met with between the equator and lat. 35° N. Three species were obtained on the green mud off the Japanese coast between 345 and 775 fathoms, and one in 2900 fathoms at Station 244 in the North Pacific. This form, *Antedon abyssicola*, is the deepest *Comatula* known.

From Station 244 until the Straits of Magellan were entered, the dredgings of the Challenger yielded no *Comatula* at all, a fact which is the more interesting because almost the same statement holds good for the Ophiurids.[1]

Single species of *Antedon* are known from the Sandwich Islands and Chile, and of *Actinometra* from Tahiti and Peru; but except for these and for the two in the Strait of Magellan, I know of no *Comatula* in the Pacific east of long. 150° E., not even on the western shores of North America. *Antedon rhomboidea* and *Antedon magellanica*, if they can be called Pacific species at all, are the only ones in that ocean south of lat. 40° S. None occur in New Zealand nor in Tasmanian waters. These two Magellan species are therefore somewhat isolated, as on entering the Atlantic the Challenger dredged no Comatulæ until reaching Station 320, in 600 fathoms, where three ten-armed species of *Antedon* were obtained. The Falkland Islands, however, seem to have yielded nothing.

[1] Zool. Chall. Exp., 1882, part xiv. p. 309.

The distribution of the two leading *Comatula* genera, *Antedon* and *Actinometra*, cannot yet be fully worked out, owing to the large number of species which are still undescribed; but that of the other generic types is easily stated.

The archaic *Thaumatocrinus* has only been found at 1800 fathoms at Station 158 in the Southern Ocean, where it was associated with *Promachocrinus abyssorum*, which also occurred at Station 147 (1600 fathoms), together with three species of *Antedon*. Another species of *Promachocrinus* is common at Kerguelen, and a third was obtained at 500 fathoms off the Meangis Islands. Three species of *Atelecrinus* are known, two from the Atlantic and one from the Pacific. The unique specimen of the latter was found at Station 174c in the South Pacific, at 610 fathoms; while one of the Atlantic species is only known from Pourtalès' dredgings in the Gulf Stream off Havana (450 fathoms). The other, found by the Challenger in 350 fathoms at Station 122 off Pernambuco, was subsequently met with by the "Blake" off Nevis, St. Lucia, and Granada, at depths of 291 to 422 fathoms.

Eudiocrinus, first obtained in quite shallow water among the Philippines by Semper, was dredged by the Challenger both in the North and in the South Pacific, at depths varying from 565 to 1050 fathoms; while the "Travailleur" found *Eudiocrinus atlanticus* at 896 metres in the Bay of Biscay.

In discussing the distribution of *Antedon* and *Actinometra*, the two principal genera of Comatulæ, it must be remembered that each of them, but especially *Antedon*, contains a very large number of species, and they should be considered for this purpose to represent subfamilies rather than genera. Thus, for example, the name *Antedon* is now given to all recent endocyclic Comatulæ with the basals metamorphosed into a rosette, and five rays bearing ten or more arms, just in the same way as the name *Echinus* was originally used for a variety of regular Urchins, which have now received different generic names. The difference between the tiny ten-armed *Antedon abyssicola* inhabiting depths of three miles and upwards in the Pacific (Pl. XXXIII. figs. 1, 2), and the littoral *Antedon elegans*, *Antedon multiradiata*, or *Antedon regalis* (Pls. VIII., IX., XLVI.), is no doubt very considerable at first sight; but there are so many intermediate links between the simple and the complex forms, that no hard and fast generic lines can be drawn. At the same time, a glance at the tabular keys to the species which are given in the following pages will show that they fall into certain very well defined groups; and the range of each of these groups, both in depth and in space, may be profitably studied.

In the first place, all the species of *Antedon* which have the two outer radials united by syzygy are limited to quite shallow water in the Eastern Archipelago. They are comparatively few in number, and have perhaps the most restricted geographical range of any of the specific groups. On the other hand, the *Antedon* species of the simple ten-armed type like *Antedon rosacea*, are most remarkably abundant, and also extremely varied in their character,—*Antedon abyssicola* and *Antedon tuberosa*, or *Antedon* *carinata*, presenting several very striking points of difference (Pl. XXIII. fig. 2; Pl. XXXIII. figs. 1, 2; Pl. XXXIV.). They fall into several sets, each of which represents a different type of *Comatula*-structure, and in several cases the distribution of these sets is fairly well defined.

The ten-armed species of *Antedon* have a wider range both in depth and in space than any other types of the genus. This is of course only to be expected; for they represent a somewhat early stage in the development of the Pentacrinoid larva, the radial axillaries and the pairs of first brachials which they bear appearing soon after the opening of the tentacular vestibule, when the whole number of tentacles does not exceed twenty-five.

These ten-armed forms are the only species of *Antedon* which occur outside the fortieth parallels of latitude, and at greater depths than 750 fathoms. There is one possible exception to this last statement. Some examples of *Antedon inæqualis* with three distichals reached me, together with fragments of *Pentacrinus naresianus* and the label of Station 175 (1350 fathoms). But there is no record in the Station Book of their occurrence here, though two Comatulæ are mentioned. But these (*Antedon breviradia* and *Antedon acutiradia*, Pl. XI. figs. 3, 5) have the general facies of deep-water forms; and this is not the case with *Antedon inæqualis* and the arms of *Antedon basicurva*, which are labelled as coming from this station. It may then, I think, be safely assumed that the only Comatulæ dredged at Station 175 were the ten-armed *Antedon acutiradia* and *Antedon breviradia*, the multibrachiate *Antedon inæqualis* not really occurring at that station. Disregarding this form, we find that out of twenty-nine stations where *Antedon* was dredged by the Challenger, "Porcupine," and other British expeditions, at depths exceeding 200 fathoms, twenty-eight yielded ten-armed species. Multibrachiate species occurred at six of these, and at one other station, this (Station 135G) being the only locality below 200 fathoms where the genus *Antedon* occurred, but was not represented by any ten-armed form. Eleven of the twelve "Porcupine" stations[1] and two of the seventeen Challenger ones were beyond the parallels of 40°. But the remaining "Porcupine" station and six of the fifteen Challenger ones within these limits yielded multibrachiate forms, though never at a greater depth than 750 fathoms. The "Porcupine" species, however, *Antedon lusitanica*, is a curious one. It is dimorphic, some individuals having ten arms only, and some having one or more distichal series (Pl. XXXIX. figs. 1, 3).

The nine dredgings of the Challenger at which *Antedon* occurred at depths between 700 and 2900 fathoms inclusive, yielded nine species of the genus, all of them small and ten-armed, and half of them belonging to the group which contains the familiar *Antedon rosacea* and *Antedon tenella*. Four of the fifteen dredgings between the fortieth parallels at depths exceeding 200 fathoms were at 1000 fathoms and upwards, and they yielded

[1] Under this general name I include all the dredgings of the "Porcupine," "Lightning," "Knight-Errant," and "Triton."

four species of *Antedon*, three of which were each found at two or more different stations.[1] Thus *Antedon abyssicola*, from 2900 fathoms (Station 244) in the North Pacific, also occurs at 2600 fathoms (Station 160) in the Southern Sea; and the remaining abyssal station south of lat. 40° S. (Station 147, 1600 fathoms), yielded three different species of the ten-armed *Antedon*-type. The species dredged at Station 135E in 1000 fathoms was only represented by Pentacrinoid larvæ, but of the eight remaining abyssal forms (found below 700 fathoms), one that occurred at four stations in the Pacific is closely allied to *Antedon tenella*, which ranges down to 740 fathoms in the North Atlantic, between 30° N. and 75° N.; while three others belong to the same group as this species and *Antedon rosacea*, which ranges in shallow water from the Færoe Banks to the Canary Islands, and possibly even to the equator.

In like manner, the Magellan and Heard Island species from the furthest south are the Antarctic representatives of *Antedon eschrichti* and *Antedon quadrata*, which are widely distributed in the Arctic Ocean. In fact, the group to which these forms belong has the greatest geographical range of any set of the ten-armed *Antedon*-type.

Antedon eschrichti (Pl. XXIV. fig. 11) and its close ally *Antedon quadrata* (Pl. XXVI. figs. 2, 3), are common in the Arctic Ocean between the meridians of 80° W. and 70° E. They were found by the "Porcupine" in the Færoe Channel, and by the Challenger off Halifax, which is their furthest southern range (lat. 43° N.). No other Comatulæ but the dimorphic *Antedon lusitanica* were found in the North Atlantic below 650 fathoms, but this form does not at all approach the *Eschrichti*-group. The Straits of Magellan, however, contain two species belonging to it; while *Antedon australis*, and *Antedon antarctica* from the neighbourhood of Heard Island are also very closely allied to, though not identical with *Antedon quadrata* and *Antedon eschrichti*, and are the southernmost Comatulæ known (Pl. XXV.; Pl. XXVI. fig. 4). None of these species, however, nor in fact any of the *Eschrichti*-group, extend down to any greater depth than 650 fathoms; but some of the Comatulæ from depths below this belong, as we have seen, rather to the North Atlantic than to the Arctic fauna. Certain of them, however, find their places in the group of ten-armed species which have the sides of the rays flattened and more or less closely approximated. One of them (*Antedon bispinosa*, Pl. XX. fig. 3) was obtained at Station 147, together with two species of the *Tenella*-group, and two others (*Antedon acutiradia* and *Antedon breviradia*, Pl. XI. figs. 3, 5) were the only two dredged with certainty at Station 175.[2] All these three occurred below 1300 fathoms.

With the exception of *Antedon bispinosa* from the Southern Sea and *Antedon lusitanica* and *Antedon multispina* of the Atlantic, all the twenty forms with laterally compressed rays (*Basicurva*-group) inhabit the Western Pacific and Australasia; and only

[1] The *Antedon breviradia* and *Antedon alternata* occurred both at 630 and 1070 and at 1350 fathoms respectively.
[2] See *ante*, p. 32.

one (*Antedon denticulata*), from 49 fathoms at Station 190 in the Arafura Sea, can be called a littoral species. The remainder all belong to the continental or to the abyssal zone. Most of them have covering plates and generally also side plates to the ambulacra; and the two ten-armed forms of *Antedon* from the Challenger dredgings which have plated ambulacra but the rays not flattened laterally (*Acœla*-group) are even more restricted in their distribution. One was found in 140 fathoms at Station 192 in the Arafura Sea, and the other in 500 fathoms off the Meangis Islands (Station 214).

Not only are the ten-armed species of *Antedon* the most widely distributed as a group, but they also have the most extensive individual range. *Antedon eschrichti* and *Antedon quadrata* of the Arctic Ocean were dredged by the Challenger in lat. 43° N. *Antedon phalangium* ranges from the north of Scotland to Morocco and throughout the western basin of the Mediterranean. The Protean *Antedon rosacea* also occurs in the Mediterranean, extends from the Færoe Banks to the Canaries, possibly even to Cape Verde and the equator, and is perhaps also found on the American coast; while *Antedon carinata* is distributed between the parallels of 15° N. and 35° S., through the Indian Ocean from Java[1] to Zanzibar, along the Atlantic coast of South America from St. Lucia to Rio Janeiro, and is also found at Valparaiso.

None of the multibrachiate forms of *Antedon* have anything like this geographical range. In the western North Atlantic there is no species with more than ten arms north of Florida, and the dimorphic *Antedon lusitanica* is the only one known on the eastern side. This last and those from Japan are the most northerly multibrachiate forms, while *Antedon setosa* from off Tristan da Cunha and the various species inhabiting Port Jackson and near the Kermadecs are the most southern representatives of these many-armed types of *Antedon*, which have almost exactly the same range in latitude as the genus *Actinometra*. Examples of each of the two great groups, those with two and those with three distichal joints, occur in the Caribbean Sea, and they are abundant between the Society Islands and the Red Sea. But, as we have just seen, they have a very limited bathymetrical range, only appearing at seven Challenger stations between 100 and 630 fathoms, and at none where the depth exceeded this latter limit.

In some of the *Antedon*-species dredged at all these seven stations the secondary arms consist of three distichal joints, the axillary with a syzygy, but at two of them bidistichate forms also occurred, together with species of *Actinometra*; and the single "Porcupine" *Antedon* with more than ten arms is *Antedon lusitanica* from 740 fathoms, in the North Atlantic, which sometimes has a distichal series of two joints. There are no tridistichate species of *Antedon* in the North Atlantic, outside the Caribbean Sea; though they occur in the South Atlantic at Tristan da Cunha and Ascension, and at five stations below 100 fathoms in the Western Pacific and Australasia.

On the other hand, the bidistichate series represented by *Antedon lusitanica* does

[1] See the remarks on this subject on p. 202.

not range further south in the Atlantic than 10° S., though it has the same distribution as the tridistichate series in the Pacific and is generally more fully represented, forms like *Antedon palmata*, *Antedon elongata*, and *Antedon indica* being often met with in considerable abundance and variety. This group is also much more common than the tridistichate group in the Caribbean Sea, especially below 100 fathoms; and it ranges down to 270 fathoms, at least 120 fathoms deeper than any member of the tridistichate group has yet been found in that locality.

The range of the genus *Actinometra*, both in depth and in space, is very much more limited than that of *Antedon*. It corresponds very closely, however, with the geographical and bathymetrical ranges of the multibrachiate species of this genus, though both alike are slightly more extensive than the range of *Actinometra*. Thus, for example, the multibrachiate forms of *Antedon* almost reach the parallels of 40°; while the northernmost *Actinometra* does not reach 36° N., either in the Atlantic or in the Pacific, and the southernmost are those of the Cape of Good Hope (34° 24′ S.) and Port Philip (37° 48′ S.). In like manner no *Actinometra* has been obtained with certainty at a greater depth than 533 fathoms; though it is possible that this should be extended to 610 fathoms in the Pacific.[1] But as we have just seen, the tri- and bidistichate groups of the multibrachiate species of *Antedon* extend down to 630 and 740 fathoms respectively.

Like these forms too, *Actinometra* is far more extensively developed in the eastern than in the western hemisphere. Several species are known from Southern Japan, and the genus is abundant all through the Eastern Archipelago and down the east coast of Australia as far as Port Jackson; while a single species from the latter locality also occurs at Port Philip and in King George's Sound (*Actinometra trichoptera*). A few more are scattered at Ceylon, the Red Sea, Madagascar, Port Natal, and the Cape of Good Hope; but they are not known at all from the West African coast, nor from South America south of Cape Frio. From this region, however, a couple of species occur abundantly up to the Caribbean Sea and the Gulf Stream, but they do not pass the parallels of 25° N.; though in the East Atlantic one species has been dredged four times beyond the thirty-fourth parallel and at much greater depths than in the Caribbean Sea, *e.g.*, 1500 metres[2] (=812 fathoms). This type (*Actinometra pulchella*) is one of special interest, not only from its singularly Protean character, but because it is the only *Actinometra* common to the two sides of the Atlantic; while it is also, with one exception, the only *Actinometra* ranging below 300 fathoms. The genus has been dredged eleven times at depths below 200 fathoms, four times by English, once by French, and six times by American expedi-

[1] There is no record of the particular dredging at the Station numbered 174 which yielded Comatulæ, the depths being 210, 255 and 610 fathoms, except that the last one yielded *Atelecrinus wyvillii*. Three species of *Actinometra* were obtained, together with five of *Antedon*, and from their general facies I should be decidedly inclined to refer them to one of the two lesser depths.

[2] According to H. Filhol (*La Nature*, 1884, p. 330), an *Actinometra*, which I take to be *Actinometra pulchella*, was obtained by the "Talisman" off Rochefort at this very unusual depth.

tions. *Actinometra pulchella* occurs at every one of these eleven stations, excepting No. 174 in the South Pacific; while it is the only *Actinometra* represented at six at least of them, including three of the deepest ones. This may be partly explained by the fact that only one of these stations was in the Pacific, all the remainder being in the Atlantic and the Caribbean Sea, but it is especially noteworthy because *Actinometra pulchella* is a dimorphic species, some forms having only ten arms, and some having bidistichate series on one or more rays. The three species obtained by the Challenger at Station 174 were all multibrachiate forms expressing widely different types of the genus; but the "Blake" dredged a ten-armed species at 450 fathoms, off Havana, and the two deepest stations in the Caribbean Sea where *Actinometra pulchella* occurred also yielded ten-armed species.

These ten-armed forms of *Actinometra* which occur in the Caribbean Sea and along the South American coast, represent an entirely different type of the genus from the ten-armed species of the eastern hemisphere. The latter mostly belong to the type of *Actinometra solaris*, with syzygies between the two outer radials, though a few forms occur in which these joints are united by bifascial articulation, as in nearly every *Antedon* and in the *Actinometra meridionalis* of the Caribbean Sea (Pl. LVI. fig. 1). The *Solaris*-type, however, has not yet been discovered in the Atlantic.

Of the multibrachiate species of *Actinometra* the tridistichate type seems to be the more extensively distributed and not the bidistichate one as in the case of *Antedon*. Thus, for example, *Actinometra parvicirra* (*a*.3.(3).(3)) occurs in South Africa, Timor, Ceram, the Philippines, Japan, the Friendly Islands, and even on the coast of Peru, so that it has a range in longitude of some 260°, occurring everywhere but in the Atlantic. This is only approached by the ten-armed *Antedon carinata*, which occurs on both coasts of South America and across the Indian Ocean from Java to Zanzibar.

IV.—THE GEOLOGICAL HISTORY OF THE COMATULÆ.[1]

So far as our present information goes the family Comatulidæ first appeared in the time of the Middle Lias and is therefore of somewhat less antiquity than the Pentacrinidæ which date back to the Trias. Comatulæ were fairly abundant all through the Jurassic and Cretaceous epochs and were especially so at certain periods, that of the Corallian in Germany and Switzerland, for instance.

The geographical distribution of recent Comatulæ is far more extensive than that of their predecessors. The distribution of the former is practically world-wide; but so far as is yet known, with the exception of an *Antedon* from Algeria and another from Syria, no fossil Comatulæ have been discovered out of Europe, not even in the Indian Tertiaries, which contain so many Echinoderm remains. None are known in America, though stem-joints of the remarkable *Pentacrinus asteriscus* are very common at certain horizons of the Jura-Trias over wide areas of the western territories; and this shows that the conditions of that long-distant age were not altogether unfavourable to the development of Crinoid life. On the other hand, the Middle Lias of France contains two species of *Antedon*, the oldest yet known; and the genus occurs, together with *Actinometra*, in the lower Oolites of both France and England; while if *Bourgueticrinus ooliticus*, M'Coy, is a *Thiolliericrinus*, as supposed by de Loriol, it is the earliest known species of this very singular genus.

Both *Antedon* and *Actinometra*, especially the former, are well represented in the Corallian of the Jura, and there are several species of *Antedon* in the Neocomian of the continent, together with a few in Britain. The Gault of Folkestone has yielded typical forms of both genera, and there are several Cretaceous species of *Antedon* scattered through Europe, the formerly obscure *Glenotremites paradoxus* being the best known. We are only acquainted with one Eocene *Comatula*; though three species occur in the French Miocene, and there are others in the Pliocene both of England and of Italy.

In the majority of cases only the centro-dorsal is preserved, though it is not uncommon for the radials to remain attached to it. But individuals with any arm-joints preserved beyond the calyx-radials are decidedly rare; and in this respect the Comatulæ differ widely from the *Pentacrinus*-type, isolated calyces of which are not often met with, though the arms are frequently extraordinarily well preserved.

One singular instance of the retention of the arms or arm-bases is afforded by *Eudiocrinus hyselyi*.[2] But for this fact the existence of *Eudiocrinus* in the fossil state

[1] I am indebted to the kindness of M. P. de Loriol for much information respecting the fossil Comatulidæ of France and Switzerland, some of it being as yet unpublished.

[2] See de Loriol, Monographie des Crinoïdes fossiles de la Suisse, Geneva, 1877–79, pl. xxi. fig. 14.

would have remained unknown, as the characters of the calyx in the recent species have not yet been sufficiently studied to give any satisfactory clue to the detection of their fossil representatives.

Most of the fossil Comatulæ have more or less well defined basals appearing externally, which have not undergone metamorphosis into a rosette as is the case in very nearly all the recent forms; and it is probable that species like *Antedon tessoni* and *Antedon orbignyi*, although they show no basals externally, will in reality prove to be no exceptions to the rule. I feel some doubt, however, with regard to the Tertiary species, only two of which are represented by more than the centro-dorsal; and this affords but little information respecting the presence or absence of a rosette. I am inclined to think myself that in the matter of basals the Tertiary species resembled their predecessors rather than their successors. But this view cannot be confirmed till the discovery of a type which shows basals at the interradial angles of the calyx, or of one in which these plates are visible on the under surface of the isolated radial pentagon. But no Tertiary species of this kind are known, and neither *Antedon alticeps* nor *Antedon italica* shows any traces of basals between the radials and the centro-dorsal.

The determination of the generic position of a Mesozoic *Comatula* is often a matter of considerable difficulty; and this is especially the case when only the centro-dorsal is preserved. In most fossil Comatulæ this part bears a considerable number of cirri which are distributed over the greater part of its surface; and it reaches a fair degree of thickness; so that there can be no doubt that these types have been correctly referred to *Antedon*. But there are a few forms in which the centro-dorsal is relatively much thinner and the number of cirri, which are almost or entirely limited to its sides, is reduced. This is the case, for example, in two species from the Great Oolite and Bradford Clay respectively, which I take to belong to *Actinometra*, rather than to *Antedon*. Specimens which have the radials preserved can in some cases be referred to *Antedon* without any difficulty, owing to the large proportion of height to width on the articular faces of the radials. Such are *Antedon æquimarginata*, *Antedon incurva*, and *Antedon scrobiculata*, the calyces of which closely resemble those of the typical forms of *Antedon* figured on Pl. II.

On the other hand, the generic identity of *Actinometra lovéni* from the Gault is equally indisputable. For there is no living *Antedon* yet known in which the centro-dorsal loses all traces of its cirri and becomes separated from the flattened radial pentagon by clefts at its sides; while these changes are not uncommon in *Actinometra* (Pl. LVII. fig. 1; Pl. LXV.). But in by far the greater number of Comatulæ which have the radials preserved, the height of these plates is quite small relatively to their width, as is invariably the case in the living *Actinometra* (Pl. V.). When these radials rest on a thick centro-dorsal which is marked by a number of cirrus-sockets (*Antedon decameros*, *Antedon greppini*) there can be no question that the type in question belongs to *Antedon*. But there are a few species with low and wide radials, the distal faces of which have a steep slope, so that they do not enter largely into the ventral aspect of the calyx. Such are the two which I have described as *Actinometra cheltonensis* and *Actinometra wurtembergica*. Only the radials of the former species are known and the slope of the articular faces is scarcely as steep as in most recent examples of the genus. It is steeper in *Actinometra wurtembergica*, which seems to have had a thicker centro-dorsal and more numerous cirri than is usually the case in recent species of the genus. One might also be inclined to refer to this genus the *Antedon picteti*, de Loriol, and *Antedon infracretacea*, Ooster, both of which occur in the Valangian and have low wide radials with a thin centro-dorsal, bearing but few cirri. They retain, however, the sloping articular faces which are so characteristic of *Antedon;* and I think therefore that, for the present at any rate, they should be referred to that genus.

Table showing the Distribution of the Fossil Comatulæ in Space and in Time.

A. = *Antedon*. *a.* = *Actinometra*. E. = *Eudiocrinus*. T. = *Thiollicricrinus*.

		England.	France.	Portugal.	Switzerland.	Italy.	Austria.	Germany.	Sweden.	Algeria.	Syria.
Lias, . .	Middle Lias, ...		A.								
Jurassic, .	Bathonian, ...	A. *a.* T ?	A. *a.*								
	Oxfordian, ...	A.	A. *a.*					A.			
	Corallian, ...		A. T.	} A. T.	A.			A. *a.* T.		A.	
	Portlandian, ...		A.	}	A.			A.			
Cretaceous,	Lower Neocomian (Valangian),				A. T.						
	Upper Neocomian, . . .	A.			A. E.						
	Gault, ...	A. *a.*									
	Cenomanian (Low. Ch.), .	A.						A.			} A.
	Sénonian (Up. Ch.), . .	A.					A.	A.	A.		}
Tertiary, .	Eocene, ...					A.					
	Miocene (Middle), . .		A.			A.					
	Pliocene, ...	A.				A.					

Two points may be noted about the fossil Comatulæ generally. The calyces of many of them reach a considerable relative size, the centro-dorsal being sometimes as much as 9 to 13 mm. in diameter, which is greater than that of nearly every living representative of the family except *Antedon eschrichti;* while this type and *Actinometra solaris* are almost the only living Crinoids with arm-bases anything like so massive as in the fossil species. The Miocene *Antedon rhodanica* has a very large centro-dorsal; but the three species from the Norwich Crag and the two from the Italian Tertiaries are all quite small.

Another character which presents itself in a large number of the Jurassic and Cretaceous species is the retention of the five-rayed perforation on the lower surface of the centro-dorsal, the peculiarities of which have been discussed in Chapter II.

The geological distribution of the three fossil genera of Comatulæ is shown in the foregoing table.

V.—CLASSIFICATION.

Until the time of Johannes Müller the number of recognised species of Comatulæ was extremely small, not more than a dozen, in fact. Retzius had described one, Linnæus two, Lamarck seven, and two more bore the names of Düben and Koren; but only three of them had more than ten arms, viz., *Comatula rotalaria* with about twenty to twenty-two, *Comatula fimbriata* with twelve to thirty, and *Comatula multiradiata* with forty to fifty.

Under these circumstances the classification of the Comatulæ presented no difficulties. But Müller's descriptive work[1] raised the total number of species to nearly forty, about half of them having more than ten arms. This very obvious character afforded him the means of separating his species into two groups, which he further subdivided according to the arrangement of the syzygies in the arms. Thus, for example, there are two sets of ten-armed Comatulæ, those like *Actinometra pectinata* (Pl. LIII. fig. 15) in which the two joints above the radial axillary are each traversed by a syzygy, and those like *Antedon eschrichti* (Pl. XXIV. figs. 10, 11) in which the first syzygy is in the third brachial. In like manner the multibrachiate forms were separated by Müller into two sets, those in which the brachial axillaries are syzygial joints (Pl. LXVIII. fig. 2), and those in which the axillaries are simple and not traversed by syzygies (Pl. XLV. fig. 2).

All the Comatulæ known to Müller could be placed in one or other of these four sets, no matter to which of the two subgenera they belonged, *Alecto* or *Actinometra*. He never made any definite attempt to separate the species of *Alecto* from those of *Actinometra*, no apparent system being determinable, either in the order of his specific descriptions or in his tabular arrangement of most of the species in the form of a key, a species of *Actinometra* not unfrequently intervening between two of *Alecto*. For more than a dozen years after the publication of Müller's memoir the classification of the Comatulæ remained practically as he left it. No one took up the subject, and no new species were described. In the year 1862, however, a step in advance was made by Messrs. Dujardin and Hupé.[2] They divided the recent Feather-stars into three genera, *Comatula*, Lamarck, *Actinometra*, Müller, and *Comaster*, Agassiz, the last named being a type which Müller had been unable to recognise as generically distinct from *Comatula*. Of his own subgenera, *Alecto* and *Actinometra*, the latter was raised into a genus by Dujardin and Hupé, who referred to it three species, while they limited Lamarck's name *Comatula* to the forms previously referred by Müller to *Alecto*, and regarded them as constituting thirty-one species. These were divided into groups having respectively ten, ten to twenty, twenty, twenty-six to forty, and more than

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1849, pp. 237–265.

[2] *Op. cit.*, pp. 192–213.

forty arms. But the French authors altogether gave up Müller's method of grouping both the ten-armed and the multibrachiate Comatulæ according to the arrangement of the syzygies in the arms and their subdivisions, placing for example *Comatula brachiolata* and *Comatula solaris* with syzygies in the first and second brachials between *Comatula adeonæ* and *Comatula echinoptera*, both of which have the third brachial a syzygy. In like manner *Comatula flagellata* with no syzygies in the brachial axillaries is placed between *Comatula japonica* and *Comatula timorensis*, in both of which the axillaries are syzygial joints. While therefore Dujardin and Hupé made a distinct advance on Müller's classification in recognising two generic types of Comatulæ, their rejection of the characters on which he relied, and rightly so, as being of much systematic value was a decidedly backward step. For all subsequent work has shown that the position of the first syzygy in the free arms and the presence or absence of syzygies in the brachial axillaries are characters of very considerable systematic value, without the aid of which the classification of the hundred or more species comprised in each of the genera *Antedon* and *Actinometra* would be even more chaotic than it is.

For some fifteen years after the appearance of Dujardin and Hupé's Histoire Naturelle, systematic work on the Comatulæ progressed with extreme slowness, the most important step being Norman's restoration of the generic name *Antedon*, owing to its priority over both *Comatula* and *Alecto*.[1] New species were described by Böhlsche, Grube, and Pourtalès; but they were never figured, and no attempt was made to assign them places in the system either of Müller or of Dujardin and Hupé. Dr. Lütken had examined from time to time a considerable number of Comatulæ which had been collected among the Pacific Islands by the agents of the Godeffroy Museum; and he arrived at the conclusion that the real distinction between *Antedon* (or *Alecto*) and *Actinometra* lies in the central or excentric position of the mouth, the number of groove trunks reaching the peristome being a character almost entirely devoid of the systematic importance attributed to it by Müller. Lütken's views were never published, and I only learnt of his holding them after myself arriving at the same conclusions; but he was good enough to inform me at the same time of a character then unknown to me, which I have since found to be of almost invariable occurrence in *Actinometra*, viz., the presence of a terminal comb on the lower pinnules (Pl. LVI. figs. 2, 4). These facts were published in my memoir on *Actinometra*,[2] where I also endeavoured to classify the species of the genus that I had been able to identify, by an extension of the method employed by Müller.

While recognising the systematic importance of the presence or absence of syzygies in the arms of Comatulæ, Müller made no attempt to classify the multibrachiate forms according to the number of joints between the successive brachial axillaries, though he furnished the means for doing this in his descriptions of many species, a process which

[1] *Ann. and Mag. Nat. Hist.*, 1865, ser. 3, vol. xv. p. 98.
[2] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1877 [1879], vol. ii. pp. 18–29.

would have enabled him to separate types that are placed very near to one another in his scheme. Thus, for example, *Comatula palmata* and *Comatula macronema* are placed respectively next to *Comatula japonica* and *Comatula reynaudi*, though the distichal axillary is the second joint above the radials in the first pair, and the third (or, counting the syzygy, the fourth) joint in the second pair. It soon appeared to me to be a very general rule among Comatulæ that "the first and second segments beyond every axillary, whether radial or brachial, are nearly always united together in the same manner as the second and third (axillary) radials."

These observations rendered the classification of the Comatulæ which were then known (1879) a comparatively easy task; and during the next three years I described several species both of *Antedon* and of *Actinometra*, arranging the multibrachiate forms according as there were one or two joints between the successive axillaries of the arms, and by the presence or absence of syzygies in these axillaries. The most common arrangements of the arm-divisions are the following—two joints, the second axillary without a syzygy, and three joints, the second bearing a pinnule, but the third axillary with a syzygy. These of course would have been equally well distinguished in Müller's classification according to the presence or absence of syzygies in the axillaries. But in Müller's scheme there is no separation from the second of these types of species like *Actinometra sentosa* (Pl. LXVI. fig. 4) in which all the outer arm-divisions consist of two joints only, but the axillaries are syzygial joints just like those of *Actinometra japonica*, or *Antedon reynaudi*. In like manner Müller's classification provides no place for forms like *Actinometra paucicirra*, in which the axillary is not itself traversed by a syzygy, but is united to the preceding joint by syzygy instead of by an articulation (Pl. LIV. figs. 1, 2).

If these characters be taken into account, and especially the mode of union of the two outer radials, whether by articulation or by syzygy, the numerous multibrachiate species of *Antedon* and *Actinometra* may be readily separated into comparatively large groups, for the further subdivision of which a more detailed examination of anatomical characters becomes necessary.

In the year 1882 Professor F. J. Bell [1] attempted "to apply a method of formulation to the species of the Comatulidæ." He stated that the leading differences between the radial, distichal, and palmar series in different species of Comatulæ "are to be found in the varying arrangement of that mode of union to which Johannes Müller applied the term syzygial"; and he therefore inserted the letter R, D, or P into his formula "whenever the respective axillary is a syzygy," placing before this letter and the generic symbol the figure 1, 2, or 3, according as the first, second, or third brachial is a syzygial joint. Bell further devised a very convenient method of briefly indicating the number of joints in the cirri and also that of these organs themselves. I have been glad to adopt

[1] An attempt to apply a Method of Formulation to the Species of the Comatulidæ; with the Description of a New Species, *Proc. Zool. Soc. Lond.*, 1882, pp. 530–536.

this method, which will be explained further on, but, on the other hand, the mode of formulation suggested by Bell to express the characters of the arm-divisions in the multibrachiate Comatulæ left very much to be desired. For the regular forms which have two or three joints in each arm-division and the axillary a syzygy, his notation is probably as short a one as could be devised. But it gives no means of distinguishing one of these types from the other, or from that of *Actinometra multiradiata* in which both occur together; and where the successive arm-divisions consist of two joints only, without syzygies in the axillaries, it gives no information at all respecting the number of the arm-divisions, *Antedon palmata* with three axillaries above the radials having the same formula as *Antedon macronema* with only one.

Bell's method is totally inapplicable to irregular types like *Actinometra multifida*, which have syzygies in the distichal axillaries but none in those of the subsequent divisions; and the consequence is that species with forty arms receive exactly the same formulæ (excepting of course for the cirrus-characters) as others with only ten to twenty. I have referred elsewhere [1] to other difficulties connected with Bell's method of formulation, which is neither elastic enough to indicate exactly on what joint the syzygy comes in the distichal or palmar series, nor does it state the number of joints in each division when there are no syzygies in the axillaries.

For some years before the publication of Bell's suggestions I had been in the habit of employing for my own use a method of formulation which should briefly express the characters of the rays and their subdivisions, and yet at the same time be elastic enough to meet all the variations of *Comatula*-structure with which I was acquainted, together with any others that I could consider as possible. It was based upon a knowledge of the structure of over two hundred species, which has enabled me to make the following generalisations.

1. All ten-armed species of *Actinometra* which have the two outer radials united by syzygy have the first two brachials united in the same way.

Examples.—*Actinometra pectinata* (Pl. LIII. fig. 15); no *Antedon* known.

2. All many-armed species of *Actinometra* which have the two outer radials united by syzygy, either have (α) all the arm-divisions of two joints also united by syzygy, and the first two brachials similarly united; or (β) there may be three distichals of which the first two are articulated and the axillary a syzygy, while the subsequent divisions (if any) consist of but two joints united by syzygy.

Examples.—(α) *Actinometra paucicirra* (Pl. LIV. figs. 1, 2, 10); (β) *Actinometra typica* (Pl. LVII. fig. 1).

3. If the two outer radials are united by bifascial articulation, the two next joints are similarly united, whether there be ten or many arms. In the former case the third brachial is always a syzygy.

[1] On the Classification of the Comatulæ, *Proc. Zool. Soc. Lond.*, 1882, pp. 731–741.

Examples.—*Antedon eschrichti* (Pl. XXIV. fig. 11), *Antedon tuberculata* (Pl. XLV. fig. 2), *Antedon multispina* (Pl. L. fig. 3); *Actinometra meridionalis* (Pl. LVI. fig. 1), *Actinometra stelligera* (Pl. LVIII. fig. 1), *Actinometra regalis* (Pl. LXVIII. fig. 2).

4. In by far the greater number of Comatulæ which have the two outer radials united bifascially, and only one further division, the third brachial is the first syzygial joint above the distichal axillary, whether this be a syzygy or not; and the two lowest brachials are also united bifascially.

Examples.—*Antedon disciformis* (Pl. XXXIX. fig. 4), *Antedon variipinna* (Pl. XLVIII. fig. 5); *Actinometra elongata* (Pl. LVII. fig. 4), *Actinometra quadrata* (Pl. LXII. fig. 1).

There are some exceptions to this rule. *Actinometra pulchella* and *Actinometra stelligera* have two articulated distichals, but the first two brachials are united by syzygy (Pl. LII. fig. 2; Pl. LVIII. fig. 1). This is also the case in both *Antedon angusticalyx* and *Antedon inæqualis* (Pl. L. fig. 1; Pl. LI. fig. 2) each of which has three distichals of the usual character; while in the group of which *Actinometra fimbriata* is the type (Pl. LXII. fig. 3) there are also three distichals followed by a syzygy in the second brachial. These exceptional syzygial unions do not occur, however, when there are no distichals present on the ray and the arms spring directly from the radial axillaries. Under these circumstances the first syzygy is always on the third brachial just as in *Antedon eschrichti* and *Actinometra meridionalis* (Pl. XXIV. fig. 11; Pl. LVI. fig. 1). This is very well shown in *Actinometra pulchella* $\left(2\frac{br}{2}\right)$, *Actinometra coppingeri* (3.2*br*), and *Antedon multispina* $\left(3.\frac{br}{2}\right)$, (Pl. LII. fig. 2; Pl. LX. fig. 2; Pl. LXIX. figs. 1, 2); and it may also be noticed even in species which usually have palmar series, such as *Antedon porrecta* and *Actinometra lineata* (3.2[(*p.*)*br*]), when both these and the distichals are absent on any part of a ray (Pl. LX. fig. 3). These multibrachiate species, therefore, are exceptions to Rule 4 in their state of fullest development. But when the primary arms remain undivided the position of their first syzygy is invariably that of the ordinary ten-armed Comatulæ, *i.e.*, on the third brachial, just as is stated in Rule 3.

5. If the two outer radials are articulated and there are two subsequent axillaries, so that palmars are present, the first arm-syzygy above the palmar axillary is in the third brachial in all cases but the following:—

α. Two palmars united by syzygy; the first two joints beyond the palmar and all subsequent axillaries are also united by syzygy.

Example.—*Antedon distincta* (Pl. LI. fig. 1).

β. Two palmars, the axillary a syzygy; the second joints beyond the palmar and all subsequent axillaries also have a syzygy.

Examples.—*Antedon porrecta*, *Actinometra sentosa* (Pl. LXVI. fig. 4).

A very singular exception to this rule is afforded by *Actinometra stelligera*, which has articulated distichals and palmars, but the first two brachials united by syzygy (Pl. LVIII. fig. 1), so that its formula is—a.2.2.$\frac{br}{2}$.

6. Whenever any arm-division, distichal, palmar, or any other consists of three joints, the first two are articulated by ligaments, the second bearing a pinnule, and the third (axillary) is a syzygy, just as in the first three brachials of *Antedon eschrichti* (Pl. XXIV. fig. 11) and *Actinometra meridionalis* (Pl. LVI. fig. 1). When, however, there are only two joints, and the second (axillary) is a syzygy, the first has a pinnule, just as in the arm-bases of *Actinometra fimbriata* (Pl. LXII. fig. 3).

Examples.—*Antedon variipinna* (Pl. XLVIII. fig. 5) and *Antedon porrecta* (Pl. LII. fig. 3); *Actinometra parvicirra* (Pl. LXI. fig. 1) and *Actinometra sentosa* (Pl. LXVI. fig. 4).

7. The hypozygal of a syzygy is always united to the preceding joint by a muscular articulation.

The method of formulation which I have devised in accordance with the above rules is as follows:—

Like Professor Bell I use R to denote the syzygial union of the two outer radials; and I assume in accordance with Rules 3 to 5 that the first syzygy on the arm is in the third brachial, unless otherwise stated. If it is in the second brachial I put $2br$ at the end of the formula; and if the first two brachials are united by syzygy $\frac{br}{2}$ is used. In like manner, and in accordance with Rule 5, $2d$ and $2p$ would indicate that there are two distichals or two palmars, of which the axillary is a syzygy; and $\frac{d}{2}$ or $\frac{p}{2}$ that the two distichal or two palmar joints are themselves united by syzygy.

The figures 1 or 2 alone would indicate that there is either only a single axillary joint, or that the axillary is the second joint and bifascially united to its predecessor; and a 3 would denote three joints of which the axillary is a syzygy.[1] If one figure occurs alone in a formula it indicates the presence of distichals only; two figures that palmars occur as well; and so on, an additional figure or letter (p', p'', p''') being added for each fresh division, *e.g.*, *Actinometra alternans*, 3, 2, 3, 2, *Actinometra sentosa* 3.2 (p. p'. br).

This may be tabulated as follows:—

Character.	Symbol used. Distichal.	Symbol used. Palmar.
One axillary joint, ...	1	1
Two joints united by syzygy, ...	$\frac{d}{2}$	$\frac{p}{2}$
Two articulated joints, ...	2	2
Two joints, the axillary a syzygy, . . .	$2d$	$2p$
Three joints, the axillary a syzygy, . . .	3	3

[1] It would of course be more consistent to write $3d$ or $3p$; but the syzygial nature of the third (axillary) joint is such a constant character (Rule 6) that until an exception is met with, I prefer to use the figure alone for the sake of brevity.

Bell's method of indicating the varying characters of the cirri is as follows :—

"If there are from 1–12 cirri, we may say there are few; if from 12–30 a moderate number; and if more than 30 a large number; if there are not more than 20 joints to the cirri we may look upon them as being few, if from 20–40 moderate, and if more than 40 numerous. I propose to use the letters *a*, *b*, and *c* to represent few, moderate, and numerous respectively; while the letter for the number of cirri will form the numerator and that for the number of joints the denominator of a fraction; and where there is a difficulty of decision one might write *ab*, or *bc*. *Antedon* and *Actinometra* may be usefully, though not of necessity, distinguished by making A or A′ part of the formula."[1] Bell prefers to use A′ for *Actinometra* rather than "a" as I have suggested, because the *a* is used in the formula for the cirri. I do not see the force of this objection, as the two letters occur at opposite ends of the species formula and only the later one is italicised; while A′ is much too like A to be readily distinguished at a glance, apart from the possibility of printer's errors. Bell's suggestion that "br." should be used instead of "b" for the brachials to avoid confusion with the *b* of the cirrus-formula is a good one, however, and I have adopted it accordingly. In my former method of formulation I denoted the presence of ten arms only by inserting a 10 into the formula of the type, thinking it more convenient to indicate this character, which is generally a sharply defined one, in a positive, rather than in a negative manner. Bell thinks, however, that "A. 10" compared with "A. 3" is very apt to mislead and to give rise to the impression that the *Antedon* in question has ten distichal joints. In deference to his scruples therefore I shall omit the 10 in future and write, as he does, the specific formula of ordinary ten-armed Comatulæ like *Antedon eschrichti*, with no other characters than the generic letter and the cirrus-fraction. Thus *Antedon phalangium* is represented by $A.\frac{bc}{c}$.

It often happens that some individuals of a species are more fully developed than others, *i.e.*, they have additional axillaries in the arm-divisions. Thus for example, one or two bidistichate series are occasionally present in *Antedon lusitanica* which usually only has ten arms (Pl. XXXIX. figs. 1, 3); while palmars are sometimes found in some forms of *Antedon quinquecostata* and of *Antedon variipinna*, but not in others (Pl. XXXVIII. fig. 1; Pl. XLIX. fig. 1). Under these circumstances I write the figure or letter which denotes the character that is variable between brackets, *e.g.*, A.(2), *lusitanica*; A.2.(2), *quinquecostata*; A.[3.(2)], *variipinna*.

In Bell's system, however, "when a character frequently though not always obtains, the corresponding letter is put within brackets."[2] If this were only meant to imply that certain characters present themselves in some individuals of a species, but not in others, Bell's method would be the same as mine. But though he goes much further than I

[1] *Loc. cit.*, p. 531.
[2] *Loc. cit.*, p. 532.

do in theory, he is by no means consistent in practice. Two of his new species, *Antedon reginæ*[1] and *Antedon briareus*,[2] are represented by single specimens only; the palmars in the former and the post-palmars in the latter, as shown in his figures, are not complete all round the calyx, so that the number of arms is thirty-eight and seventy-one respectively instead of forty and eighty. The corresponding symbols are therefore enclosed within brackets in his specific formulæ.

From my experience with *Actinometra parvicirra* I can quite believe it possible that examples of *Antedon reginæ* may eventually be found in which there are no palmars and so not more than twenty arms; but until this is the case I see no reason to enclose the sign for the palmars between brackets in the specific formula. Since, too, there may be an axillary beyond the post-palmar in *Actinometra briareus* with its seventy to eighty arms, I do not think it probable that examples of the type will ever be found without some post-palmar series, *i.e.*, with forty arms or less; and the use of the brackets in this case would be extremely misleading, though it is no doubt correct for the subsequent division, which Bell ignored altogether. But even in this case I should wait to use the brackets till the obvious reasons for doing so presented themselves.

Bell does not always follow his own rule of employing brackets when the arm-divisions are not equal all round the calyx. Thus he describes *Antedon irregularis* as having eleven to twenty-two arms, and he figured an individual in which half the primary arms do not bear distichal axillaries.[3] He does not, however, put the sign for the distichals within brackets, as he ought consistently to do; for the presence of the distichal axillary is a character which, as he expresses it, "frequently but not always obtains" in this species. In like manner his figure and description of *Antedon elegans*[4] show that half, *i.e.*, five, if not more, of the primary arms may remain undivided. But he does not put the distichal figure in brackets as his system demands. His most serious lapses in this respect are indicated by his formula for *Actinometra parvicirra*.[5] He gives it as A′.3.3. No brackets being used at all, the reader is led to infer that the presence of three distichals and three palmars is a character which "always obtains" in this species. But I described some specimens in 1879 which had only twenty arms and no palmars developed at all; while I also figured one with only three of the ten distichal

[1] Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert," 1881–82, London, 1884, p. 115.

[2] Bell's formula for this type is very incorrect. Not only has he referred it to *Antedon* when it is in reality an *Actinometra*, but he twice stated that the post-palmar series consist of two joints without syzygies in the axillaries (pp. 155, 163); whereas as a matter of fact his figure on pl. xiv. shows that this is only the case in nine out of the twenty-seven post-palmar series, just one-third of the whole!! In all the remaining eighteen series there are three joints like the distichal series, with a syzygy in each axillary; and this arrangement, which occurs in two-thirds of the divisions, should therefore be regarded as typical. Furthermore there are four cases of axillaries above the post-palmars, three of which have syzygies like the distichal axillaries. Bell takes no notice of these, however, and so misses the opportunity of contrasting this type, a.3.2.3.3 with *Actinometra alternans*, a.3.2.3.2; and from the formula which he gives, A.3.2(2), one would be led to imagine that the specific relations of the type were rather with *Actinometra multifida* (a.3.2.2).

[3] "Alert" Report, p. 161, pl. xiii. fig. A. [4] *Ibid.*, p. 162, pl. xiii. fig. B. [5] *Ibid.*, p. 155.

series present, so that the number of arms is reduced to thirteen,[1] and Bell has himself examined individuals with less than twenty.[2] According to his rule, therefore, the formula should be—A'.(3).(3). but in the formula which he actually gives the brackets are altogether omitted. I should write it myself as—a.3.(3), to indicate that while some distichal series are always present in every individual, palmar series may occasionally be entirely absent. This appears to me to be the only possible way in which brackets can be profitably employed. Bell, however, thinks otherwise, as is shown by the following passage:[3]—

"From the table of *Antedon* formulæ some facts become at once apparent :—

"(*a*) There are six examples among the more than ten-rayed forms in which the arms are not a regular multiple of ten—that is, not 20, 40, or 80; this is clear from the sign for the palmar or post-palmar being in these cases placed within brackets."

The first line of this passage contains a repetition of an error in terminology which was made by Bell in 1882,[4] and was afterwards corrected by myself.[5] He seems, however, to consider the point an unimportant one and continues to use the expression to which I took exception. There are no *ten-rayed* forms of *Antedon*, though there are plenty which are *ten-armed*. The arms were clearly distinguished from the rays by Müller, who laid the foundation of the descriptive terminology now in use for the Crinoids. But Bell persists in using the word *rays* when he only means *arms*. This is unfortunate, as it leads to confusion between the five-rayed but ten-armed *Antedon* and the truly ten-rayed *Promachocrinus*, a point to which I have before alluded.

Bell has evidently made the generalisation quoted above on the basis of his formulæ, without special reference to the individuals he examined. He describes his single specimen of *Antedon gyges* as having forty-one arms, and I find this to be due to the presence of one post-palmar series, of which Bell's formula gives no hint. He is thus able to include this type among those forms in which the arms are a regular multiple of ten, *i.e.*, forty. Then again he gives the formula of *Antedon articulata* as A.2.2. But the exact number of forty arms which this expression denotes does not occur in his specimen, which also has one post-palmar series; while I have seen individuals with less than forty arms. According to Bell's own system the formula of this type and perhaps also that of *Antedon gyges* should be A.2.(2).(2). We find then that not only on the six, but in all the eight multibrachiate forms of *Antedon* for which he gives formulæ the arms are not a regular multiple of ten. But this is in no way a specially remarkable fact. The singularity would be if the number of arms always were a regular multiple of ten, as is generally though not always the case in *Actinometra paucicirra* (Pl. LIV. figs. 1, 2). But this is a most exceptional species. No one can examine any large collection of multibrachiate Comatulæ without becoming immediately aware of the extreme irregularity in

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 51, 52, pl. ii. fig. 9.
[2] "Alert" Report, p. 168.
[3] *Ibid.*, p. 155.
[4] *Proc. Zool. Soc. Lond.*, 1882, p. 532, note.
[5] *Ibid.*, p. 732, note.

the extent of the arm-divisions. Individuals with a similar distichal axillary on each primary arm and no further division, so that the number of arms is exactly twenty, are extremely rare, except in *Actinometra paucicirra*, and to a less degree also in *Actinometra pulchella*. Another Caribbean species (*Antedon spinifera*) not unfrequently has exactly thirty arms, owing to the very regular presence of palmar axillaries upon the inner pair of every four secondary arms. But I cannot call to mind any species of *Comatula* among the many hundred forms which I have examined in which the total number of arms is exactly forty, owing to the presence of ten distichal series and twenty series of palmars. I have seen an *Actinometra parvicirra* with thirty-nine arms, an *Antedon articulata* with forty, and Bell's unique specimen of *Antedon gyges* has forty-one. But I do not remember any species which always has exactly forty, and I doubt if there be one; while I can say with tolerable confidence that no one will ever find a specific type which always has ten distichal axillaries, twenty palmars, and forty post-palmars, thus giving rise to exactly eighty arms. The logical result of Bell's use of brackets therefore would be that every *Comatula* with eleven to nineteen arms should have the symbol for the distichals placed between brackets; for those with twenty-one to thirty-nine arms there should be brackets round the palmar sign and generally also round the distichal one as well; while the formulæ of types which have over forty and less than eighty arms should have the last, if not the two last, symbols within brackets.

A reference to Bell's formulæ[1] for *Antedon articulata* and *Antedon gyges*, and to those for *Actinometra alternans*, *Actinometra parvicirra*, and *Actinometra multifida*, will show, however, that he has not written them out according to his own system, for none of them have any brackets at all, although in each case he knows of individuals in which the number of arms is not an exact multiple of ten.

There is another point too which he does not seem to have fully considered in the construction of his formulæ. The multibrachiate Comatulæ, such as *Antedon occulta* (Pl. XLVIII. fig. 1) and *Actinometra stelligera* (Pl. LVIII. fig. 1), in which the successive arm-divisions typically consist of two joints each, the axillary without a syzygy, are as a rule extremely regular in their characters. But the case is quite different in those forms which typically have three distichals and three palmars with syzygies in both the axillaries. It is extremely rare to meet with examples of these species in which one or more of the three-jointed distichal and palmar series are not replaced by two jointed series without syzygies in the axillaries. Thus, for instance, I have described specimens of *Actinometra parvicirra* with eighteen and twenty arms respectively, in which half the distichal series were two-jointed, and the other half three-jointed; and a similar irregularity occurs among the palmars. In twelve individuals, however, ninety-six out of one hundred and eleven distichal series, and sixty-seven out of seventy-six palmar series, were three-jointed;[2] and I was thus definitely enabled to make out the characters of the type and to write its

[1] "Alert" Report, p. 155. [2] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 44, 45.

formula—a.3.(3). This method, a determination of the characters present in the majority of cases, is the only one which can be safely relied on for fixing the characters of a species; and it is therefore apparent that the formulæ given by both Bell and myself for species of which we have only seen single individuals are necessarily liable to subsequent correction.

Bell has encountered this difficulty of irregular arm-divisions, and has met it by giving three formulæ for one species which he names *Actinometra variabilis*.[1] It seems to me that two would have been sufficient, as the characters indicated by the first, A′.3.2., are also expressed in the third, A′.3.(2).(2); while there must be a considerable mistake somewhere; for Bell's first and second formulæ do not provide for more than forty arms, though he gives the total number of arms as sixty to ninety. His second formula is A′.3.3., which of course represents a very different type from A′.3.(2).(2). So far as one may judge from his figured specimen, the last is much the most correct, for out of thirteen palmar series only two consist of three joints. On some part of every ray there are three divisions above the palmars, each, with but one exception, consisting of two simple joints. I find that a similar arrangement presents itself upon each of the other three specimens of this type, and I should therefore write its formula as—a.3.2.2.2.2, not using brackets for the last figure because a fifth post-radial axillary occurs in each of the four individuals examined. Neither of Bell's formulæ, however, allow for more than three post-radial axillaries, while his second one A′.3.3. would indicate by the absence of brackets a type with exactly forty arms, and regular distichal and palmar series of three joints each all round the cup, *i.e.*, such a form as *Actinometra parvicirra*, while in reality *Actinometra variabilis* only resembles that species in the constant presence of three distichals, its later arm-divisions being totally different from those of that type.

While therefore it is extremely desirable to be able to examine a good number of individuals before attempting to describe and give a formula for any new specific type of multibrachiate Comatulæ, I do not think that there is any serious objection to describing a species from one individual only. For so far as the characters of the arm-divisions are concerned, I have found it to be an almost invariable rule that the characters which present themselves most frequently in any one individual are those which distinguish the species. Thus, for example, bidistichate series only presented themselves in five out of twelve specimens of *Actinometra parvicirra*,[2] in which the number of distichals is typically three. Two of these individuals were certainly abnormal, the numbers of bidistichate and tridistichate series being exactly equal. But in the other three specimens the largest number of bidistichate series was three, and they never presented themselves at all in seven individuals. The same may be said, though with a somewhat less degree of certainty, respecting the palmar series, sixty-seven of the seventy-six present consisting of three joints. Palmars only occurred in eight of the twelve specimens examined, and were abnormal in but four of them, one species being unusual in having three two-jointed

[1] "Alert" Report, p. 155.

[2] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. p. 44.

series, and only two of three joints. But, excepting in rare cases like this, the predominant characters of the individual may be safely taken as those of the type, and the formula constructed accordingly.

Bell's method of writing a formula for every slight variation, as he has done in the case of *Actinometra variabilis*, would result in the following list of formulæ for *Actinometra parvicirra*.

$$\text{a.}(3)\ ;\ \text{a.}\frac{(3)}{(2)};\ \ \text{a.}3.(2);\ \text{a.}3.\frac{(2)}{(3)};^{1}\ \text{a.}3(3)\ ;\ \text{a.}2.\frac{(2)}{(3)};\ \text{a.}2.(3),\text{ and so on.}$$

Such a collection of formulæ would be worse than useless from its confusion, and very far from being the shorthand system which Bell rightly wishes to see employed. It would be much easier to refer to the specific diagnosis at once than to try and make out the predominant characters of the arm-divisions from a supposed shorthand of this kind.

Two points must therefore be noted in determining the formula of a species. 1. What are the characters of the majority of the arm-divisions in a given individual, or better still, in a number of individuals? 2. Whether examples ever present themselves in which a given character, such as the occurrence of distichal, palmar, or post-palmar divisions, is sometimes entirely absent? In this case, but only in this, the corresponding symbol should be put between brackets in the formula, *e.g.*—

Antedon lusitanica, A.(2).
Actinometra parvicirra, a.3.[3.(3)].
Actinometra multiradiata, a.3.2{*p*.(*p'*)*br*}.

But the fact that all the ten distichals or twenty palmars do not always occur in every individual of a species is no reason for placing the corresponding symbol in brackets. Were this done, I have no hesitation in saying that both symbols would have to be enclosed in brackets in the formula of every species with less than forty-one arms and no post-palmar divisions. This of course would be absurd, and render the use of formulæ altogether futile.

The principles of classification which have been explained above [2] enable us to divide the numerous species of *Antedon* and *Actinometra* respectively into groups of very variable size. These are arranged in the following lists, which contain the names of all the species described by myself and my predecessors, Retzius, Lamarck, Müller,

[1] This is similar to the expression given by Bell for *Antedon elegans*, in which there are generally two palmars, but sometimes three. His figured specimen presents one case of the latter to four of the former; and it is therefore clear that the formula should be written A.3.2.

[2] I may just remark here that I cannot at all agree with the dictum of Walther that "Wer sich je mit Crinoiden beschäftigt hat, der wird wissen, wie wenig specifischen Werth die Gabelungen der Arme besitzen" (Palæontographica, 1886, Bd. xxxii. p. 182). Walther's experience seems to have been limited to a comparatively small number of fossil Crinoids, not always in the best state of preservation. But so far as concerns the recent Crinoids, both stalked and free, the number and characters of the arm-divisions afford points of much importance in the discrimination of species. I am convinced that the same may be said of the fossil Neocrinoids, if not of the Palæocrinoids too, provided that a sufficient range of specimens is brought under consideration.

Böhlsche, Pourtalès, Grube, Bell and others, so far as my knowledge of them extends. A few of my own undescribed species, from the "Blake" collection and elsewhere, are also added, as they have received names somewhat prematurely, owing to their being the hosts of Myzostomida, which have been described by Professor von Graff. One or two of Professor Lütken's MS. names are included, as they belong to easily recognisable types, *e.g.*, *Antedon protecta*; but others, such as *Actinometra mutabilis* and *Actinometra trachygaster*, are omitted, as I have found a considerable variety of types under each of these names in the different collections that I have examined.

I have added a few remarks respecting the absence of certain well-known names, such as *Antedon sarsii* and *Actinometra timorensis*, and also with regard to the presence of certain species in altogether different groups, both specific and generic, from those to which they have been referred by their original describers—(See the numbers before the names).

In order to exhibit more completely the range of structural variation which is to be met with among the Comatulæ, I have included the formulæ for various species that I have examined but have not yet described. Some rather variable species appear in more than one group,[1] and to draw attention to their peculiarities the name is followed in each case by the formula of the other group in which the species also occurs. Thus *Actinometra pulchella* (10),[2] and $\left(2.(2).\frac{br}{2}\right)$.

In one or two cases I have departed from the strict numerical sequence in order to avoid separating too widely species which are really very closely allied, on the sole ground that one has an axillary more than the other. Thus A.3. $\frac{p.br.}{2}$ immediately succeeds A.3.$\frac{br}{2}$, while a.3.2($p.br$) and a.3.2(p,p',br) follow most naturally directly after a.3.2.br., instead of being separated from the latter group by several intervening ones, as was the case in my preliminary list.[3]

List of Species.

Genus ANTEDON.

I. A.R.2.2.2.	
A.R.3.2.(2).	1. *elegans*
A.R.3.3.3.	*multiradiata*
A.R.3.3.3.3.	2. *microdiscus*

[1] It has not been worth while to repeat the name in one or two cases, *e.g.*, *Antedon elegans* (A.R.3.2.(2)), and I have therefore used brackets for the last figure.

[2] The 10 is not used here to indicate that there are ten joints in the distichal series, but as a short way of denoting the presence of only ten arms. I trust that the abbreviation will not be misunderstood. See p. 47.

[3] *Proc. Zool. Soc. Lond.*, 1882, pp. 746, 747.

II. A.10. [only ten arms].

abyssicola
abyssorum
acœla
aculeata
acutiradia
adeonæ
alternata
anceps (3)
angustipinna
antarctica
armata
australis
balanoides
barentsi
basicurva
bidens
bispinosa
brevipinna (2)
breviradia
carinata
carpenteri
columnaris
cubensis
defecta
denticulata
discoidea
dübeni
duplex (2)
echinata
eschrichti
exigua
flexilis (2)
gracilis
hageni
hirsuta
hystrix
impinnata
incerta
incisa
informis
lævipinna
lævis
lævissima
latipinna
lineata
longicirra
longipinna
3. *lovéni*
lusitanica (2)
magellanica
4. *milberti*
milleri
multispina $\left(3\frac{br}{2}\right)$
parvicirra
parvipinna
perspinosa
petasus
5. *phalangium*
pinniformis
prolixa
pumila
pusilla
6. *quadrata*
remota
rhomboidea
rosacea
serripinna
spinicirra
7. *tenella*
tenuicirra
tessellata
tuberosa
valida
8. *variipinna* [3(2)].

III. A.2.

brevipinna (10)
clemens
compressa
disciformis
duplex (10)
flexilis (10)
lusitanica (10)
macronema
marginata
patula
pourtalèsi (2.2)
quinquecostata (2.2)
robusta

A.2.2.

articulata (2.2.2)
bimaculata
brevicuneata
elongata
imparipinna
indica
lævicirra
manca
palmata (2.2.2)
pourtalèsi (2)
protecta
quinquecostata (2)

A.2.2.

regalis | *similis* | *spinifera* (2.2.2)
reginæ | *spicata* | *tuberculata*

A.2.2.2.

æquipinna | *flagellata* | *palmata* (2.2.)
articulata (2.2.) | *gyges* | *spinifera* (2.2.)
conjungens | *occulta*

IV. A.3.$\frac{br}{2}$.

angusticalyx | 10. *inæqualis* $\left(3.\frac{p.br.}{2}\right)$ | *multispina* (10)

9. *granulifera* $\left(3.\frac{p.br.}{2}\right)$

A.3.$\frac{p.br}{2}$.

distincta | 9. *granulifera* $\left(3.\frac{br.}{2}\right)$ | 10. *inæqualis* $\left(3.\frac{br}{2}\right)$

A.3.

anceps (10) | *reynaudi* | *variipinna* [3.(2)]
angustiradia | *savignyi* (3.2)

A.3.1.

A.3.2.

acuticirra | *quinduplicava* | *variipinna* [(3)]
ludovici | *savignyi* (3)

A.3.2.3.

A.3.2{(*p.*)*br*} | *porrecta*

A.3.3. | *bipartipinna* | *philiberti*

A.3.3.3.

REMARKS.

1. *Antedon elegans*, Bell. I place this species in the first group because I find on examination that the two outer radials are united by syzygy. This important fact escaped the notice of Bell;[1] and his specific formula is incorrect in other points besides the omission of the R. The species now appears therefore in an altogether different group from that to which I at first assigned it on the basis of his description.

[1] "Alert" Report, pp. 155, 162.

2. *Antedon microdiscus*, Bell. This is another species like *Antedon elegans* which has the two outer radials united by syzygy, although they were not so described by Bell, who assigned to the type a formula so unusual for an *Antedon*,[1] (A.3.3(3)), that I was led to examine the species for myself, with the result mentioned above. His formula is defective in another respect besides the all-important omission of the R; for it takes no account of any arm-divisions beyond the third axillary above the radials, and could not therefore apply to any species with more than eighty arms. He says, however, "probably as many as 90 arms in an adult," and nine sets of quaternary arms are represented in his figured specimen. They are absent, however, in one of the smaller examples of his type, which for this and other reasons I am disposed to refer to *Antedon multiradiata*. But their presence is nowhere indicated in the formula given by Bell; and he also puts the 3 indicating the tertiary or post-palmar series in a bracket, which would imply that the full number of eight series is not developed on every ray. I much doubt, however, whether an example of this or of any other type will ever be found with exactly eighty arms owing to the presence of forty post-palmar axillaries and none beyond them; and his formula only tells us that every individual of this species does not conform to this very regular arrangement.

Bell not only omits all reference to the quaternary arms in his better developed individuals of this type, but he says of the tertiary arms that "of the three joints the axillary may or may not be a syzygy." His figured specimen has the full number (forty) of tertiary arms, and the axillary is a syzygy in each case. But in the smaller individuals there seem to be some exceptional series of two joints only, the axillary not a syzygy. This is probably the condition alluded to by Bell, but it would have been better if he had described it more precisely, for a series of three joints with the axillary *not* a syzygy is an arrangement which I have not met with in any *Comatula*, though it is to be found in the Pentacrinidæ.

3. *Antedon lovéni*, Bell. Bell has given the name *lovéni*[2] to the form which appeared as *Antedon insignis* in his first list;[3] and as this is the host of *Myzostoma coriaceum*, the name should be altered in the Report on the Myzostomida by Professor von Graff.[4] On the other hand *Antedon lovéni* of Bell's first list has been since described by him as *Antedon pumila*.[5]

4. *Antedon milberti*, Müll., sp. Müller's two species, *Comatula milberti* and *Comatula jacquinoti*, appear to me to be identical; and the second name thus becomes a synonym of the first.

5. *Antedon phalangium*, Müller, sp. This Mediterranean species was for a long time but very imperfectly known, and examples of it were described by Barrett from the

[1] "Alert" Report, p. 155.
[2] "Alert" Report, p. 158.
[3] *Proc. Zool. Soc. Lond.*, 1882, p. 534.
[4] Zool. Chall. Exp., part. xxvii., 1884, pp. 14, 18, 40.
[5] "Alert" Report, p. 157.

Sound of Skye, first as *Comatula woodwardii*,[1] and then as *Comatula celtica*,[2] both of which names must now lapse.

6. *Antedon quadrata*. This is the Arctic type which was referred to *Antedon celtica*, Barrett, first by von Marenzeller[3] and afterwards by Duncan and Sladen,[4] and has since been rebaptized by myself.[5]

7. *Antedon tenella*, Retzius, sp. This species, which dates back to 1783, was described by Say in 1825 as *Alectro dentata*, and is better known in Europe as *Alecto sarsii*, Düben and Koren.

8. *Antedon variipinna*, Carpenter. To this species I now refer my own *Antedon crenulata*, together with the *Antedon decipiens* and *Antedon irregularis* of Bell. Some forms of it seem to have but ten arms.

9. *Antedon granulifera*, Pourtalès. There is a syzygy between the two palmar joints of this species, which escaped the notice of Pourtalès.[6]

10. *Antedon inæqualis*, n. sp. Most examples of this species that I have seen conform to the type A.3.$\frac{br}{2}$, but in one individual there is a single series of two palmars, the axillary with a syzygy, while the first brachial above it is also traversed by a syzygy (Pl. LI. fig. 2). I much doubt, however, whether this is anything more than an abnormal development; but I have recorded it in order to guard against the possibility of similar forms being subsequently found and described as new species.

Genus ACTINOMETRA.

I. (i) a.R.$\frac{br}{2}$.

1. *brachiolata* 2. *pectinata* 3. *solaris*.

(ii) a.R.$\frac{d.(p.)br.}{2}$ 4. *paucicirra*

(iii) a.R.3.$\frac{p.br}{2}$. *distincta*

a.R.3.$\frac{p.p.'p.'' \ldots\ldots\, br.}{2}$.

multibrachiata *novæ-guineæ* *typica*

[1] On two species of Echinodermata, new to the Fauna of Great Britain, *Ann. and Mag. Nat. Hist.*, 1857, ser. 2, vol. xix. p. 33.
[2] *Ibid.*, vol. xx. p. 44.
[3] Die Coelenteraten, Echinodermen und Würmer der k. k. Österreichisch-ungarischen Nordpol-Expedition, *Denkschr. d. k. Akad. d. Wiss. Wien*, 1877 [1878], Bd. xxxv. p. 380.
[4] A Memoir on the Echinodermata of the Arctic Sea to the West of Greenland, London, 1881, p. 75, pl. vi. figs. 5, 6.
[5] On the Crinoidea of the North Atlantic between Gibraltar and the Færoe Islands, *Proc. Roy. Soc. Edin.*, 1883–84, vol. xii. p. 375.
[6] *Bull. Mus. Comp. Zoöl.*, 1878, vol. v. No. 9, p. 215.

II. a.10 [only ten arms].			
	blakei	*echinoptera*	5. *pulchella* $\left(2.(2)\frac{br}{2}\right)$
	cumingi	*meridionalis*	6. *rubiginosa*
III. (i) $a.2.\frac{br}{2}.$		*maculata*	*pulchella* $\left(10;\ \&\ 2.2.\frac{br}{2}\right)$
$a.2.2.\frac{br}{2}.$		*pulchella* $\left(10;\ \&\ 2.\frac{br}{2}\right)$	*stelligera* $\left(2.2.(2)\frac{br}{2}\right)$
$a.2.2.2.\frac{br}{2}.$		*stelligera* $\left(2.2.\frac{br}{2}\right)$	
$a.2.2.2.2.\frac{br}{2}.$		*nigra*	
(ii) a.2.2.			
a.2.		*elongata*	*simplex*
a.2.3.		*rotalaria*	
a.2.3.3.		*valida*	
a.2.3.3.3.			
IV. (i) $a.3.1.1.\frac{2br.(o)}{\frac{br.(i)}{2}}.$			
a.3.2*br*.			
	borneensis	*discoidea* [3.2(*p.br*)]	*lineata* [3.2(*p.br*)]
	7 *coppingeri*	*fimbriata*	
a.3.2(*p.br*).			
	discoidea (3.2*br*)	*lineata* (3.2*br*)	*multiradiata*[3.2(*p.p′.br*)]
a.3.2(*p.p′.br*)		*multiradiata* [3.2(*p.br*)]	*sentosa*
(ii) a.3.			
	japonica (3.3)	*quadrata*	*trichoptera* (3.3)
	8. *parvicirra* [3.(3.3)]		
a.3.2.			
a.3.2.2.		*multifida*	
a.3.2.2.2.2.		9. *variabilis*	
a.3.2.3.		*grandicalyx*	
a.3.2.3.2.		*alternans*	
a.3.2.3.3.			
	10. *briareus*	*divaricata*	*magnifica*

a.3.$\frac{2}{3}\left(\frac{o}{i}\right)$2.2.	*belli*	
a.3.$\frac{2}{3}\left(\frac{o}{i}\right)$3.	*duplex*	
a.3.$\frac{2}{3}\left(\frac{o}{i}\right)$3.3.	11. *nobilis*	
a.3.3.		
japonica (3)	*robustipinna*	*trichoptera* (3)
parvicirra (3)		
a.3.3.2.	*littoralis*	
a.3.3.3.	*bennetti* (3.3.3.3)	*parvicirra* [3(3)]
a.3.3.3.3.		
bennetti (3.3.3)	*regalis*	*schlegeli*
peroni		

1. *Actinometra brachiolata*, Lam., sp. I refer to this type the form described by Müller[1] under the MS. name *Comatula rosea*, Mus. Vienna. He noted its close relationship to and possible identity with Lamarck's type, and an examination of both has convinced me that they are really identical.

2. *Actinometra pectinata*, Linn., sp. I have come to the conclusion that *Actinometra affinis*, Lutken, MS., which appeared in my former list,[2] is identical with the form which Retzius referred to the *Asterias pectinata* of Linnæus. The *Alecto purpurea* of Müller[3] is probably a young form of the same type.

3. *Actinometra solaris*, Lam., sp. The type for which Bell gave a formula under the name of *Actinometra albonotata*[4] is now regarded by him as a variety of *Actinometra solaris*.[5] The following specific names have also been applied to this type at different times—*hamata*, *imperialis*, *intermedia*, *robusta*, and *strota*. (See p. 288.)

4. *Actinometra paucicirra*, Bell. The form described by Bell under this name[6] turns out to be only the premature stage of the type to which I referred in my Preliminary Report as *Actinometra jukesi*.[7] But it has not yet been formally described, and Bell's name therefore must take precedence.

5. *Actinometra pulchella*, Pourt., sp. This is the *Antedon pulchella* of Pourtalès, another form of which was also described by him as an *Antedon alata*.[8]

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 250.
[2] *Proc. Zool. Soc. Lond.*, 1882, p. 747.
[3] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 132.
[4] *Proc. Zool. Soc. Lond.*, 1882, p. 535.
[5] "Alert" Report, p. 165.
[6] *Ibid.*, p. 169.
[7] *Proc. Roy. Soc.*, 1879, p. 390.
[8] Reports on the Results of Dredging under the Supervision of Alexander Agassiz, in the Gulf of Mexico, by the United States Coast Survey Steamer "Blake," Lieutenant Commander C. D. Sigsbee, U.S.N., Commanding, *Bull Mus. Comp. Zoöl.*, 1878, vol. v. No. 9, pp. 215, 216.

6. *Actinometra rubiginosa*, Pourt., sp. This form was originally described as an *Antedon* by Pourtalès, before the two genera were distinctly separated.[1]

7. *Actinometra coppingeri*, Bell. The formula assigned to this type by Bell[2] is that of a ten-armed species, with a syzygy in the third brachial. But the number of arms varies from twelve to twenty, and there is a syzygy in the second joint above the distichal axillary.

8. *Actinometra parvicirra*, Müll., sp. This protean type has been variously described under the following names—*annulata*, *mertensi*, *meyeri*, *polymorpha*, *timorensis*, *wahlbergi*.

9. *Actinometra variabilis*, Bell. This species appeared in my former list[3] in the group (A.3.3.), this being the formula which I was led to assign to it on the basis of that previously given by Bell.[4]

10. *Actinometra briareus*, Bell, sp. Bell has described this species[5] as an *Antedon* with the formula A.3.2.(2); though the majority of the palmar series are three-jointed and some of them are followed by another series of the same character.

11. *Actinometra nobilis*, n. sp. *Actinometra dissimilis* of Part I.[6] appears to be a varietal form of this type.

Some curious points of contrast may be noticed in the two lists given above. There are three very distinct types of *Actinometra* in which the two outer radials are united by syzygy. (1) The ten-armed (*Actinometra solaris*); (2) those with two distichals (*Actinometra paucicirra*); and (3) those with three (*Actinometra typica*). In the latter case each subsequent division (if present) consists of only two joints united by syzygy. On the other hand, all the recent species of *Antedon* yet described which have the radials a syzygy have three distichals, while the palmars and subsequent divisions either resemble the distichals, or consist of two articulated joints. Species of *Antedon* like *Actinometra paucicirra* and *Actinometra typica* are, like those of the *Solaris*-type, yet to be described.

More than half the species of *Antedon* belong to the simple ten-armed type with articulated radials like *Antedon eschrichti* (Pl. XXIV. fig. 11); while half the remainder have only two joints in each of the first three arm-divisions, as in *Actinometra conjungens* (Pl. XLV. fig. 1). But there are not ten described ten-armed species of *Actinometra* which have articulated radials, nor ten with two-jointed distichal series. Both these types, which together include over three-quarters of the species of *Antedon*, thus present themselves but rarely in *Actinometra*.

On the other hand, we find in this genus a much greater number and variety of the

[1] List of the Crinoids obtained on the Coasts of Florida and Cuba by the United States Coast Survey Gulf Stream Expeditions in 1867, 1868, 1869, *Bull. Mus. Comp. Zoöl.*, 1869, vol. i. No. 11, p. 356.

[2] *Proc. Zool. Soc. Lond.*, 1882, p. 535.

[3] *Ibid.*, p. 747.

[4] *Ibid.*, p. 535.

[5] "Alert" Report, pp. 155, 163.

[6] Zool. Chall. Exp., part xxxii. pp. 110, 111.

tridistichate species than occur in *Antedon*. I do not know any species of the latter genus with articulated radials in which there is a fourth post-radial axillary, such as occurs in *Actinometra alternans*, *Actinometra variabilis*, *Actinometra magnifica*, and *Actinometra bennetti;* and it is decidedly rare to find a third axillary; while the singular variations presented by *Actinometra belli* and *Actinometra nobilis* are altogether unknown in *Antedon*.

The above tables show that it is possible to make a preliminary classification of the species of Comatulæ by using the characters of their successive arm-divisions.

But how are we to deal with the seventy odd species of *Antedon* which have only ten arms, or with the thirty more which have bidistichate primary arms? The characters of systematic value which may be employed for this further classification are those of the cirri, arms, and pinnules. The number of the cirri themselves and also that of their component joints are very useful characters within certain limits. *Antedon valida* and *Antedon parvipinna*, which are both figured on Pl. XV., are obviously quite distinct specific types; and the same may be said of *Antedon alternata* and *Antedon incerta*, represented on Pl. XVIII., not only as regards the cirrus-characters, but with respect to the pinnules also.

The shape and the relative sizes of these latter organs, especially at the bases of the arms, often afford characters of much systematic value, as will be seen by comparing the flagellate lower pinnules of *Antedon quadrata* and *Antedon australis* (Pl. XXVII. figs. 8–16) with the stiffer ones of *Antedon occulta* and *Antedon variipinna* (Pl. XLVIII. figs. 2, 3); while those of *Antedon valida*, *Antedon incerta*, and *Antedon macronema* (Pl. XV. figs. 5, 6; Pl. XVIII. fig. 5; Pl. XXXVIII. fig. 4) are of an altogether different type from either of the others just mentioned.

Another very useful character for systematic purposes is to be found in the shape of the arm-joints. In one large group of *Antedon*-species the radial axillaries and the next few joints beyond them have their apposed sides much flattened, as is well seen in Pl. XV. fig. 6. In the absence of this very striking peculiarity, the shape of the arm-joints, as seen from the dorsal side, is often of much use in classifying species. Thus, for example, the elongated joints of *Antedon phalangium* (Pl. XXVIII. fig. 1), the short compressed triangular joints of *Antedon patula* (Pl. XLIII.), and the rounded joints of *Antedon variipinna* (Pl. XLIX. fig. 1) all afford good specific characters; while in the genus *Actinometra* the contrast is strong between the short discoidal joints of *Actinometra fimbriata* and the triangular ones of *Actinometra elongata* (Pl. LVII. fig. 2; Pl. LXII. fig. 3).

The condition of the ambulacra in the arms and pinnules is also of much use in classification. Thus, for example, *Antedon acœla*, *Antedon incerta*, *Antedon inæqualis*, and other forms have both side plates and covering plates on the pinnule-ambulacra, which are often better defined than in the Pentacrinidæ; while in other species, such as

Antedon eschrichti and *Antedon carinata*, the ambulacral plating is reduced to small and irregular spicules without definite arrangement.

By means of these various characters, then, it is possible to subdivide the large specific groups, both in *Antedon* and in *Actinometra*, and to make out a detailed classification of the numerous species belonging to each genus. Except in a few cases, however, it would be premature as yet to make any attempt at distinguishing the structural and the adaptive characters respectively among those which we are at present inclined to regard as of specific value.

VI.—DESCRIPTION OF THE SPECIMENS.

Class CRINOIDEA.

Order NEOCRINOIDEA.

Family COMATULIDÆ, d'Orbigny, 1852; *emend.* P. H. Carpenter, 1888.

Crinoids with the calyx closed below by the enlarged top joint of the larval stem, which develops cirri and generally separates from the stem joints below it, so that the calyx is free. The basals may form a more or less complete ring on the exterior of the calyx, or be only represented by an internal rosette. Five or ten rays, either simple or more or less divided. The first axillary is the second, or (very rarely) the first joint above the calyx-radials. Definite interradial plates usually absent.

The mouth central, except in one genus.

Remarks.—The family Comatulidæ, which was established by d'Orbigny[1] in 1852, is practically equivalent to a group which was proposed more than twenty years previously by de Blainville,[2] under the name of the "Astérencrinides libres." So far as I am aware, de Blainville was the first author to make any definite separation of the Feather-stars from the remaining Stellerids.

He divided this order into three families, the Asteridea, the Asterophydea, and the Asterencrinidea, which last Miller had previously called Crinoidea.

De Blainville further subdivided the Asterencrinidea into two sections, the first of which was "les Astérencrinides libres." He defined it as having a "corps libre, et sans tige qui servirait à le fixer"; and he referred to it the single genus *Comatula*, Lamarck.

In the great work of Goldfuss,[3] which was published a few years later, there is, however, no special separation of the genus *Comatula* from the other Stellerids, and it simply appears as the first genus in his order "Asterites liberi," altogether separate from the Stalked Crinoids, which are classed as the Stilasteritæ, though the resemblance between them and *Comatula* did not escape the notice of Goldfuss. He gave an account of the anatomy of two recent species, and referred to the genus some fossils from Solenhofen,

[1] Cours élémentaire de Géologie et de Paléontologie stratigraphique, 1852, t. ii. fasc. i. p. 138.
[2] Dict. d. Sci. Nat., 1830, t. lx. p. 229.
[3] Petrefacta Germaniæ, Düsseldorf, 1826-35, vol. i. p. 201.

while he also gave the names *Solanocrinus* and *Glenotremites* to some other fossil forms of which only parts of the calyx were preserved. Some of Goldfuss's species were made the types of new genera by Agassiz,[1] and Müller referred to them as follows in his first communication to the Berlin Academy on the subject of the Crinoidea:[2]—

"Die ungestielten Crinoiden mit Armen bilden 3 Familien (1) *Articulata*, gen. *Comatula*, Lam., und *Comaster*, Ag. (2) *Costata* mit schaligem gerippten Kelch und entgegengesetzten Pinnulæ, wovon sonst bei allen übrigen Crinoiden kein Beispiel vorkommt, gen. *Saccocoma*, Ag. (3) Tessellata, gen. *Marsupites*."

The above passage must not be understood as meaning that "Articulata," Müller, is a synonym of "Comatulidæ," d'Orbigny, and should therefore take precedence of it. For there were Stalked as well as Unstalked Crinoidea Articulata and Crinoidea Tessellata; and in the subsequent memoir on *Pentacrinus* Müller made these the two primary divisions of the Crinoidea, altogether apart from the question of the presence or absence of a stalk. But in his second preliminary communication[3] he made a passing reference to "die in der Familie der Comatulinen enthaltenen Gattungen *Comatula* und *Comaster*," the latter genus being regarded by him as identical with *Solanocrinus*, Goldfuss.

Müller never said anything more definite about the family Comatulinæ, however, though he recognised *Alecto* and *Actinometra* as two subgenera of *Comatula*, Lamarck. The Stalked Crinoids remained in an equally chaotic condition for many years. But about 1850 Bronn and d'Orbigny made separate attempts to class them into families. The former author[4] established the family Astylidæ, though without defining it, and referred to it the recent *Comatula* and three fossil genera. Among these were *Marsupites* and *Saccocoma*, both of which, as we have seen above, had been made the types of separate families by Müller. This was also done by d'Orbigny,[5] who divided the Crinoidea into ten families, one of which was the Comatulidæ, and this name, or its shortened form "Comatulæ," has been in use for the family of the Feather-stars ever since, though the number of genera referred to the family has varied enormously.

D'Orbigny included in it the recent *Comatula*, Lamarck, and three other genera which were based on the characters of various fossil species. None of these, however, are now recognised; and the same is true of a number of genera established by other palæontologists; for with one exception all the true Comatulids which have been as yet discovered in the fossil state can be referred either to de Fréminville's genus *Antedon*, which has priority over *Comatula*, or to Müller's subgenus *Actinometra*, which has gradually acquired generic rank. The exception is the five-armed species from the Valangien of Switzerland,

[1] *Mém. Soc. Sci. Nat. Neuchatel*, 1835, t. i. p. 193.
[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1840, p. 91.
[3] *Ibid.*, 1841, p. 179.
[4] Lethæa Geognostica, 1851, Bd. i. Th. 1, p. 23.
[5] Cours élémentaire de Paléontologie et de Géologie stratigraphique, 1852, vol. ii. fasc. i. p. 138.

which represents a recent generic type first discovered by Semper and named by him *Ophiocrinus*. In consequence, however, of the preoccupation of this name it has been since changed to *Eudiocrinus*. Thus then the great number of generic names which have been given to the fossil Comatulæ become reduced to three, *Antedon*, *Actinometra*, and *Eudiocrinus*. Three new genera have been established by myself for new types of recent Comatulæ, viz., *Atelecrinus*, *Promachocrinus*, and *Thaumatocrinus*; and these six are all that could strictly be included in the family Comatulidæ until quite recently. Pictet[1] has also referred to it both *Marsupites* and *Saccocoma*, but Dujardin and Hupé[2] removed *Marsupites* to the Cyathocrinidæ, and added to the Comatulidæ the sessile *Eugeniacrinus* and its allies, which had been grouped under the Eugeniacrinidæ in Bronn's "Thierreich." Zittel[3] restored this family to its proper position and restricted d'Orbigny's name to the Feather-stars proper; while *Saccocoma* was replaced in Müller's group, the Costata, which had been established for its reception in 1840.

Quite recently, however, it has become necessary to add a seventh genus to the family, viz., the fossil *Thiollierierinus*, which represents a permanent form of a late stage in the development of the *Antedon*-larva. It has been well described by de Loriol[4] as an *Antedon* with a *Bourgueticrinus*-stem. The stem-joints of the larval *Antedon* are closely similar to those which are characteristic of the family Bourgueticrinidæ, their faces bearing strong transverse ridges with a deep fossa on each side.

In ordinary Comatulæ the centro-dorsal, after separating from the stem beneath it, soon loses all trace of its previous connections, owing to a more or less extensive deposition of limestone at its dorsal pole; whereas in *Thiollierierinus* the connection between the lower stem-joints and the cirrus-bearing centro-dorsal seems to have been maintained much longer, if not throughout life. For the under surface of the centro-dorsal bears a well-developed articular facet like that on an ordinary stem-joint of *Bourgueticrinus* or *Rhizocrinus*. It would appear therefore that the centro-dorsal with the few cirri which were developed upon it remained permanently attached to the stem below, so that *Thiollierierinus* would represent the permanent condition of an *Antedon*-larva during the development of its second whorl of cirri. We cannot be absolutely certain about its characters, however, until an entire example of the genus has been discovered. But the presence of an articular facet on the under surface of its centro-dorsal is a feature which is sufficient to distinguish it very markedly from the six genera of recent Comatulæ.

[1] Traité de Paléontologie, Paris, 1857, vol. iv. p. 287.
[2] *Op. cit.*, p. 186.
[3] Handbuch der Palæontologie, Bd. i., Abth. 1, p. 395.
[4] Description de quatre Échinodermes Nouveaux, *Mem. Soc. Pal. Suisse*, 1880, vol. vii. p. 10.

The general relations of these seven genera of Comatulidæ are expressed in the following table :—

I. Centro-dorsal has no articular facet on its lower surface.
  A. Five rays.
    i. Mouth central or subcentral. Oral pinnules have no comb.
      a. Radials separated by interradials, ... 1. *Thaumatocrinus*, n. gen.
      b. Radials united laterally.
        (1) Basals persist as a closed ring. No pinnules on lower brachials, ... 2. *Atelecrinus*, n. gen.
        (2) Basal ring incomplete or invisible externally.
          α. Five arms only, ... 3. *Eudiocrinus*, Carpenter.
          β. Ten arms, ... 4. *Antedon*, de Fréminville.
    ii. Mouth excentric or marginal. Oral pinnules have a terminal comb, ... 5. *Actinometra*, Müller.
  B. Ten rays, ... 6. *Promachocrinus*, n. gen.
II. Centro-dorsal has an articular facet below, ... 7. *Thiollierierinus*, Étallon.

Genus 1. *Thaumatocrinus*, P. H. Carpenter, 1883.

1883. *Thaumatocrinus*, P. H. Carpenter, Phil. Trans., 1883, pt. iii. p. 919, pl. lxxi.

Definition.—Calyx composed of a centro-dorsal, basals, radials, and primary interradials, the latter resting on the basals and so separating the radials laterally. That on the anal side bears a short jointed appendage. Mouth central and protected by five large oral plates which occupy the greater part of the disk, and are separated from the calyx-interradials by two or three rows of small irregular plates. Five arms only.

Remarks.—*Thaumatocrinus* has already been described and its peculiarities discussed in Part I. of this Report (pp. 370–372), and it is not necessary therefore to refer again to the reappearance of certain Palæocrinoidal characters in this remarkable genus. As compared with the more typical Comatulæ it is peculiar in having persistent basal and oral plates, the latter occurring in no other Comatulid, and in the simplicity of the rays, which remain undivided, so that there are only five arms, as in *Eudiocrinus* (Pl. VII.).

Thaumatocrinus renovatus, P. H. Carpenter, 1883 (fig. 1; Part I. pl. lvi. figs. 1–5).

Description of an Individual.—The total width of the calyx across the disk is barely 2 mm.; and the height of the centro-dorsal and radials together is about the same. The former is rounded below, with its central canal completely closed up, so that it must have been detached for some little time from the remainder of the stem. The bases of half a dozen cirri are attached to it, and there are pits for the reception of two or three more. In the largest stump which is preserved the first two joints are quite short, as is usually the case in all cirri; but the third reaches a length of 1·5 mm., so that the cirri must have been very like those of some species of *Eudiocrinus*, which have a succession of very long joints following the short basal ones (Pl. VII. figs. 2, 7).

The basals are almost trapezoidal, much wider below than above, and in contact with one another by their truncated lower angles. The middle of the lower edge of each is slightly tubercular. On their narrow upper edges rest the interradials, which are oblong and a little higher than wide. Four of them terminate in a free edge at the margin of the disk, where they are in contact with the lowest anambulacral plates. But that on the anal side bears a small tapering appendage of four or five joints, the last of which seems to end freely. The radials are larger than the interradials and somewhat strongly arched. There is a muscular articulation between them and the first brachials; but the articulation between these and the next joints appears to be only bifascial. The arm-joints are long, slender, and cylindrical. One arm seems to be broken at a syzygy in the sixth brachial; while another has a syzygy in the fourth, and again in the eighth brachial. The second brachial bears the first pinnule, which is on the right side in three arms, and on the left in the other two. The pinnules are very delicate and composed of long slender joints.

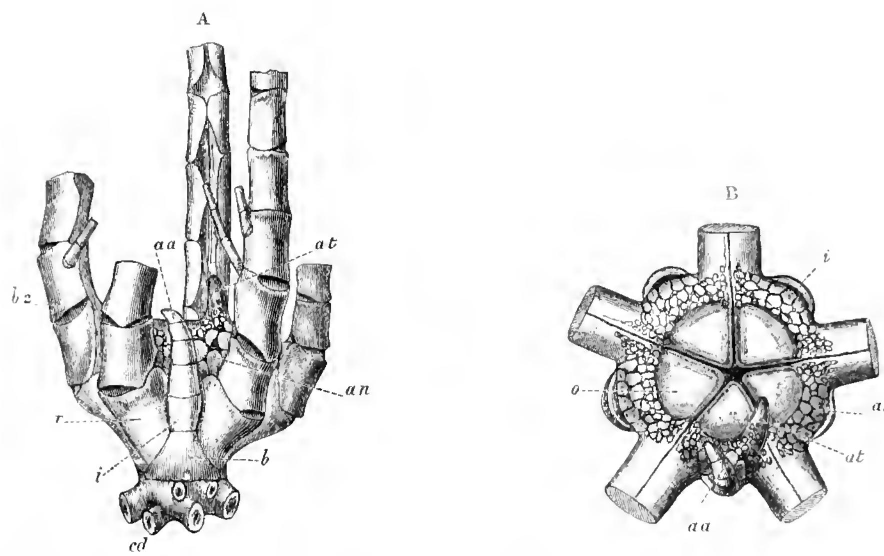

FIG. 1.—*Thaumatocrinus renovatus*, P. H. Carpenter. A, The calyx, anal side. B, The disk from above. *aa*, anal appendage; *an*, anambulacral plates; *at*, anal tube; *b*, basal; b_2, second brachial; *cd*, centro-dorsal; *i*, interradial; *o*, oral; *r*, radial. × 15.

The central portion of the disc is occupied by five relatively large oral plates which stand up around the peristome; while between them and the margin are two or three irregular rows of small anambulacral plates, some of them extending up on to the lower part of the long anal tube. The brachial ambulacra are not plated, however, and lie in the arm-grooves, close down between the muscles but with no traces of sacculi.

Colour in spirit.—Dirty white.

Locality.—Station 158, March 7, 1874; lat. 50° 1′ S., long. 123° 4′ E.; 1800 fathoms; Globigerina ooze; bottom temperature, 33°·5 F. One specimen, much mutilated and probably young.

Genus 2. *Atelecrinus*, P. H. Carpenter, 1881.

1869. *Antedon*, Pourtalès (*pars*), Bull. Mus. Comp. Zoöl., 1869, vol. i. No. 11, p. 356.
1878. *Antedon*, Pourtalès (*pars*), Bull. Mus. Comp. Zoöl., 1878, vol. v. No. 9, p. 214.
1881. *Atelecrinus*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1881, vol. ix. No. 4, p. 16.
1882. *Atelecrinus*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 488.

Definition.—Centro-dorsal acorn-shaped, and bearing five vertical double rows of cirrus-sockets, those of each row alternating with one another, and with those of adjoining rows. They have horseshoe-shaped rims, the arches of which are directed upwards while the two ends slant downwards and outwards. Radials separated from the centro-dorsal by a complete circlet of basals. The first six or more brachials bear no pinnules.

Remarks.—The first example of this genus which was actually obtained was dredged by Pourtalès[1] in 1869 off Cojima on the coast of Cuba. Two small ten-armed Comatulæ were brought up from a depth of 450 fathoms, and were briefly described by Pourtalès under the name of *Antedon cubensis*. But the description given by him only applies to the larger and more perfect specimen, which differs considerably from the smaller and much mutilated one. He seems to have recognised that the two were different, for in his description[2] of the Crinoids obtained by the "Blake" expedition of 1877–78 he wrote as follows :—"To this species (*i.e.*, *Antedon cubensis*) I refer provisionally two specimens very much mutilated, having lost the cirrhi and the arms, differing somewhat from my type specimen, but possibly the differences may be due to age." He then described an individual dredged at Station 43 ("Blake") in 339 fathoms, to which I shall refer directly, and added that a smaller and equally mutilated one had been previously dredged by himself in 450 fathoms near Havana.

These two specimens are quite different from the type of *Antedon cubensis*, and also, though in a less degree, from one another. Not only are the first radials visible, and the second but little shorter than broad, as was mentioned by Pourtalès, but the first radials are separated from the acorn-shaped centro-dorsal by a complete circlet of basals, and there are no pinnules upon any of the first six arm-joints, which are the only ones preserved. An equally mutilated specimen of Pourtalès' second type was dredged by the Challenger (1873) in 350 fathoms, off Barra Grande (Pl. VI. fig. 7); seven more perfect ones, making nine in all, were obtained off Nevis, St. Lucia, and Granada, during the cruise of the "Blake" in 1878–79, between 291 and 422 fathoms; while a single example of a third species (Pl. VI. fig. 5) was dredged by the Challenger in the neighbourhood of Fiji, in the year 1874.

These eleven individuals, representing three different species, are distinguished from all other living Comatulæ by certain very definite morphological peculiarities, which impart an interest to this type second only to that of the archaic *Thaumatocrinus*. Its

[1] *Bull. Mus. Comp. Zoöl.*, 1869, vol. i. No. 11, p. 356.
[2] *Ibid.*, 1878, vol. v. No. 9, p. 214.

two leading characters are—(1) the persistence of the embryonic basals which do not undergo transformation into a rosette, but remain on the exterior of the calyx between the centro-dorsal and the radials; and (2) the absence of pinnules from the lowest joints of the arms (Pl. VI. figs. 5, 7). A third character, of no great morphological value, but important from its apparent constancy, is the acorn-like shape of the centro-dorsal, and the arrangement of the cirrus-sockets upon it in alternating double rows, with the ends of their horseshoe-like rims projecting somewhat outwards.

The extent of development of the basals of *Atelecrinus* varies with the size of the individual, apparently diminishing with age as in the Pentacrinoid larvæ of ordinary Comatulæ (Pl. XIV. figs. 5–7). In the smallest specimen of *Atelecrinus balanoides* they are wide but low pentagons which fall away very rapidly from their interradial apices to the points where they meet one another beneath the radials. The middle of each basal rests on the top of one of the interradial ridges at the upper end of the centro-dorsal, just as the basals of *Pentacrinus* rest on the upper ends of the interradial ridges of the stem. In older individuals, however, just as in the *Antedon*-larva (Pl. XIV. figs. 5–7), the amount of the first radials which is visible on the exterior of the calyx becomes relatively less and less, and the same is the case with the basals. These are best described as triangular, with their lower angles extended so as to meet those of their fellows and separate the radials from the centro-dorsal by what is practically little more than a line, only visible at all under specially favourable conditions of light. Each of the basals, when isolated, has the form of a short triangular prism with a flattened plate-like extension on each side. They are in complete lateral contact, so as to form an unbroken ring on the under surface of the radial pentagon, very much as in *Pentacrinus alternicirrus* or in *Pentacrinus wyville-thomsoni*. *Atelecrinus cubensis* has comparatively large basals which are of nearly uniform height (0·5 mm.) all round the calyx, rising very slightly at the interradial angles; while in *Atelecrinus wyvillii* each basal is slightly arched, with its apex interradial, and it is only in contact with the outer edge of the centro-dorsal at the interbasal sutures (Pl. VI. fig. 5).

All three species agree, however, in the absence of any rosette and in the persistence of the basals upon the exterior of the calyx, a feature which appears in no other recent *Comatula* except *Thaumatocrinus* and the very doubtful *Comaster;* while a further peculiarity lies in the complete closure of the basal ring so as to separate the radials altogether from the centro-dorsal. Several, if not all, fossil Comatulæ have persistent primary basals in the form of prismatic rods, which meet one another in the centre of the under surface of the radial pentagon, and extend outwards towards its interradial angles. But they do not always reach the periphery so as to appear externally between the radials and the centro-dorsal, as they gradually thin out; and there is only one described form in which there is a complete ring of united basals on the exterior of the calyx.

As regards the characters of its calyx, therefore, *Atelecrinus* is certainly to be regarded as a permanent larval form. The absence of the pinnules from the lower parts of the arms points to the same conclusion, as has been explained elsewhere.[1]

I have only been able to examine the disk in the two Challenger specimens, and in one of these it is not very well preserved. But they both agree in the slightly excentric position of the mouth, and in the large size of the peristome, so that the anal tube is pushed backwards behind the centre about as much as the mouth is in front of it (Pl. VI. figs. 4, 6).

Unlike the two Endocyclic Comatulæ with five rays and a rosette (*Antedon* and *Eudiocrinus*), *Atelecrinus* is not a littoral type at all, nor does it extend upwards above 200 fathoms. On the other hand it is not known to occur below 610 fathoms; so that bathymetrically it falls very far short of the archaic *Thaumatocrinus* (1800 fathoms). Apart from this last type, however, the geographical range of *Atelecrinus*, although fairly extensive, is the least so of the five-rayed Comatulæ. In the Caribbean Sea and the East Atlantic it ranges from 24° N. to 9° S.; while it also occurs in the Pacific near Fiji in 19° S. If the fossil calyx mentioned by Schlüter[2] as having persistent basals also belong to this genus, it will date back to the Cretaceous period.

The three existing species of *Atelecrinus* may be distinguished from one another as follows :—

I. Second radials transversely oblong and but little incised. Basals not specially prominent at the angles of the calyx, ... 1. *balanoides*, n. sp.

II. Second radials markedly incised and about as long as wide.
  - A. Basals separated from the centro-dorsal at its interradial angles, . 2. *wyvillii*, n. sp.
  - B. Basals produced outwards at the interradial angles, . . . 3. *cubensis*, Pourtalès, sp.

1. *Atelecrinus balanoides*, n. sp. (Pl. VI. figs. 6, 7).

1879. *Antedon cubensis*, Pourtalès (*pars*), Bull. Mus. Comp. Zoöl., 1879, vol. v. No. 9, p. 214.
1881. *Atelecrinus balanoides*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1881, vol. ix. No. 4, p. 16, pl. i. figs. 1–6.
1882. *Atelecrinus balanoides*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 489.

Centro-dorsal acorn-shaped, reaching 5 mm. high by nearly 35 mm. in diameter. It bears five vertical double rows of cirrus sockets, the upper ends of which are separated by more or less distinct interradial ridges. Four to six sockets in each row, the dorsal pole, though rough, being free from functional sockets. The ends of their horseshoe-shaped rims slant downwards and outwards, but are much more prominent in some individuals than in others.

The cirri have three or four quite short, almost triangular basal joints. The next is two or three times as long as wide, and its successors are much elongated, reaching 2·5 mm., with a slight tendency to overlap one another on the ventral side of the cirrus.

[1] *Bull. Mus. Comp. Zoöl.*, 1882, vol. ix. No. 4, pp. 14, 15.
[2] *Zeitschr. d. deutsch. geol. Gesellsch.*, 1878, p. 66.

There are probably about thirty-five joints, the length much exceeding the breadth till the penultimate, which is followed by a very small terminal claw. The last six joints taper rapidly.

The basal ring is a very thin plate, rising at the interradial angles into triangular elevations, which are produced slightly outwards and rest upon the upper ends of the interradial ridges of the centro-dorsal. First radials broad and tolerably flat, their size varying with the age of the individual. Second radials more arched, oblong, and quite free laterally, their breadth in the adult being one and a half times their length. Axillaries pentagonal, sometimes twice the length of the second radials, into which they have a slight backward projection. Their width is about equal to their length, but their proportions and also those of the second radials vary slightly in different individuals.

First brachials well separated laterally, with their inner sides shorter than the more rounded outer ones.

Second brachials irregularly quadrate, projecting slightly backwards into the first. The following joints have oblique ends and markedly unequal sides. Except in the syzygial joints, the length is at first less than the breadth, but gradually becomes more equal, and exceeds it after the fifteenth joint. Terminal joints relatively longer and more equal-sided. Arm-bases smooth, but the middle and later joints overlap slightly.

The first syzygium on the third brachial. The following syzygies at intervals of from one to six, usually of two or three joints.

First pinnule nearly always on the twelfth brachial, and consisting of about a dozen elongated joints. The following ones increase in size and in the number of joints, decreasing again towards the arm-ends. The lower joints of the middle and later pinnules bear irregular spinous processes on their dorsal edges.

Mouth somewhat excentric, and surrounded by a large peristome. A little way behind this is the anal tube, which is also slightly excentric in position. Disk 6 mm. in diameter. In the Challenger specimen a very few minute calcareous granules are visible on its ventral surface, and also on its sides between the rays. The "Blake" specimens are more naked. The brachial ambulacra lie close down upon and between the muscular bundles, and have a few scattered sacculi at their sides. Colour of skeleton white or brownish-white.

Locality.—Station 122, September 10, 1873; off Barra Grande; lat. 9° 5′ S., long. 34° 50′ W.; 350 fathoms; red mud. One specimen. Also obtained by the U.S. Coast Survey steamer "Blake" at five stations in the Caribbean sea, between 291 and 422 fathoms.

Remarks.—Although this species was not dredged till four years after Pourtalès had published his description of *Antedon cubensis*, I have preferred to regard it as the type of the genus *Atelecrinus* for the following reasons. Pourtalès' description of

Antedon cubensis, which has pinnules on the second and following brachials, does not correspond to the characters of the smaller specimen which he called by this name, as it has a complete basal ring, and there are no pinnules on any of the arm-joints which are preserved; while another reason is that the dredgings of the "Blake" in the years 1877–79 have led to the discovery of eight examples of *Atelecrinus balanoides*, all of them better preserved than the single individual which was referred by Pourtalès to *Antedon cubensis*.

The first specimen of *Atelecrinus balanoides* known to science was dredged by the Challenger in 1873; but its cirri had disappeared, together with the whole of the arms above the fifth brachials (Pl. VI. fig. 7). The Pacific species (*Atelecrinus wyvillii*) was not much better (Pl. VI. fig. 5), and it was not till I received the "Blake" collection in 1880 that I was able fully to realise the singular peculiarities of the type represented by the two Challenger specimens which are figured on Pl. VI.

The distinctive characters of *Atelecrinus balanoides* are (1) the transversely oblong shape of the second radials, which are but slightly incised to receive the bluntly angular proximal edges of the axillaries; and (2) the outline of the lower part of the calyx, which slopes uniformly downwards from the radials on to the centro-dorsal, without the basals being specially prominent at the interradial angles as they are in *Atelecrinus cubensis.*

The difference is very much of the same kind as that between the basals of *Pentacrinus wyville-thomsoni* and *Pentacrinus mülleri* respectively.

The nine individuals of *Atelecrinus balanoides* which I have examined, all agree very well in their general characters, but differ considerably in the relative proportions of the two outer radials and of the lowest brachials respectively. In all of them which have enough of the arms preserved, the first pinnule is on the twelfth brachial, except in one arm of one individual, in which the tenth joint bears the first pinnule.

2. *Atelecrinus wyvillii*, n. sp. (Pl. VI. figs. 4, 5).

1882. *Atelecrinus wyvillii*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 492.

Description of an Individual.—Centro-dorsal acorn-shaped, 4 mm. high by 3 mm. wide. The double rows of cirrus-sockets are well separated from one another by intervening spaces, and do not reach the dorsal pole. Four, or rarely five, sockets in each row, the ends of which stand out prominently and give a serrate appearance to the lateral edge of the plate. The upper portion is uniformly smooth, without any interradial ridges; but the edge is marked by five slight incisions situated interradially.

The basals are nearly uniform in height throughout their whole width, but are somewhat arched in form. The apex of each arch is interradial, and the interval between it and the notched edge of the centro-dorsal below is only occupied by perisome. Hence the basal ring is really only in contact with the centro-dorsal at its five lowest points, *i.e.*, at the interbasal sutures, immediately beneath the middle points of the first radials. The latter have exceedingly high muscle-plates projecting inwards; but their dorsal surface is barely half as long as that of the second radials. These are nearly square, but deeply incised to receive the strong backward projections of the axillaries, which are roughly rhombic and slightly wider than long.

First brachials well separated laterally, with the inner sides much shorter than the outer ones, and the distal edge much incised to receive the strong backward projections of the quadrate second brachials. The following joints have markedly unequal sides, with a syzygy in the third or fourth, and again in the fifth, sixth, or seventh brachial.

Disk almost naked, 4 mm. in diameter. Mouth somewhat excentric and surrounded by a large peristome, immediately behind which is the anal tube. Brachial ambulacra close down upon and between the muscular bundles. Skeleton light brownish-white.

Locality.—Station 174c, August 3, 1874; lat. 19° 7′ 50″ S., long. 178° 19′ 35″ E.; 610 fathoms; coral mud; bottom temperature, 39° F. One mutilated specimen.

Remarks.—This type differs from the other two species of the genus in the greater squareness of the second radials, and in the curious relation of the basals to the centro-dorsal. They are of uniform height, as in *Atelecrinus cubensis*, but are not in contact with the centro-dorsal at the interradial angles of the calyx, being separated from it on the exterior by a gap which is filled up by perisome (Pl. VI. fig. 5). Apart from its purely morphological importance, this Pacific species is also interesting as showing the wide distribution of the genus; and it is the only one of the three which is known as yet to extend below the limit of the continental line (500 fathoms), though each of the others has been dredged below 400 fathoms.

Genus 3. *Eudiocrinus*, P. H. Carpenter, 1882.

1868. *Ophiocrinus*, C. Semper, Archiv f. Naturgesch., 1868, Jahrg. xxxiv. Bd. i. p. 68.
1869. *Comatula* (*Ophiocrinus*), P. de Loriol, Denkschr. d. allg. Schweiz. Gesellsch. f. d. ges. Naturw., 1869, Bd. xxiii. p. 57.
1879. *Ophiocrinus*, P. H. Carpenter, Proc. Roy. Soc., No. 194, 1879, p. 385.
1879. *Ophiocrinus*, P. de Loriol, Monographie des Crinoïdes fossiles de la Suisse, Geneva, 1877–79, p. 277.
1882. *Eudiocrinus*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 493.
1883. *Eudiocrinus*, E. Perrier, Comptes rendus, 1883, t. xcvi. No. 11, p. 725.
1886. *Eudiocrinus*, E. Perrier, Les Explorations sous-marines, Paris, 1886, p. 275.

Definition.—Centro-dorsal and calyx like those of *Antedon*; but the radials bear the brachials directly without the intervention of axillaries, so that there are only five undivided arms. Mouth central. Sacculi abundant, scanty, or absent altogether.

Remarks.—The genus *Ophiocrinus* was established by Semper in 1868 for an elegant little *Comatula* with five undivided rays, which he had discovered in the Philippine Islands; and in the following year a fossil species was described by de Loriol from the

Neocomian of Switzerland. The generic value of the type was doubted by Schlüter;[1] and I had formerly myself some hesitation in regarding it as equivalent to *Antedon*, *Actinometra*, and *Promachocrinus*.[2] For there is no definite character, except the simplicity of the rays, which can separate *Eudiocrinus* from the ordinary ten-armed *Antedon;* and in one of the three species of the ten-rayed *Promachocrinus* the rays divide so as to form twenty arms (Pl. LXX.), while in the two others there are ten undivided rays (Pl. LXIX. figs. 5, 9, 10). But this character alone would hardly justify the separation of the simpler type of *Promachocrinus* from the twenty-armed form; while I have an abnormal specimen of an *Antedon* with only nine arms, owing to one of the rays not dividing, which is the case with all the rays of *Eudiocrinus*.

Nevertheless, it sometimes happens that a character, which is only of specific value in one type, may be of generic value in another. Five recent species of *Eudiocrinus* are known, four of which range from Japan into the South Pacific Ocean (lat. 37° S.), while one occurs in the East Atlantic, and another has been found fossil in the Neocomian of Switzerland. The simplicity of the rays thus appears to be a character of some morphological importance, and I am, therefore, disposed to admit the generic position which was originally assigned to the type by Semper. Unfortunately, however, it cannot continue to bear the name by which he described it. For Salter, fifteen years before Semper's description of *Ophiocrinus*, had designated by the same generic name an obscure Crinoid from the Devonian of South Africa; and the confusion thus existing was increased by the posthumous publication in the year 1878 of the late Professor Angelin's monograph of the Swedish Silurian Crinoids, in which the name *Ophiocrinus* is connected with a third and totally distinct type.

Professor Semper's genus being thus preoccupied, I proposed in 1882 to call the type *Eudiocrinus* (ἔνδιος, calm), in allusion to the fact that the four recent species of it, which were then known, were limited to the Pacific Ocean. Curiously enough, however, a few months before I suggested this name, several specimens of a new species of *Eudiocrinus* were dredged by the French exploring vessel "Travailleur" in the Gulf of Gascony, and, therefore, in European Seas. The type was naturally designated as *Eudiocrinus atlanticus* by Professor Perrier,[3] who gave a brief description of the characters which distinguish it from the Pacific species.

Eudiocrinus, like *Antedon*, has a central mouth (Pl. VI. fig. 2), and a more or less hemispherical or conical centro-dorsal, an isolated specimen of which could not be distinguished from the corresponding part of an *Antedon* (Pl. III. fig. 7*a*; Pl. VI. fig. 1; Pl. VII. figs. 1, 3, 4). The radials, however, in the only recent species which I have been able to examine, differ slightly from those of the ordinary *Antedon*-type which is illustrated on Pls. I.–IV. The articular faces are low relatively to their width (Pl. III.

[1] *Zeitschr. d. deutsch. geol. Gesellsch.*, 1878, p. 40.
[2] *Quart. Journ. Geol. Soc.*, 1879, vol. xxxvi. p. 41.
[3] *Comptes rendus*, 1883, t. xcvi. No. 11, p. 725.

fig. 7*a*), a character which presents itself in *Antedon carinata* (Pl. III. fig. 1*a*) and in *Antedon macronema* (Pl. IV. fig. 3*a*), and is more especially distinctive of the genus *Actinometra*, in which the muscle-plates, well marked in *Eudiocrinus*, are very much reduced in size (Pl. V. figs. 1–5, *b*).

The special peculiarity of the calyx in *Eudiocrinus semperi*, however, is the way in which the muscle-plates stand up above the sides of the radials, owing to their edges being strongly folded in towards the central articular ridge which separates them (Pl. III. figs. 7*a*, 7*c*). In many species of *Antedon* the articular facets of adjacent radials are in close contact along the whole length of their sides, as for example in *Antedon eschrichti* (Pl. I. fig. 8*a*), *Antedon basicurva* (Pl. II. fig. 2*a*), and *Antedon breviradia* (Pl. III. fig. 4*b*). But in other cases the ventral edges of the muscle-plates are more or less folded outwards from the centre of the calyx, so that its interradial angles are marked by five notches, which lie at the upper ends of the sutures between the radials as in *Antedon antarctica* (Pl. I. figs. 6*a*, 6*b*), *Antedon incisa* and *Antedon angusticalyx* (Pl. II. figs. 1*a*, 1*d*, 4*a*, 4*d*), the young *Antedon breviradia* and *Antedon quinquecostata* (Pl. III. figs. 5*a*, 5*c*, 6*c*, 6*d*). But in *Eudiocrinus semperi* this notch is continued down to the dorsal surface of the radials as a wide groove between the everted muscle-plates of every two adjacent radials (Pl. III. figs. 7*a*, 7*c*); so that in a dorsal view of the calyx (Pl. III. fig. 7*b*) its interradial angles are not sharp but deeply incised. An indication of the same character appears in *Antedon quinquecostata* (Pl. III. fig. 6*b*); but on the other hand the young calyx of *Antedon breviradia*, which has the ventral edges of its muscle-plates strongly folded outwards (Pl. III. figs. 5*a*, 5*c*), presents a very sharply pentagonal outline in dorsal view (Pl. III. fig. 5*b*). The same is the case in *Antedon carinata*, which has rather markedly everted muscle-plates (Pl. III. figs. 1*a*, 1*c*, 1*d*); while on the other hand *Antedon incisa*, in which this latter character is less evident, has slight notches at the interradial angles of the dorsal surface of the radials (Pl. II. figs. 1*a*, 1*c*, 1*d*). The *Eudiocrinus*-calyx, therefore, presents no characters which do not occur in some one or other of the many species of *Antedon;* but they are all considerably exaggerated, and are combined together in a somewhat unusual manner.

The interradial sutures on the dorsal surface of the radials are marked by slight grooves, and there are corresponding grooves on the upper face of the centro-dorsal. But they do not appear to have been occupied by any tertiary basals in the form of a star (Pl. III. fig. 7*b*). The rosette is tolerably distinct, with a large central opening and well marked radial spouts. But the interradial processes are scarcely visible, so that there appear to be only five openings, one at the inner end of each interradial suture (Pl. III. fig. 7*b*).

The calyx of the fossil species of *Eudiocrinus* (*Eudiocrinus hyselyi*) like that of nearly all the secondary species of *Antedon* and *Actinometra*, is of a very generalised type; and, but for the discovery of specimens with the arms attached, it would have been impossible, as de Loriol[1] remarks, to differentiate the species from the numerous forms of *Antedon* which occur associated with it.

Neither arms, pinnules, nor cirri of *Eudiocrinus* present any characters which can be said to distinguish them from the ordinary *Antedon*-type; and the disc with its central mouth might be readily taken for that of an *Antedon*, except for the fact that the primary ambulacra do not divide, but proceed straight on to the five arms (Pl. VI. fig. 2). The sacculi which are usually so abundant at the sides of the ambulacra in *Antedon*, are, however, far less constant in *Eudiocrinus*. Abundant in *Eudiocrinus indivisus*, and *Eudiocrinus atlanticus*, they are scanty in *Eudiocrinus varians*, and altogether absent in the two remaining species, so far as my knowledge of them extends.

The cirri of *Eudiocrinus atlanticus* are described by Perrier[2] in the following terms:—"Il n'existe également entre les longues pièces des cirrhes dorsaux que de très faibles coussinets charnus, et les cirrhes, dans le plupart des échantillons, se montrent étendus en ligne droite et rassemblés dans une attitude qui rappelle celle que certaines araignées donnent fréquemment a leurs pattes."

"L'*E. atlanticus* est, au point de vue de la locomotion, une intéressante modification du type Comatule; il ne peut en effet, se fixer solidement aux corps étrangers, comme le font les autres animaux du même groupe, et il est probable qu'il repose le plus souvent les bras et les cirrhes étendus sur le limon de l'Océan, n'ayant à craindre, dans les profondeurs où il vit, ni les vagues ni les courants; mais les masses musculaires de ses bras indiquent qu'il doit être aussi un habile nageur. La plupart des *Antedon*, et surtout les *Actinometra*, sont au contraire organisés pour s'accrocher solidement aux corps sous-marins et nagent peu."

It appears to me that Perrier has (as usual) drawn a somewhat hasty conclusion from the majority of his fifteen specimens of *Eudiocrinus atlanticus*, with their cirri fully extended. A large collection of Comatulæ at any particular locality is sure to contain a number of individuals with the cirri stretched out in a straight line. *Antedon phalangium*, for example, has cirri very like those of *Eudiocrinus*, composed of elongated joints with small interarticular bundles (Pl. XXVIII. figs. 1–3). Great numbers of this species, with which Perrier is well acquainted, were dredged by the "Porcupine" off the coast of Tunis. The cirri of some are spread out horizontally; while in others they are turned directly downwards, so as to form a sort of basket below the centro-dorsal, and in yet others the cirri are mostly bent upwards, so as to lie alongside the arms, as in the examples of *Antedon gracilis*, and *Antedon valida*, figured on Pl. XV. Indeed all the three positions may occur in the same individual. The same variations appear in the long-jointed cirri of *Antedon macronema* from Sydney Harbour (Pl. XXXVIII. fig. 5). I have seen individuals of this type in which some cirri are horizontally extended, while others make two or three coils round the stem of a sea-weed or other support. The same

[1] Monog. Crin. foss. Suisse, p. 279.

[2] *Comptes rendus*, 1883, t. xcvi. No. 11, p. 726.

difference of position occurs in the short cirri of *Antedon carinata*, numbers of which were found by the Challenger at Bahia; while many instances of the same kind occur among the Comatulæ dredged by the Challenger in the Eastern Archipelago and by the "Blake" in the Caribbean Sea. (See also Pl. XXXIII. fig. 6, and Pl. LXX.)

I do not think therefore that Perrier is entitled to consider *Eudiocrinus atlanticus* as a specially interesting modification of the *Comatula*-type with regard to its locomotive powers, for it presents no peculiarities which do not occur in several species of *Antedon*. It is true that like other species of the genus (Pl. VI. fig. 1; Pl. VII.) it has large and powerful muscular bundles between the successive arm-joints; and from this perhaps we may draw the conclusion that it was "un habile nageur." But the last sentence of the passage quoted above, wherein *Eudiocrinus atlanticus* is contrasted with *Antedon* and *Actinometra* as regards its swimming powers and mode of life, entirely ignores all that has been written upon the subject of late years.

It is true that the muscular bundles of *Eudiocrinus*, as also those of *Atelecrinus* (Pl. VI. figs. 4, 7) and of many deep-sea Comatulæ, appear large by contrast with those of other types in which they do not appear prominently on the ventral surface of the arms, owing to their being covered by a thick and more or less opaque perisome. But when this is removed the large muscular bundles become visible, as seen in Dr. Carpenter's figure of *Antedon rosacea*.[1] The same is the case in *Antedon eschrichti*, the muscular bundles of which, when properly exposed, have at least as great a relative size as those of any *Eudiocrinus*; and if the size of the muscle-plates on the arm-joints be any criterion of the strength of the muscular bundles attached to them, there is little to choose in this respect between *Antedon eschrichti*, *Actinometra paucicirra*, and *Actinometra nobilis*.

The position assumed by the cirri, and the appearance of the muscular bundles on the ventral surface of the arms of *Eudiocrinus atlanticus*, are not therefore characters of such importance as Perrier seems to think, when he contrasts this type with "la plupart des *Antedon*." I do not see that this species, with its cirri between 15 and 20 mm. in length, is any less well adapted for fixing itself to submarine bodies, than *Antedon phalangium* and many other species of the same genus which have cirri like those of *Eudiocrinus atlanticus* (Pl. XXVIII.; Pl. XXX. figs. 4. 8; Pl. XXXIII. fig. 6). Neither do I know what authority Perrier has for his statement that most species of this genus swim but little, while implying that *Eudiocrinus atlanticus* swims a good deal. It certainly cannot be anything more than a somewhat hasty generalisation, which he could not possibly have made had he stopped to consider why the muscular bundles of *Eudiocrinus* appear so large in contrast to those of "la plupart des *Antedon*." But when he goes on to speak of the species of *Actinometra* as being those which are specially adapted to fix themselves and to swim but little, he falls into very considerable error. For, as will be shown immediately in reference to another part of his description of *Eudiocrinus*, he has not

[1] *Phil. Trans.*, 1866, pl. xxxiv. fig. 2.

taken the trouble to make himself sufficiently acquainted with the works of his predecessors, and has therefore committed himself to various statements which will not bear investigation.

I do not know what grounds of fact he has for his assertion that the species of *Actinometra* swim but little. If, as I believe, it is merely an inference from the supposed small size of the muscular bundles between the arm-joints, his premises are wrong, as I have explained above; while I do not know that he has ever been able to observe living species of the genus, and to notice their abstention from the performance of swimming movements. On the other hand, Professor Semper has kept various forms of *Actinometra* in an aquarium for weeks together, and his observation of the regular alternating movements of their arms while swimming was mentioned by myself as long ago as 1877.[1] I pointed out in the same memoir, and again five years later[2] that the cirri of *Actinometra* are few in number, and almost entirely limited to the margin of the discoidal centro-dorsal; while those of *Antedon* are numerous and more or less extensively distributed over the under surface of the centro-dorsal. But yet Perrier tells us that "surtout les *Actinometra*" as compared with *Antedon* are adapted to fixing themselves by their cirri. The extreme inconsistency of this assertion with the real facts of the case becomes still more apparent, when it is remembered that in many species of *Actinometra* the cirri borne on the centro-dorsal during early life drop off, and their sockets become gradually obliterated (Pl. LIV. figs. 1–9; Pl. LXV. figs. 1–6). It was mentioned in my preliminary Report[3] that I had found the centro-dorsal of many *Actinometra*-species to be in the form of a simple flat plate, more or less stellate in form, but entirely devoid of cirrus-sockets; while in other individuals only a few imperfect sockets are present, owing to their not having been completely obliterated. The occurrence of a fossil *Actinometra* presenting these characters was also noticed;[4] and other references were made to this peculiarity as it was found in a successively increasing number of species of the genus.[5] Copies of the papers in which this character was described were sent to Professor Perrier, who seems nevertheless to be altogether unacquainted with its occurrence. For it is difficult to see how *Actinometra paucicirra* or *Actinometra divaricata* (Pl. LIV. fig. 1; Pl. LXIII. fig. 8), with its perfectly flat centro-dorsal entirely devoid of cirri, can be regarded as one of those Comatulæ which are especially "organisés pour s'accrocher solidement aux corps sous-marins."

After making these somewhat ill-considered remarks, Perrier goes on to describe the disc of *Eudiocrinus atlanticus*, which is not more than 5 mm. in diameter and is thus very small in proportion to the size of the arms, which attain 120 mm., while the cirri are from 15 to 20 mm. long.[6] Perrier then adds "Il résulte de ce que nous venons de

[1] *Journ. Linn. Soc. Lond.* (Zool.), 1877, vol. xiii. p. 446.
[2] *Bull. Mus. Comp. Zoöl.*, 1882, vol. ix. No. 4, p. 13.
[3] *Proc. Roy. Soc.*, 1879, pp. 389–391.
[4] *Quart. Journ. Zool. Soc.*, 1880, vol. xxxvi. p. 51.
[5] The Comatulæ of the Leyden Museum. Notes from the Leyden Museum, 1881, vol. iii. pp. 196, 208.
[6] *Comptes rendus*, 1883, t. xcvi. No. 11, p. 727.

dire que, malgré la simplicite de leurs bras, les *Eudiocrinus*, loin d'être un type primitif de Comatules, représentent au contraire un type notablement modifié."

I do not quite know what Perrier would regard as a primitive type of *Comatula*, and I have not been able to arrive at any fixed ideas upon that subject myself. But if his inference that *Eudiocrinus* is a much modified type has no better foundation than is given in his description of *Eudiocrinus atlanticus*, as would appear from his own remarks just quoted, I do not think that much can be said for it. This species approaches more nearly to *Antedon* than any of the other four comprising the genus; for it has a bifascial articulation between the first two joints above the radials like *Eudiocrinus semperi* and *Eudiocrinus japonicus;* but it also possesses what these have not, viz., abundant sacculi; and these organs are abundant in *Eudiocrinus indivisus* as in *Antedon*. This latter form is, however, much further removed from the ordinary *Antedon*-type than *Eudiocrinus atlanticus*, owing to the syzygial union of the two joints above the radials, which only occurs in a very few species of *Antedon*. Perrier's inference as to the notably modified character of *Eudiocrinus* appears, however, to be entirely founded upon his knowledge of the single Atlantic species; while he makes some considerable errors in his comparison of it with the other Comatula genera, *Antedon* and *Actinometra*.

Eudiocrinus has a somewhat wider geographical range than *Atelecrinus*, extending over more than 70° of latitude in the West Pacific, and occurring at about 45° N. in the Atlantic. The type of the genus was found near Bohol in the Philippine Islands by Professor Semper some twenty years ago. A second species (*Eudiocrinus semperi*), was dredged by the Challenger shortly after leaving Sydney, and again off New Zealand. A third (*Eudiocrinus varians*), was met with off the north-east part of the Philippine Group, at the lowest bathymetrical limit of the genus; while a fourth came up from 565 fathoms, to the south of the Bay of Yedo, and has also been collected at lesser depths in Japanese waters. To these must now be added the Atlantic species dredged by the "Travailleur" in 896 metres[1] (486 fathoms). The bathymetrical range of the type is thus very considerable, and it has been dredged four times below 500 fathoms, on two of which occasions the depth exceeded 900 fathoms. The only fossil species known occurs in the Valangien and Lower Urgonien of Switzerland.

The species of *Eudiocrinus* fall into two unequal groups. The first one comprises Semper's type (*Eudiocrinus indivisus*), in which the first two joints beyond the radials are united by syzygy; while in the four remaining species there is a bifascial articulation between these two joints. In describing the other three Pacific species, I spoke of the fourth brachials as being traversed by a syzygy and bearing a pinnule in *Eudiocrinus*

[1] This depth (896 metres) is that mentioned by Perrier in his first description of *Eudiocrinus atlanticus* (*Comptes rendus*, 1883, t. xcvi. p. 725). Recently, however, he has said :—" Les *Eudiocrinus* vivent à environ 1200 mètres de profondeur, dans les regions vaseuses " (Les Explorations Sous-marines, p. 275), and on the same page is figured a specimen of *Eudiocrinus atlanticus* from 1000 metres. It may be well to remember that *Eudiocrinus indivisus* and *Eudiocrinus japonicus* have both been dredged in less than 50 fathoms.

semperi and *Eudiocrinus japonicus*, while in *Eudiocrinus varians* the first pinnule is on the second brachial.[1] But in his description of *Eudiocrinus atlanticus*, Perrier[2] says "La première syzygie se trouve entre la quatrième et la cinquième pièce des bras; c'est la cinquième qui porte la première pinnule; la place de la première syzygie distingue l'*Eudiocrinus atlanticus* de l'*E. indivisus*, Semper; celle de la première pinnule la distingue des trois autres espèces."

In reality, however, the position of the first syzygy and that of the first pinnule in *Eudiocrinus atlanticus* are exactly the same as in *Eudiocrinus semperi* and *Eudiocrinus japonicus*. In describing the fourth brachial of these two species as a syzygy I was using precisely the same terminology as was employed by Müller[3] in his diagnoses of *Antedon rosacea*, *Antedon phalangium*, and *Antedon eschrichti*, when he wrote "Das erste Syzygium befindet sich am dritten Armglied." Perrier however employs a different terminology, which, as I have explained in Part I. and elsewhere,[4] has several disadvantages from a morphological point of view. He describes the fourth and fifth brachials as united by syzygy. It is perfectly true that these are primitively the fourth and fifth joints of the arm, exactly in the same way as the composite third brachial of *Antedon rosacea* consists of the united third (hypozygal) and fourth (epizygal) joints of the growing arm, as described by Dr. Carpenter.[5] But since the hypozygals of all the brachial syzygies of *Eudiocrinus atlanticus*, *Eudiocrinus semperi*, or of *Antedon rosacea* entirely lose their individuality as arm-joints, bearing no pinnules and taking no part in the movements of the arm, I believe that it is more correct for descriptive purposes to follow Müller and to consider the compound or syzygial joint as one arm-segment only. In accordance with the Müllerian terminology, therefore, I described the fourth brachial of *Eudiocrinus semperi* as being or having a syzygy, after going into the subject rather fully in two memoirs which were published in 1882.[6] Perrier, however, in apparent ignorance of all that had been written on the subject by Müller, Dr. Carpenter, and myself, not only introduces, though seemingly without knowing it, a new descriptive terminology, but also imagines that I had used it before him. He has made a very similar error in his description of *Democrinus* (*Rhizocrinus*), and it is much to be desired that for the sake of future workers he would take the trouble to acquaint himself with the current nomenclature before writing his descriptions; or at any rate that if he decides to introduce a new descriptive method, he would make some statement to that effect. The present result is that he describes a difference between *Eudiocrinus atlanticus* and *Eudiocrinus semperi* or *Eudiocrinus japonicus*, which does not exist in reality. In all three species alike there is a syzygy in the fourth brachial, as Müller would have described it, with a pinnule on the epizygal.

[1] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 495.
[2] *Comptes rendus*, 1883, t. xcvi. No. 11, p. 725.
[3] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1849, p. 252.
[4] *Proc. Zool. Soc. Lond.*, 1882, pp. 734, 735.
[5] *Phil. Trans.*, 1866, p. 721.
[6] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 515; and *Proc. Zool. Soc. Lond.*, 1882, pp. 734, 735.

Although the principal diagnostic character on which Perrier established *Eudiocrinus atlanticus* thus turns out to be due to an erroneous method of nomenclature, he mentions a subsidiary one which merits more attention. For he finds that "L'*E. atlanticus* se distingue également de ces dernières espèces par le nombre et la grandeur des organes, si répandus chez les Crinoïdes, nommés *corps sphériques* ou *saccules*. Les saccules manquent aux *E. japonicus*, et *E. Semperi*; ils sont petits et rares chez l'*E. varians*."[1] In this respect, therefore, the Atlantic species is sharply distinguished from both *Eudiocrinus semperi* and *Eudiocrinus japonicus*, which resemble it most closely in the structure of the skeleton; while they have over twenty-five cirrus-joints, of which there are only fifteen in *Eudiocrinus atlanticus*.

The mutual relations of the five species of *Eudiocrinus* may, therefore, be expressed as follows:—

I. First two brachials united by syzygy. First pinnule on the second brachial, . 1. *indivisus*, Semper, sp.
II. First two brachials united by a bifascial articulation.
 A. First pinnule on the second brachial, ... 2. *varians*, n. sp.
 B. First pinnule on the fourth brachial.
  1. Sacculi absent. Twenty-five or more cirrus-joints.
   α. Disk plated. First brachials nearly oblong, . . . 3. *semperi*, n. sp.
   β. Disk naked. First brachials trapezoidal, . . . 4. *japonicus*, n. sp.
  2. Sacculi abundant. Fifteen cirrus-joints, ... 5. *atlanticus*, Perrier.

Eudiocrinus varians, n. sp. (Pl. VII. figs. 3–7).

1882. *Eudiocrinus varians*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 496.

Centro-dorsal low, nearly hemispherical, bearing about twenty cirri in two rows which leave the dorsal pole free. Two forms of cirrus occur in the same individual.—(1) With two or three short basal joints, the last of which is nearly square, while the following joint is considerably longer, and the succeeding ones still more so, reaching 3 mm. in length. Terminal joints unknown. (2) Eight at least of the lower joints are quite short, few of them being longer than wide, and that but slightly so. Remainder unknown.

Radials partially visible. First brachials nearly oblong, inclined to be trapezoidal, with small lateral processes which are the edges of the muscle-plates for articulation with the radials. Second brachial also nearly oblong, with traces of a backward process into the preceding joint, a pinnule on the right and a small process on the left side. The following joints have somewhat unequal sides, with a pinnule on the shorter and a large wing-shaped process on the longer side, which ceases on the sixth, or may go on to the eighth joint. Succeeding brachials quadrate and unequal-sided, with the pinnule on the longer side. The twelfth and following joints are distinctly longer than wide. Syzygia in the fourth and eighth or ninth brachials; then an interval of two to five joints between successive syzygia.

[1] *Comptes rendus*, 1883, t. xcvi. No. 11, p. 726.

The first few pinnules have wide basal joints, the fourth and fifth of which are sometimes expanded towards the dorsal side. This is most marked in the larger specimen. The later pinnule-joints are elongated, but very much more slender in the small specimen than in the larger one. The lower pinnules appear to be the longer, containing more numerous, though shorter joints. That on the fourth brachial in the larger specimen is almost 12 mm. long, and consists of twenty-five joints.

Disk 5 mm. wide. It bears numerous calcareous nodules, but the brachial ambulacra only have delicate rods and networks of limestone at their sides. Sacculi are present, though small, inconspicuous, and few in number Skeleton white.

The smaller specimen is 3·2 mm., and the larger 4·5 mm. across the centro-dorsal.

Locality.—Station 205, November 13, 1874; lat. 16° 42′ N., long. 119° 22′ E.; 1050 fathoms; grey ooze; bottom temperature, 37° F. Two mutilated specimens.

Remarks.—This is a very singular species. The two mutilated individuals described above resemble one another very closely in the characters of the calyx and arms, while the cirri and pinnules vary considerably. In the smaller one I can find no certain trace of any but the long-jointed cirri like those of *Eudiocrinus semperi* and *Eudiocrinus japonicus* (Pl. VI. fig. 1; Pl. VII. figs. 2, 7).

But in the larger form, which retains the bases of two, if not more of these, the majority of the remaining cirrus-stumps consist of numerous short joints but little longer than wide (Pl. VII. figs. 3, 5).

In the smaller form again, most of the pinnules are quite slender and delicate, with somewhat glassy joints, which are twice, or more than twice, as long as wide (Pl. VII. fig. 4). But in the larger one they are usually considerably stouter and more massive, though one or two of the lowest pinnules are much more slender than their fellows, and somewhat resemble those of the smaller individual (Pl. VII. fig. 3). This species is at once distinguished from *Eudiocrinus semperi* and *Eudiocrinus japonicus*, which resemble it in having an articulation between the first two brachials, by the presence of a pinnule on the second one.

Eudiocrinus semperi, n. sp. (Pl. III. fig. 7; Pl. VI. figs. 1–3).

1882. *Eudiocrinus semperi*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 497.

Centro-dorsal small, nearly hemispherical, or somewhat flattened, thickly covered with cirrus-sockets, except at the dorsal pole. These have strongly marked articular rims around the opening of the central canal, and are from twenty to thirty in number. Cirri probably 30 mm. long, and tapering, of twenty-six joints; the first three or four quite short, the next more than twice as long as wide, and the four following ones the longest, sometimes exceeding 2 mm. The remainder diminish slowly in size, but exhibit no traces of any dorsal spines.

Radials partially visible. First brachials nearly oblong, widening slightly and then narrowing a little. Second brachials quadrate, and appearing in a side view of the specimen to project strongly backward into the first brachials, as the surfaces of both joints rise towards the middle of their line of junction. The following joints have unequal sides, the fourth having a syzygy and bearing a pinnule on the shorter side, usually the right. The seventh joint is more oblong, while the eighth and following brachials become more distinctly unequal-sided, the breadth being about equal to the length of the longer side which bears the pinnule. Further out on the arms the length gradually increases in proportion to the breadth, and the joints become more and more cylindrical. Second syzygy from the seventh to ninth brachial; and the later syzygial intervals vary from one to four joints.

The lower pinnules are all about equal in length, and consist of some twenty joints. Except in the first four or five pinnules all but the lowest joints are twice as long as broad, or slightly longer, and more transparent and glassy than the cirrus-joints. Ovaries short, not extending over more than three or four joints. Towards the arm ends the pinnules gradually decrease both in length and in the number of joints.

Mouth central. Disk and arm-bases rather closely plated, but the brachial ambulacra merely have irregular rods and networks of limestone at their sides. They lie close down between the muscles and show no traces of sacculi. Skeleton white.

Disk 5 mm. in diameter. Radial pentagon 4 mm. Spread probably about 150 mm.

Localities.—Station 164, June, 12, 1874; lat. 34° 8′ S., long. 152° 0′ E.; 950 fathoms; green mud; bottom temperature, 36°·5 F. One specimen.

Station 169, July 10, 1874; lat. 37° 34′ S., long. 179° 22′ E.; 700 fathoms; blue mud; bottom temperature, 40°·0 F. Two specimens.

Remarks.—I have named this species after Professor C. Semper of Würzburg, to whom we owe the discovery during his residence in the Philippine Islands of the type species of *Eudiocrinus* (*Eudiocrinus indivisus*). The absence of pinnules on the second and third brachials distinguishes *Eudiocrinus semperi* both from the type and also from *Eudiocrinus varians*. Furthermore, both these species have sacculi, which are abundant in *Eudiocrinus indivisus*, but rare in *Eudiocrinus varians;* while I have not been able to find them even on the pinnules, either of *Eudiocrinus semperi*, or of the closely allied *Eudiocrinus japonicus*, though they are abundant in the Atlantic species.

Eudiocrinus semperi, like other Comatulæ, exhibits a certain amount of local variation. All three specimens were obtained in a very mutilated condition, hardly anything remaining of one of them but the calyx and the bases of the arms. But sufficient remains of the other two to indicate a considerable amount of flexibility in some of their characters. That from the lesser depth (Station 169) is the larger of the two, and its disk bears larger and more numerous plates; while there are fewer cirri on the centro-dorsal, and the pinnule-joints are somewhat shorter and less glassy than those of the individual from Station 164. In the former also both the antero-lateral rays have the first pinnule on the left side; while the latter presents a curious variation. The first pinnule is on the right side in the two posterior rays, and on the left in the left anterior one, the right anterior one being broken at the syzygy in the fourth brachial. The anterior ray has been repaired at this syzygy, but no pinnule has been developed on the epizygal. The fifth brachial, however, bears a pinnule as usual on the left side, but that on the sixth is on the same side; so that the first pinnule on the right of the ray does not come till the seventh brachial.

Eudiocrinus japonicus, n. sp. (Pl. VII. figs. 1, 2).

1882. *Eudiocrinus japonicus*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 499.

Centro-dorsal relatively large, conical, and covered except at the dorsal pole by from forty to fifty cirrus-sockets, each with a well-marked articular rim around the opening of the central canal. Cirri more than 35 mm. long, tapering, and consisting of twenty-seven joints. The first three are quite short, the fourth a good deal longer than wide, and the next four the longest, but scarcely reaching 2 mm.; the following ones diminish slowly in size, but have no traces of any dorsal spine.

Radials just visible. First brachials trapezoidal, the sides commencing to slope inwards almost immediately beyond the proximal edge. The second brachials, as seen from below, are also trapezoidal, being narrower along their proximal edges, where they project backwards into the preceding joints, both surfaces rising towards the line of junction. The next four or five joints have unequal sides, the fourth being a syzygy, and bearing a pinnule on its shorter side. In the only specimen with all the arm-bases preserved, one of them has the first pinnule on the left side. The fifth and one or two following joints also have the pinnule on the shorter side. The next is more oblong, and its successor again a syzygy, with the pinnule on its longer side. The succeeding joints have still more markedly unequal sides, the breadth being about equal to the length of the longer side. After the second syzygy there is an interval of four or five joints between successive syzygia.

The lowest pinnules are apparently tolerably equal, consisting of some twenty stout joints, of which only a few middle ones are longer than wide. Beyond the eighth brachial, the pinnule-joints become relatively longer and thinner and the pinnules more slender. Ovaries short, not extending over more than three or four joints.

Mouth central or subcentral. Disk naked, 7 mm. in diameter; the brachial ambulacra close down between the muscles, with a few supporting rods and networks of limestone, but no traces of sacculi. Skeleton white.

Locality.—Station 235, June 4, 1875; lat. 34° 7′ N., long. 138° 0′ E.; 565 fathoms; green mud; bottom temperature, 38°·1 F. Three much mutilated specimens.

Remarks.—It is with some hesitation that I have separated this species from the preceding one. It is altogether larger and more massive than *Eudiocrinus semperi*, with a larger and more distinctly conical centro-dorsal and more numerous cirri. The first brachials have larger muscle-plates for articulation with the radials, and are more trapezoidal in outline; and as the second brachials are relatively longer than those of *Eudiocrinus semperi*, and at the same time more trapezoidal in form, the base of each arm is considerably constricted at the junction of its first two joints (Pl. VII. fig. 1).

The general proportions of the remaining arm-joints and of the pinnules appear to be much the same in the two types, excepting that in the smaller *Eudiocrinus semperi* the joints of the lower pinnules are rather longer relatively to their width than in *Eudiocrinus japonicus*. Of the twelve arms which are preserved in three individuals of the latter species, only one has the first pinnule on the left side; while in *Eudiocrinus semperi* this appears to be normally the case in the two antero-lateral rays.

There are some specimens of *Eudiocrinus* in the University Museum at Berlin, which were kindly shown to me by Dr. Hilgendorf, who had collected them in Japan. I think that they are probably identical with the type just described. They have rather fewer cirrus-joints, and the junctions of the first eight brachials are distinctly tubercular. The tubercle between the first two is in the middle line, and those between the following joints lie alternately on either side of the arm. The three Challenger examples, however, show no traces of these tubercles, with the exception of the median one, which is far less marked than in the Berlin specimens.

Genus 4. *Antedon*, de Fréminville, 1811.

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1828. *Pentacrinus*, Fleming, *Ibid.*, p. 493.
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Definition.—Centro-dorsal usually somewhat hemispherical or conical, rarely discoidal, and generally bearing at least twenty cirri, often several more, which leave but little of its under surface free. Outer faces of the radials relatively high, with large muscle-plates, and much inclined to the vertical axis of the calyx.

Disk with a central or subcentral mouth and five equal ambulacra, which extend on to all the arms. These are ten or more in number, all of the same length, and may have an ambulacral skeleton which is most differentiated on the pinnules. Sacculi almost always present on the pinnules, if not elsewhere.

History.—This genus was established in 1811 by de Fréminville,[1] who was the first to remove the Feather-stars from the confusion of the Linnean genus *Asterias* and to give them a definite generic rank. A similar course was taken three years later by Leach, who was probably unaware of de Fréminville's work, and established the genus *Alecto* for the Feather-stars; but the same can hardly be said of Lamarck, who deliberately rejected de Fréminville's generic name, replacing it by one of his own making, viz., *Comatula*, and he doubtfully referred de Fréminville's species *Antedon gorgonia* to his own

[1] Mémoire sur un nouveau genre de Zoophites de l'ordre des Radiaires, *Bull. Soc. Philom. Paris*, 1811, t. ii. p. 349. In this note de Fréminville referred to an illustration of *Antedon* in the Encyclopédie Méthodique; and Perrier has consequently been led to mention the latter work as that in which the name *Antedon* was first proposed *Nouv. Archiv. Mus. Hist. Nat.*, t. ix., 1886, p. 79).

new species *Comatula carinata*,[1] which he had established in apparent ignorance of the fact that Leach had proposed *Alecto carinata* in the previous year.

The authority of the great French zoologist and the appositeness of the name which he proposed both contributed to cause this somewhat ostentatious neglect of the work of a fellow-countryman to be overlooked by naturalists in general; and Lamarck's name was used in succession by J. S. Miller, von Schlotheim, de Blainville, Goldfuss, Agassiz, and Münster. Among these authors Miller deserves especial mention, for he was the first naturalist after Llhuyd and Linck who distinctly recognised the morphological resemblance between the Feather-stars and the Stalked Crinoids, a point which Lamarck had entirely failed to notice; and Miller accordingly drew up a new generic definition of *Comatula* which was based upon this idea.[2] He seems to have preferred this name to *Alecto*, which genus he regarded as less precisely defined than Lamarck's *Comatula*.

Johannes Müller also used *Comatula* in his first communication to the Berlin Academy upon the subject of the Crinoidea; but in the next year (1841) he formally adopted *Alecto*, Leach, as the generic name of several new species, while in the year 1843 he applied it to the six Lamarckian species which he had not previously mentioned in this relation, and subsequently also to the *Asterias multiradiata* of Linnæus.

When Müller first proposed the name *Actinometra* he regarded it as denoting a genus equivalent to *Alecto;* but he eventually reduced both these names to subgeneric rank and assigned a generic position to *Comatula*. Dujardin and Hupé, however, dropped *Alecto* altogether and restored generic rank to *Actinometra*, making it equivalent to *Comatula*. Soon afterwards, Norman very rightly restored de Fréminville's name, *Antedon*, which had been suffered to fall into disuse; and it is now universally used for the typical Endocyclic Comatulæ with five dividing rays, both recent and fossil. There are, however, a very large number of generic names which have been applied to the centro-dorsals of fossil Comatulæ, both with and without the radials attached, *e.g.*, *Glenotremites*, *Solanocrinus*, *Hertha*, *Decameros*, *Decacnemos*, *Allionia*, *Comaster*, &c. *Pterocoma* and *Geocoma* were the names given by Agassiz and Fraas to species from the Solenhofen Slate and the Chalk of the Lebanon respectively. *Ganymeda*, Gray, is in all probability the centro-dorsal of *Antedon rosacea;* while on the other hand, *Hyponome*, Lovén, is the detached visceral mass of an *Antedon* common at Cape York.

The stalked larva of *Antedon* was first described as a dwarf species of *Pentacrinus*, which name Fleming proposed to change into *Hibernula*, this genus being distinguished from *Pentacrinus* as then known by the presence of two openings to the digestive canal. De Blainville, on the other hand, noticed the differences between the characters

[1] In his description of *Antedon gorgonia* de Fréminville referred to the Encyclopédie Méthodique, partie des Vers, pl. cxxiv., fig. 6. But Lamarck quoted this figure as representing his *Comatula mediterranea*.

[2] *Op. cit.*, p. 128.

of the larval stem and those of the West Indian *Pentacrinus*, and so proposed to call the European form *Phytocrinus*. This was rendered unnecessary, however, by J. V. Thompson's discovery that *Pentacrinus europæus* is the young stage of *Antedon rosacea;* and it is now clear that *Kallispongia*, Wright, is a real Comatulid larva, and not a mimetic Keratose sponge, as was at first supposed.

An attempt has recently been made by Walther[1] to re-establish *Solanocrinus*, Goldfuss, as a genus distinct from *Antedon*. I do not think, however, that there are any really good reasons for this change. The fossil species which Walther refers to *Solanocrinus* appear to him to present no syzygial unions in the arms, and this is the only character of any real generic value which he can bring forward as separating *Solanocrinus* from *Antedon*. I have explained elsewhere,[2] however, that the absence of syzygies in the arms of *Solanocrinus costatus*, *Solanocrinus imperialis*, and *Solanocrinus gracilis*, is to my mind less certain than Walther believes; while I strongly suspect from his figures and descriptions that in all these three types the two outer radials are united by syzygy, just as in *Antedon fluctuans* and *Antedon multiradiata* (Pls. VIII., IX.). I cannot therefore yet acquiesce in Walther's restoration of Goldfuss's genus, though it is quite possible that this course may become necessary at some future time.

De Fréminville did not give any etymology for his new generic name *Antedon*, and no clue as to its gender is to be obtained from the name of his single species *Antedon gorgonia*. But when the genus was re-established by Mr. Norman in 1865 he used *Antedon* as a masculine noun, and in this course he was followed by Sir Wyville Thomson, Dr. Carpenter, M. Sars, Lütken, Marion, von Marenzeller, Greeff, Ludwig, and others. In 1877, however, it was determined by the late Mr. Spedding[3] that *Antedon* is really a feminine name, and should be more correctly spelt *Anthedon*. Since that date it has been used as a feminine noun by Pourtalès, Ludwig, Duncan and Sladen, Bell, Verrill, J. V. Carus, Greeff, Dr. Carpenter and myself; though Schlüter, Rathbun, Marshall, Herdman, Dendy, Vogt and Yung, Walther, and, till lately, Perrier, have continued to use it in the masculine gender. In Perrier's latest publication,[4] however, the following passage occurs about the name:—"*Antedon rosaceus* qui, selon la remarque de Victor Carus doit être remplacé par celui d'*Antedon rosacea*, Antedon étant une nymphe. Ce savant exposé est suivi d'une étude des mœurs des *Antedon* qui contient plusieurs constatations intéressantes." As I was unable to find the authority for Perrier's statement in any of the zoological works of Professor Carus, I wrote to him upon the subject, and he was good enough to inform me that the facts referred to by Perrier had been contained in a letter and not in any of his published works. He also kindly gave me a reference to the

[1] Untersuchungen über den Bau der Crinoideen, Palæontographica, 1886, Bd. xxxii. p. 175.

[2] The Generic Position of Solanocrinus, *Ann. and Mag. Nat. Hist.*, 1887, ser. 5, vol. xix. pp. 81–88.

[3] *Nature*, 1877, vol. xv. p. 366.

[4] Mémoire sur l'Organisation et le Développement de la Comatule de la Méditerranée (Antedon rosacea, Linck) *Nouv. Archiv. Mus. Hist. Nat.*, Paris, 1886, t. ix. fasc. 1, p. 79.

following passage in Pausanias where *Anthedon* occurs as the name of a nymph (ix. 22, 5):—

"Τῆς δὲ Βοιωτίας τὰ ἐν ἀριστερᾷ τοῦ Εὐρίπου, Μεσσάβιον ὄρος καλούμενον, καὶ ὑπὸ αὐτῷ Βοιωτῶν ἐπὶ θαλάσσης πόλις ἐστὶν Ἀνθήδων. γενέσθαι δὲ τῇ πόλει το ὄνομα οἱ μὲν ἀπὸ Ἀνθήδονος νύμφης, οἱ δὲ Ἀνθῶνα δυναστεῦσαι λέγουσιν ἐνταῦθα, Ποσειδῶνός τε παῖδα καὶ Ἀλκυόνης τῆς Ἄτλαντος."

"That part of Bœotia which lies on the left of the Euripus is called the Messabian Mountain, and below it on the coast is a town of the Bœotians called Anthedon. Some say that the town was called after a nymph Anthedon, others that Anthon a son of Poseidon and Alcyone daughter of Atlas reigned there."

It is clear, however, that although *Antedon* is etymologically incorrect, De Fréminville's spelling of the name must be retained; but at the same time the question of its gender may be regarded as finally settled.

Remarks.—De Fréminville's definition of *Antedon*, like those of *Alecto* by Leach and of *Comatula* by Lamarck, would apply almost equally well to all the various forms of Feather-stars. But that given by Mr. Norman[1] is of a much more limited character, as it commences with the words "Mouth central. Anus lateral." This character alone was sufficient to separate *Antedon* from Müller's genus *Actinometra* as defined by Dujardin and Hupé three years before, but we now know four other genera of Endocyclic Comatulæ.

The essential characters of the calyx of *Antedon* have been fully explained already, and there is therefore no need to refer to them again. It is distinguished from *Promachocrinus* by the presence of five rays only, and from *Eudiocrinus* by the fact that these rays divide so that there are ten primary arms, which may themselves divide again. The presence of pinnules on the arm-bases and the lateral union of the radials distinguish *Antedon* from the two remaining genera of recent Endocyclic Comatulæ, *Atelecrinus* and *Thaumatocrinus* respectively; while the want of a comb on the oral pinnules, the presence of sacculi, and the central mouth distinguish it very clearly from *Actinometra*.

The oral pinnules of *Antedon* are extremely variable in their characters. In some species, such as *Antedon multispina*, and *Antedon angustipinna*, they are comparatively small and insignificant (Pl. XIII. fig. 1; Pl. XXIX. fig. 1). In others like *Antedon gracilis*, *Antedon valida*, *Antedon incerta* and *Antedon lusitanica* they have a number of short, but very wide basal joints, and are therefore somewhat massive in appearance (Pl. XII. fig. 3; Pl. XV. fig. 6; Pl. XVIII. fig. 5; Pl. XXXIX. fig. 2). In *Antedon occulta*, and in a large number of similarly bidistichate species, they are stiff and styliform and stand up round the edge of the disk as if to shield it from danger, a character which Lütken has expressed in the specific name *Antedon protecta*. They are more slender and flexible and consist of much elongated joints in *Antedon longipinna* and *Antedon*

[1] *Ann. and Mag. Nat. Hist.*, 1865, ser. 3, vol. xv. p. 101.

exigua (Pl. XXX. fig. 1; Pl. XXXII. fig. 4); while in the group of species allied to *Antedon eschrichti* they are more or less flagellate, consisting of a large number of relatively short joints (Pl. XXIV. figs. 1–3, 7–9; Pl. XXV. figs. 1–3; Pl. XXVII. figs. 8, 9). There is much less variation in this respect in the oral pinnules of *Actinometra*, which are always provided with a terminal comb (Pl. LIII. figs. 3–6), a character which never occurs in *Antedon*.

On the other hand, the sacculi which are almost invariably present in this genus, never occur in *Actinometra*, even when species of the two genera are living side by side in the same locality; and this fact is a very strong argument against the theory of Vogt and Yung[1] that the sacculi are symbiotic Algæ, as I have explained elsewhere.[2] There are a few species of *Antedon*, *e.g.*, *Antedon quinquecostata*, in which they are small and poorly developed, though they are abundant in others obtained at the same localities; and in some other instances the condition of the specimen has been such that I have not been able to assure myself satisfactorily of the presence of sacculi. This is the case for example with the two specimens of *Antedon abyssicola* from 2900 fathoms, the greatest depth at which Comatulæ have been obtained; but they are fairly abundant in another individual of the same species from 2600 fathoms in the Southern Sea. There are few species of *Antedon* in which they are not present; though they are more variable in their occurrence among the species of *Eudiocrinus*, as has been already explained.

The very definite relation of the sacculi to the side plates of the ambulacra in those species of *Antedon* which have a highly differentiated ambulacral skeleton is a very strong argument against the views of Vogt and Yung that they are symbiotic Algæ. It was pointed out on p. 127 of Part I. how the distal edges of the side plates are notched for the reception of the sacculi, and figures were given on pl. liv. illustrating this character in four species of *Antedon*. But it does not occur at all in species of *Pentacrinus* and *Metacrinus* which live at the same localities as these Comatulæ (Stations 170A, 175, 192, 214), and I cannot think, therefore, that the problem of the nature of the sacculi has been solved by Vogt and Yung. These are not the only difficulties which suggest themselves in connection with the details of their theory as I have explained elsewhere.[3]

Classification.—It has been shown on a previous page how the numerous recent species of *Antedon* may be associated together into groups of variable size, according to the characters of the rays and of their subdivisions. The first group to be considered includes those species in which the two outer radials are united by a syzygy and not, as is most frequently the case, by a bifascial articulation. Five of the eight recent species of *Pentacrinus* are distinguished by this character, and it occurs in several species of

[1] *Op. cit.*, p. 570.

[2] On the Supposed Presence of Symbiotic Algæ in Antedon rosacea, *Quart. Journ. Micr. Sci.*, 1887, new ser., vol. xxvii. p. 386.

[3] *Ibid.*, pp. 380–384.

Actinometra, both ten-armed and multibrachiate, *e.g.*, *Actinometra pectinata*, *Actinometra paucicirra* and *Actinometra typica* (Pl. LIII. fig. 15; Pl. LIV. figs. 1, 2; Pl. LVII. fig. 1).

I do not know, however, of any ten-armed *Antedon* belonging to this group, and the three species immediately to be described, in which the rays divide three or four times, present one very exceptional feature in their organisation. It is a very general rule among Neocrinoids that the mode of union of the first and second joints beyond the radial and all subsequent axillaries is the same as that between the two outer radials.[1] But this rule does not always hold good in the case of syzygial unions, though it is true amongst other species, of *Pentacrinus wyville-thomsoni* and *Pentacrinus alternicirrus*, of *Actinometra difficilis* and *Actinometra paucicirra* (Pl. LII. fig. 2; Pl. LIV. figs. 1, 2), in all of which the two outer radials, the two distichals and the first two brachials are respectively united by syzygy.

In *Actinometra multibrachiata* and in *Actinometra typica* there are three joints in the distichal series, the first two articulated and the third a syzygy. But in the numerous remaining arm-divisions there are only two joints which are united by syzygy like the two outer radials (Pl. LVI. fig. 2; Pl. LVII. fig. 1).

The three species of *Antedon* now to be described are, however, still more irregular; for in neither distichal, palmar, nor brachial series are the first two joints united by syzygy, as is the case with the two outer radials. This latter character seems to have presented itself in three Jurassic species of *Antedon*. Quenstedt[2] has described the two outer radials of *Solanocrinus* (*Antedon*) *costatus* as united by syzygy, and his description is borne out by his figures, one of which shows a first brachial of such a size that I feel tolerably certain of its being really a syzygial joint as in *Actinometra strata* and *Actinometra pectinata* (Pl. LIII. figs. 2, 15). Walther's recent description of *Solanocrinus costatus*[3] contains the passage "Radiale II. mit Radiale III. verschmolzen, doch durch eine Nahtlinie getrennt;" and it is odd that he did not follow Quenstedt in describing the union as a syzygial one. The large size and the pentagonal shape of the radial axillaries in his *Solanocrinus imperialis* seem to me to indicate clearly that these are syzygial joints; and I am very strongly inclined to believe that the large joints which he describes as "Axillaria" are really compound joints, consisting of the first and second distichals united by syzygy, as in *Actinometra paucicirra* (Pl. LIV. figs. 1, 2). These pieces are more distinctly separate in the five remaining distichal series of his specimen, while in some cases at any rate, the large first brachials would appear to be syzygial joints. The same may be said of Walther's single specimen of *Solanocrinus gracilis*,[4] of which he remarks as a possibility that the apparently simple second or axillary radial "als verschmolzenes Radiale II. + Radiale III. aufgefasst werden könnte."

[1] See Part I. p. 49.

[2] Encriniden, p. 172, Tab. 96, figs. 26, 28.

[3] *Op. cit.*, p. 172.

[4] *Ibid.*, p. 174.

If then there really were syzygial unions between the two outer radials and the first two distichals and brachials respectively of *Solanocrinus imperialis* and *Solanocrinus gracilis*, these two species would represent a type which is not as yet known to occur in the recent *Antedon* at all, but only in *Actinometra paucicirra* and its allies; while the ten-armed *Antedon costatus* is represented at the present time by the various species belonging to the type of *Actinometra solaris* (Pl. LIII. figs. 2, 15).

The three species of *Antedon* belonging to this first series which were dredged by the Challenger, may be classified as follows:—

Antedon, Series I.

The two outer radials united by syzygy.

A. Three distichals, the axillary a syzygy.
- I. Subsequent divisions of two articulated joints, ... 1. *fluctuans*, n. sp.
- II. Subsequent divisions like the distichals.
  - *a.* Three axillaries above the radials, ... 2. *multiradiata*, n. sp.
  - *b.* Four axillaries above the radials, ... 3. *microdiscus*, Bell.

1. *Antedon fluctuans*, n. sp. (Pl. VIII.).

Specific formula, A.R.3.2.(2).$\frac{b}{c}$.

Centro-dorsal a thick disk, bearing about twenty-five marginal cirri. These have thirty to thirty-five joints, of which the fifth to eighth are much longer than broad. The following ones diminish in length and gradually develop a sharp forward projecting spine which decreases slightly in the short terminal joints, but increases again on the penultimate as the opposing spine to a strong recurved claw.

Three radials visible, the second free laterally, but united to the third by syzygy. The rays are quite free and may divide four times. Three distichals, the axillary with a syzygy. Palmars and post-palmars (when present) usually of two articulated joints. Arms from twenty-six to nearly forty in number, and composed of short, smooth, and obliquely quadrate joints. A syzygy in the third brachial; the next anywhere between the twelfth and the sixtieth, with others at intervals of six to twenty joints.

The second distichal bears a long, tapering pinnule of about forty joints, the basal ones tolerably stout and the terminal ones small. The second, and sometimes also the third brachials have similar but smaller pinnules, and the following ones decrease slowly in size, becoming long and slender again towards the arm-ends.

Disk much incised, and the interradial regions more or less covered with rather large plates. The ambulacra as far as the last axillary are raised and strongly plated ridges. But those of the arms and pinnules, including even that on the second distichal, are unprotected.

Colour in spirit,—the skeleton a light brownish-white, with the perisome sometimes darker. Sacculi abundant, especially on the pinnules, and sometimes appearing on the outer ends of the plated disk-ambulacra.

Disk 8 mm.; spread probably 80 to 90 mm.

Locality.—Station 190, September 12, 1874; lat. 8° 56′ S., long. 136° 5′ E.; 49 fathoms; green mud. Two mutilated individuals and one fragment; one varietal form.

Other Localities.—H.M.S. "Alert," 1881; Torres Strait. One specimen.

Remarks.—Three of the Challenger specimens agree very closely in their general characters, though the frequency of the arm-divisions, and therefore the number of arms, varies considerably. All the distichal series consist of the usual three joints with a syzygy in the axillary; nearly all the palmars have but two joints without a syzygy; post-palmars are present in every individual, and in the majority of cases resemble the type of the palmars, so that the arm-formula becomes A.R.3.2.2. (Pl. VIII. fig. 1).

There was, however, a fourth specimen obtained besides these three, from which it differs in many points, though not, I think, sufficiently so to entitle it to a distinct specific rank (Pl. VIII. fig. 2). The colour of the calyx and arms is the same brownish-white as in the type, but the cirri have a strong reddish-brown tint (which was probably purple during life) with white bands at the inter-articular lines, and the lower joints are shorter relatively to their width than in the type-forms, though remaining longer than wide. The difference from the type is most apparent, however, in the arm-divisions. For four out of the ten distichal series have but two joints, the axillary without a syzygy; and out of the twelve palmar series which remain, six have two and the other six three joints, while there are no post-palmars at all, although they occur in each of the three type-specimens. The arms too, are somewhat more massive than in these last, and their component joints, instead of being smooth and obliquely quadrate, are relatively shorter and more wedge-shaped, with a slight tendency to overlap.

The differences between this individual and the other three, which agree so closely in their general characters, are certainly very marked; but it is difficult to find in any one of them an adequate reason for specific distinction. This conclusion is confirmed by the fact that a third form which combines certain characters of each of the other two was obtained in Torres Strait by Dr. Coppinger of H.M.S. "Alert." Being in a somewhat mutilated condition it was not described by Professor F. J. Bell in his Report on the "Alert" Echinoderms, but was put aside until the arrival of better preserved material; and I am indebted to him for the opportunity of referring to it here. It resembles the type-form in the shape of its arm-joints but has no post-palmar series; and it further resembles the varietal Challenger specimen in having purplish cirri with white bands as described above. It is tolerably clear, therefore, that as in so many other cases, we are here dealing with a somewhat variable specific type, and I propose to designate it accordingly as *Antedon fluctuans.* It is curious, however, that while the two most dissimilar forms were dredged at the same Station in the Arafura Sea, the intermediate one was obtained at a much less depth in Torres Strait, and that no others have been met with at any intervening locality. When examining the "Alert" specimen I found a small *Myzostoma* upon it, which Professor von Graff has named *Myzostoma quadricaudatum.*

Antedon fluctuans is a type of considerable interest from a systematic point of view. For the syzygial union of the two outer radials is in no case accompanied by a similar union of the first two joints after each subsequent axillary. Whether there be three distichals, as is normally the case, or two only, as in some exceptional rays, there is always the bifascial articulation between the first two joints above the radials and above every successive axillary, just as in the ordinary many-armed *Antedons.* In the case of *Antedon fluctuans,* the palmar and post-palmar series (when present) normally consist of two joints only, and this character distinguishes the type from *Antedon multiradiata* and *Antedon microdiscus,* in which there are three joints between the successive arm-divisions (Pl. IX.; Pl. XXXVII. fig. 3). I know of no other described species but these with which *Antedon fluctuans* is likely to be confounded, provided, of course, that the syzygial union of the radials be properly recognised.

2. *Antedon multiradiata,* n. sp. (Pl. IX.; Part I. pl. lv. figs. 3, 4).

Specific formula, A.R.3.3.3.$\frac{b}{c}$.

Centro-dorsal a thick, slightly convex disk, bearing from twenty to twenty-five marginal cirri. These are rather long, consisting of forty or fifty, or occasionally more joints, few or none of which are longer than wide. The last half have a small blunt spine projecting slightly forwards, which forms a strong and sharp opposing spine on the penultimate.

Three radials visible, the second short and free laterally, but united to the third by syzygy. The rays are quite free and may divide four times, each series of three joints with the axillary a syzygy. About forty arms of smooth and short triangular joints, which become blunter and more square towards the ends. A syzygy in the third brachial, the next anywhere between the sixteenth and forty-fifth joints, with others at intervals of seven to nineteen joints.

The distichal pinnules of moderate length, consisting of about twenty-five stout joints; the size gradually decreases to that on the second brachial, and the next pair are considerably smaller, the following ones increasing slowly in size, but never becoming very large.

Disk much incised and paved with large plates between the ambulacra, which are elevated ridges with plated walls, but the plating scarcely extends beyond the level of the last axillary.

Disk about 15 mm.; spread probably about 12 cm.

Colour in spirit,—a deep reddish purple with patches of whiter tint. Sacculi deeply coloured, and abundant along the sides of the pinnule-ambulacra.

Locality.—Station 187, September 9, 1874; off Booby Island, Torres Strait; lat. 10° 36′ S., long. 141° 55′ E.; 6 fathoms; coral mud. Two imperfect individuals.

Remarks.—This species differs from *Antedon fluctuans* in the composition of the later arm-divisions, which resemble the distichal series in consisting of three joints with a syzygy in the axillary, in the sensible decrease in the length of the pinnules after that on the second brachial, and in the greater number of the cirrus-joints. The grouping of the arm-divisions is the same as that of *Antedon microdiscus*, in which, however, there is a fourth post-radial axillary (Pl. XXXVII. fig. 4). This is absent in *Antedon multiradiata*, which has fewer cirri and smaller basal pinnules than *Antedon microdiscus*. Several isolated disks of *Antedon multiradiata* were obtained by the Challenger in Torres Strait, and two of them were figured in Part I. (pl. lv. figs. 3, 4). Owing to the freedom of the rays, which are not bound together by perisome, the disks are very deeply incised and have a markedly stellate appearance. The so-called recent Cystidean *Hyponome sarsii* of Lovén[1] is nothing but one of these *Antedon*-disks covered with a well-developed calcareous plating, both at the sides of the ambulacra and in the interambulacral regions. It is not unlikely to have been the disk of *Antedon multiradiata* which was found in this condition at Booby Island by the Challenger, as it has a more extensive plating than *Antedon microdiscus*, while *Antedon bidentata*, the other species dredged at that locality, has a quite naked disk.

3. *Antedon microdiscus*, Bell (Pl. XXXVII. figs. 4–6).

Specific formula—A.R.3.3.3.3.$\frac{c}{c}$.

1884. *Antedon microdiscus*, Bell, Rep. Zool. Coll. H.M.S. "Alert," London, 1884, p. 163, pl. xv.

Description of an Individual.—Centro-dorsal relatively large, with about three rows of cirri on its sides, but the dorsal surface slightly convex and free from them. Forty to forty-five joints in the cirri, few or none of them being longer than wide; the distal ones quite short, with tolerably well-marked spines, that on the penultimate being sharp and distinct.

First radials barely visible; the next two united by syzygy. The rays divide four and sometimes five times, each series of three joints with the axillary a syzygy.

Arms of smooth joints, the lower ones short and nearly triangular, but becoming more oblong after about the sixtieth. A syzygy in the third and again in about the thirtieth brachial, with others at intervals of twelve to fourteen joints.

[1] On Hyponome sarsii, a recent Cystidean, *Canadian Naturalist*, N.S., 1869, vol. iv. pp. 265–268.

Distichal and palmar pinnules large and stout, composed of forty to fifty joints, the second one rather the longer. Their lower joints are large but not specially marked; the following ones diminish in size, but gradually develop a projection of the dorsal edge at their distal end, which disappears in the smaller terminal joints. The third and following pinnules decrease rapidly both in length and in stoutness, after which the length slowly increases again.

Disk-ambulacra protected by a well-developed calcareous plating which ceases at the arm bases; anal tube also considerably plated, but the other interpalmar areas are unprotected.

Colour in spirit,—skeleton brownish-white, and the perisome mottled with grey. Sacculi very abundant on the pinnules.

Disk 17 mm., spread about 20 cm.

Locality.—Station 186, September 8, 1874; Torres Strait; lat. 10° 30′ S., long. 142° 18′ E.; 8 fathoms; coral mud. One specimen.

Remarks.—Only one example of the species was obtained by the Challenger, but it did not come into my hands with the rest of the collection, having been given by Sir Wyville Thomson to the National Museum at Stockholm, where I found it in August of last year (1886), and Professor Lovén has since been kind enough to send it over to England for my further examination.

A larger specimen of the same type was obtained in 1881 at Port Molle, Queensland, by H.M.S. "Alert," and was described by Professor F. J. Bell,[1] together with some smaller individuals already in the National Collection from Nicol Bay, Australia.

There was a very important omission, however, in Bell's description; for he entirely overlooked the fact that the two outer radials are united by syzygy, a character which, next to those of the genus, is of primary importance for systematic purposes. His description and figure rather led me to suspect the presence of this character long before I saw the Challenger specimen, and my suspicions were verified when I examined his types for myself. He likewise makes no mention of any axillaries beyond the post-palmars, although such must be present to bring the number of arms up to ninety, the number which he describes in the adult, while several quaternary arms are represented in his figure. His specific formula must be altered therefore from $A.3.3.(3).\frac{c}{c}$. to $A.R.3.3.3.3.\frac{c}{c}$.

It is the presence of this fourth axillary above the radials which is one of the characters distinguishing this species from *Antedon multiradiata*. I have not seen any specimen without it, though it is much more frequent in the individual from Port Molle than in those from Nicol Bay and Torres Strait. These last resemble one another in having a smaller number of cirrus-joints and a better-developed penultimate spine than in the type.

[1] "Alert" Report, p. 163, pl. xv.

The joints of the cirrus figured by Bell[1] are much wider than long; whereas in the Challenger specimen this is only the case in the outer part of the cirrus, some of the lower joints being as long as or longer than wide, and in premature cirri the length is distinctly greater than the width, while the penultimate spine is especially prominent.

Bell described the second or palmar pinnule of his type specimen as being a good deal longer than the first or distichal one. This is not the case, however, in that dredged by the Challenger; and the pinnules show no trace of the slightly keeled basal joints described by Bell. But the distal edges of the basal joints are somewhat sharp, and beyond the sixth joint they project slightly over the bases of the succeeding ones (Pl. XXXVII. fig. 6). This feature gradually develops into a blunt slightly spinous process, which is most marked about the fifteenth joint and disappears altogether after the twenty-fifth; but in the palmar pinnule figured by Bell it is not visible till the eighteenth segment and continues till near the end of the pinnule. It is this feature apparently which led Bell to say—"the more distal joints are provided with a spine or tuft of spines."

The anal tube of this individual contains a species of *Anilocra*, the Isopod which was described and figured in Part I. in the same position on the disk of *Actinometra paucicirra* (see Part I. p. 133, pl. lv. fig. 1).

Antedon, Series II.

The two outer radials articulated; ten arms.

Remarks.—It has been pointed out already that the number of species of *Antedon* which have articulated radials and only ten arms is very considerable; and it therefore becomes necessary for the purposes of specific discrimination to arrange them into groups of comparatively small size. I have had considerable difficulty in effecting this object, as the absence of any axillaries on the arms deprives us of an important aid to classification. By using the characters of the arm-bases and of the lower pinnules, however, I have found it possible to classify most of the ten-armed species of *Antedon* in five groups, which I propose to call by the names of their more characteristic or best known species,—thus, the *Eschrichti*-group, the *Tenella*-group, &c.

The radials and lower brachials have flattened sides. Pinnule-ambulacra generally plated,	1. *Basicurva*.
The rays not flattened laterally. Pinnule-ambulacra well plated,	2. *Acoela*.
The first two or three pairs of pinnules long and flagellate, with numerous short and wide joints,	3. *Eschrichti*.
The joints of the lowest pinnules, which are often long and slender, are longer than wide, frequently very much so,	4. *Tenella*.
The first pair of pinnules are comparatively small, and their joints but little longer than wide; one or more of the second, third, and fourth pairs are longer and more massive, with stouter joints than their successors,	5. *Milberti*.

[1] "Alert" Report, pl. xv. fig. *d*.

The first of these groups to be considered is one which has hitherto been entirely unknown to me except in fossil Comatulæ, and therefore consists entirely of new species discovered during the cruise of the Challenger. I will call it the *Basicurva*-group, for it is in *Antedon basicurva* that its principal distinctive characters are, on the whole, most clearly visible.

In all the species of this group not only the two outer radials, but also the lowest brachials of adjacent rays, come into very close mutual apposition, so that their sides are flattened against one another.[1]

Fig. 2, A, represents a calyx of *Antedon basicurva* from which three rays have been entirely removed; and it then appears that the two lateral faces of each pair of outer

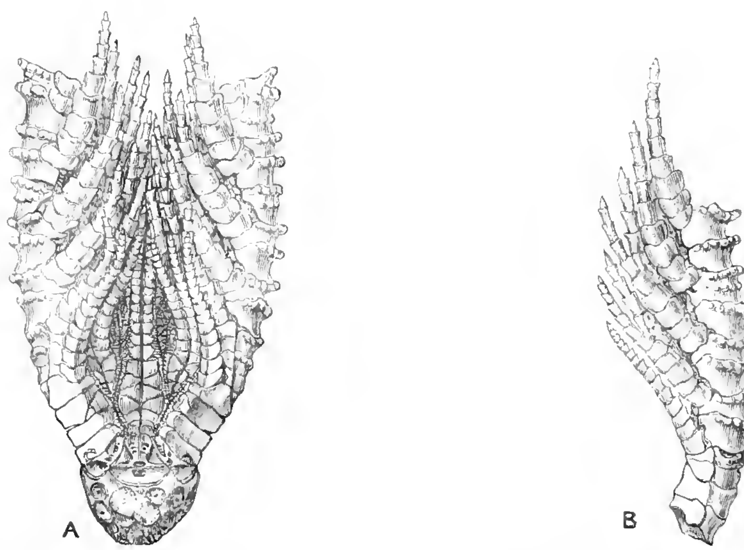

FIG. 2.—*Antedon basicurva*, × 3. A. Side view of the calyx and arm-bases after the removal of three rays, so as to show the sides and inner faces of the other two. The two outer radials, two lower brachials, and in a less degree also the third and fourth, have their outer sides flattened against one another. The genital pinnules have the third and fourth, and sometimes the fifth joints greatly expanded, but the following ones are smaller. B. The lower part of an arm from its inner side, to show the flattened inner faces of the first three brachials, including both the hypozygal and the epizygal of the third.

radials are quite smooth and flat, like those of the first radials at the bottom of the calyx, and they are in close apposition with those of the second and axillary radials in adjacent rays. In like manner the outer faces of the first brachials on adjacent rays come into close mutual contact and are very perceptibly flattened. The same is true of the second, and in a less degree also of the third brachials, all these three joints being somewhat compressed laterally, with flattened sides and sharp, straight, outer edges. The inner edges and sides of the second and third brachials present the same feature, as seen in fig. 2, B, so that the lower portions of the arms lose their usual rounded character

[1] This character is more or less distinct in some forms of *Antedon milberti*, but appears to be a varietal rather than a fundamental one (see p. 197).

and come to have a somewhat "wall-sided" appearance. In some species, such as *Antedon valida*, *Antedon incerta*, and allied forms, which have large first pinnules, the second brachials that bear them have quite short outer sides which are scarcely flattened at all. But the lower pinnule-joints are extremely modified. Their outer sides are flattened where they meet the corresponding pinnules of adjacent rays, while their inner sides seem to have been cut away so as to let the pinnules lie close against the arm (Pl. XV. figs. 5, 6; Pl. XVIII. fig. 5).

On the other hand, there are some species in which the wall-sided nature of the arm-bases is so comparatively inconspicuous that it might readily escape notice by an untrained eye. It is a peculiarity which becomes more prominent with age, the radial and brachial joints of young individuals being always longer relatively to their width than in the adult condition, so that those of adjacent rays come less closely into contact.

This flattening of the apposed sides of the radials and lower brachials is a character which, so far as my knowledge goes, does not appear in any of the Pentacrinidæ, though it is very marked in the fossil *Solanocrinus costatus*, Goldfuss. Quenstedt[1] figures a ray of this species in which the flattened sides of the syzygial axillaries and of the two lowest brachials are very clearly shown. He says that "von der Seite zeigten nur das erste und zweite Armglied eine breitere Fläche, die mit dem dritten plötzlich schmal wird, und alsdann ganz verschwindet, zum Zeichen, dass mit dem vierten Gliede die Arme schon ganz getrennt waren, und sich mit ihren Innenrändern nicht mehr berührten." In like manner Walther[2] says of the same type "dass, wie bei dem Stück von Quenstedt die drei untersten Armglieder mit seitlichen Gelenkflächen eng verbunden sind und einen *Brachialen Pseudo-kelch* bildeten, so dass sich also die Arme erst vom vierten Glied an bewegen konnten."

In *Encrinus* and in some species of *Apiocrinus* this character is considerably exaggerated, the radials and the lower parts of the arms fitting very closely against their fellows on either side. Traces of it also appear in *Holopus*, as described on p. 206 of Part I.

In all but two of the twenty species which belong to the *Basicurva*-group, and have the lower parts of the rays flattened laterally and wall-sided, there are definite covering plates on the pinnule-ambulacra which rest on a limestone band more or less completely segmented into side plates, as for example in *Antedon breviradia* (Pl. XIX. fig. 4). But in two species, *Antedon denticulata* and *Antedon pusilla*, there is no ambulacral skeleton at all, a peculiarity which separates them very distinctly from the other members of the group.

[1] Encriniden, p. 174, tab. xcvi. fig. 26*a*.

[2] *Loc. cit.*, p. 171.

These may be classified very readily according to the characters of the cirri and lower pinnules, as shown in the following scheme :—

1. The *Basicurva*-group.

The radials and lower brachials have flattened sides.

A. Pinnule-ambulacra plated.
- I. Later cirrus-joints have dorsal spines.
  - a. First pinnule smaller than the second. Eighty cirrus-joints, . . 1. *longicirra*, n. sp.
  - b. First pinnule longer than the second.
    - 1. Sixty cirrus-joints or more.
      - Basal joints of first pinnule much flattened on the outer side. First two joints of the distal pinnules expanded and trapezoidal, 2. *calida*, n. sp.
      - First pinnule but little flattened on the outer side. First two joints of distal pinnules not specially marked, . . 3. *incerta*, n. sp.
    - 2. Thirty to fifty cirrus-joints.
      - (*a*) First pinnule flattened on the outer side. Cirri irregularly disposed.
        - (i.) Pinnule on third brachial carinate, like that on second, 4. *gracilis*, n. sp.
        - (ii.) Pinnule on third brachial small, like that on fourth.
          - *a*. Calyx and arm-bases not spinous.
            - * Second and third radials rounded, but not specially convex.
              - Second radials very short, . . 5. *lusitanica*,[1] n. sp.
              - Second radials of moderate length. Later arm-joints carinate, . . . 6. *breviradia*, n. sp.
            - ** Second and third radials sharply convex or carinate.
              - Axillaries wider than long, . . 7. *spinicirra*, n. sp.
              - Axillaries longer than wide, . . 8. *acutiradia*, n. sp.
          - *β*. Calyx and arm-bases very spinous. Arm-joints with large curved spines, . . . 9. *bispinosa*, n. sp.
      - (*b*) First pinnule not flattened on the outer side. Cirri in ten vertical rows, ... 10. *latipinna*, n. sp.
    - 3. Less than thirty cirrus-joints.
      - (*a*) Pinnule on third brachial a good deal smaller than that on second. Arms spinous. First radials invisible, . . 11. *multispina*,[2] n. sp.
      - (*b*) Pinnule on third brachial not much smaller than that on second. Arms smooth. First radials visible, . . 12. *echinata*, n. sp.
- II. Less than thirty cirrus-joints without dorsal spines.
  - a. Pinnules of eighth and following brachials have broad lower joints, and strong plates covering the genital glands.
    - 1. Third and fourth joints of genital pinnules broad and nearly flat on the outer side, but the fifth joint smaller.
      - (*a*) First radials concealed by centro-dorsal; lower arm-joints with raised and crenulated distal edges, . . . 13. *basicurva*, n. sp.
      - (*b*) First radials distinctly visible. Arm-bases smooth, . . 14. *incisa*, n. sp.

[1] This is also a bidistichate species. See pp. 110, 217, and Pl. XXXIX. fig. 1.

[2] This is also a tridistichate species. See pp. 117, 248, and Pl. LXIX. figs. 1, 2.

2. Lower joints of genital pinnules uniformly expanded.
    (*a*) First radials concealed; less than twenty cirrus-joints.
        (1) Calyx and arm-bases bluntly spinous; First pinnules almost flagellate with twenty joints or more, . 15. *tuberosa*, n. sp.
        (2) Calyx and arm-bases smooth; first pinnules more styliform, of about fifteen joints, . . . 16. *parvipinna*, n. sp.
    (*b*) First radials visible; over twenty cirrus-joints, . . 17. *flexilis*,[1] n. sp.
b. Pinnules of tenth and following brachials have the lower joints as long as or longer than wide, and no extensive plating over the genital glands, 18. *aculeata*, n. sp.

B. Pinnule-ambulacra not plated.
  I. Two radials visible; arm-joints short. Stoutest pinnule on sixth brachial. Cirrus-joints long and smooth, ... 19. *denticulata*, n. sp.
  II. Three radials visible; arm-joints long. Stoutest pinnule on second brachial. Cirrus-joints short and carinate, ... 20. *pusilla*, n. sp.

1. *Antedon longicirra*, n. sp. (Pl. XVII.).

Specific formula—$A.\frac{b}{c}$.

Description of an Individual.—Centro-dorsal somewhat conical, bearing about twenty cirri. These are enormously long (80 mm. or more), and consist of about eighty segments, the lower ones of which are longer than wide. The middle joints are slightly compressed laterally, and gradually develop a dorsal keel, which becomes rather large in the shorter terminal joints, but is much reduced in size towards the end, and the terminal claw is very small.

The ends of the basal rays are just seen above the centro-dorsal and the three radials are visible, all rather long. The first two are oblong and the third pentagonal. The axillaries and the first two brachials have sharp lateral edges and flattened sides; all the radials and the oblong first brachials are very convex, the centre rising to form a sharp tubercle. Ten arms, of over one hundred joints, the lower ones triangular, but wider than long, and gradually becoming carinate so as to develop a forward projecting dorsal spine. Beyond the thirtieth joint they become laterally compressed and begin to overlap. This is reduced again in the last few joints, which diminish rather rapidly in size.

Syzygies in the third and eleventh brachials, and afterwards at intervals of four to six joints.

The pinnules are all stiff and styliform, consisting of elongated cylindrical joints. The second pair are considerably longer than the first, which are relatively small. The disk and ambulacra are well plated; but the side plates and covering plates are not fully differentiated on the pinnules. Sacculi very rare, or absent altogether.

Colour in spirit,—light whitish-brown.

Disk about 7 mm.; spread about 20 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

[1] This is also a bidistichate species. See p. 217 and Pl. XLII.

Remarks.—This fine species is sufficiently distinguished by the great size of its cirri, which are considerably longer than those of any other *Antedon* that I have seen with the exception of *Antedon valida* (Pl. XV. fig. 5). The appearance of the tertiary basals and of all three radials on the exterior of the calyx, together with the small size of its lower pinnules, separate it very clearly from the two species which come nearest to it in the characters of the cirri, viz., *Antedon valida* and *Antedon incerta* (Pl. XV. fig. 5; Pl. XVIII. fig. 4). Both of these show little or nothing of the first radials externally, and have large and peculiarly modified lower pinnules.

Antedon longicirra is one of the few species of the genus which appear to be unprovided with sacculi. The careful examination of several pinnules (both decalcified and otherwise) has altogether failed to reveal their presence except in one doubtful case; though from my experience with *Antedon valida* it is not improbable that they may occur on other pinnules which I have not examined. But there are no notches for their reception in the imperfectly differentiated side plates. In fact the ambulacra of this species are more like those of the Pentacrinidæ than is the case in any *Antedon* I know. For there are no definite side plates, the covering plates resting on a continuous limestone band which ceases some little way from the end of the pinnule, so that the last few joints have no ambulacral skeleton at all, as in so many Pentacrinidæ (see Part I. p. 55; pl. xv. fig. 7).

2. *Antedon valida*, n. sp. (Pl. XV. figs. 5–8).

Specific formula—A.$\frac{b}{c}$.

Centro-dorsal large and conical with the ventral angles produced, and bearing about fifteen cirri. These may reach 80 mm. in length and consist of about sixty-five joints, of which the seventh to the twelfth are considerably longer than wide. From the twenty-fifth onwards the joints are short and wide, with a strong dorsal spine.

The first radials just visible; second and third strongly convex in the middle of their line of junction. The borders of all three radials and of the lowest brachials are fringed with strong spines. The axillaries and first brachials have straight edges and flattened sides. Second brachial and hypozygal of the third flattened on the inner side only. The junction line of the first two brachials somewhat tubercular.

Ten arms, of triangular, slightly overlapping joints, the later ones somewhat compressed laterally. Syzygies in the third and about the twelfth brachials, and others at intervals of four to fifteen joints.

The second brachials have large stout pinnules, the first eight joints of which have broad and flattened outer sides. The third, fourth, and fifth joints have their inner edges bent upwards and somewhat thickened, but in the next following joints these are sharpened and form a keel. The third brachial has a similar but smaller pinnule with flattened outer side. The next two pairs of pinnules have broad and carinate lower joints, and the later pinnules are more styliform, with the two basal joints expanded and trapezoidal, and the following ones elongated. Disk thickly covered with plates which extend out on to the arms at the sides of the ambulacra, and also over the genital glands. Pinnule-ambulacra have well defined side plates and covering plates. Sacculi very rare.

Colour in spirit,—light whitish-brown.

Disk 11 mm.; spread probably 20 cm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. Two mutilated individuals, and one younger.

Remarks.—The very stout cirri of this fine species are as long as those of *Antedon longicirra*, though consisting of fewer joints. This is owing to the greater length of the first twenty joints in those of *Antedon valida*, as will be evident from a comparison of the figures on Pls. XV. and XVII. The two species also resemble one another in the almost entire absence of sacculi. Although I have examined many pinnules of *Antedon valida*, there is only one in which I have been able to distinguish the sacculi at all clearly; and even in this there are not more than about a dozen on the whole pinnule. They are sufficient, however, to show that sacculi may be present in *Antedon longicirra*, *Antedon acutiradia*, and other species, although I have not been able to find them on those pinnules which I have examined for the purpose.

Antedon valida and *Antedon longicirra* are, however, very distinctly separated by the characters of the pinnules borne on the second brachials. In the latter species this pinnule is comparatively inconspicuous and smaller than its successor; but in *Antedon valida*, as in *Antedon incerta*, it consists of short and wide joints, the lowest of which are flattened on the outer side, where they meet those of adjacent rays, and cut away on the inner, so as to give a very singular appearance to the basal part of the pinnule, which it is not easy to describe. It is well shown, however, on Pl. XV. figs. 5, 6, and Pl. XVIII. fig. 5, and it reappears in a modified form in *Antedon lusitanica* (Pl. XXXIX. fig. 2). This flattening on the outer side of the first pinnule is much better marked in *Antedon valida* than in *Antedon incerta*. But in both species alike the second brachial itself is not much flattened on its small outer face (Pl. XV. fig. 6), though its inner side and that of the hypozygal of the third brachial are distinctly flattened (Pl. XV. fig. 5; Pl. XVIII. fig. 5), while the outer face of the hypozygal is in no way specially marked. The distal pinnules of *Antedon valida* are remarkable for the expanded and trapezoidal shape of their two basal joints (Pl. XV. figs. 7, 8), a feature which scarcely appears at all in *Antedon incerta*, though it is characteristic of the group of European and Circumpolar species of which *Antedon eschrichti* is the type (Pl. XXIV. fig. 13).

Both *Antedon valida* and *Antedon incerta* have a very well-developed anambulacral plating on the disk, which extends out on to the arms above the muscular bundles at the sides of the ambulacra, as in many Pentacrinidæ, and also over the genital glands. The side plates and covering plates are better differentiated on the pinnules, however, than is the case in that family. In the immature example of *Antedon valida*, which was obtained at the same station as the two individuals above described, the axillaries and lower brachials are more widely separated and have their sides less flattened than in the adult condition. The basal joints of the first pinnules, however, have their usual appearance, and also those of the distal pinnules. The axillaries are rather hexagonal than triangular, and a considerable portion of the first radials is visible externally, while the arm-joints are relatively longer and more quadrate, as is always the case in young individuals.

3. *Antedon incerta*, n. sp. (Pl. XVIII. figs. 4, 5; Part I., pl. liv. figs. 6, 7).

Specific formula—A.$\frac{b}{c}$.

Description of an Individual.—Centro-dorsal bluntly conical, with the upper angles slightly produced. About twenty stout and long cirri, sometimes reaching 50 mm., with nearly seventy joints. The ninth to twelfth are longer than wide, and the following ones gradually shorten and develop a dorsal keel, which is most marked in the middle third.

First radials barely visible; the next two somewhat sharply carinate. The axillaries and first brachials with sharp edges and flattened sides. The second and the hypozygal of the third brachial flattened on the inner side only. The junction line of the first two brachials somewhat tubercular.

Ten arms, of tolerably smooth subtriangular joints, which gradually become quadrate. A syzygy in the third brachial; the next between the fifteenth and twentieth, and others at intervals of seven to fifteen joints.

The lower pinnules are stout, with broad carinate joints, diminishing from the second to the sixth brachial and then increasing slowly. The later ones are styliform with the two lower joints slightly expanded. The basal joints of the first pinnule have their outer sides somewhat flattened, and the third, fourth and fifth joints have their inner edges truncated, so as to be flattened against the arm.

Disk thickly covered with plates which extend out on to the arms at the sides of the ambulacra and also over the genital glands. The pinnules have well-defined side plates and covering plates, most of the former being notched for the presence of sacculi, which are small, but pretty regularly distributed.

Colour in spirit,—dirty yellowish-white.

Disk about 10 mm.; spread probably about 18 cm.

Locality.—Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. One specimen.

Remarks.—This is a smaller species than *Antedon valida* (Pl. XV. figs. 5, 6), the cirri, though containing the same number of joints, not reaching more than 50 mm. in length, as compared with 80 mm. in that species. The flattening of the outer side of the basal pinnules is not so evident, and the lower joints of the distal pinnules show but little trace of the expanded trapezoidal form which is so characteristic of *Antedon valida* (Pl. XV. fig. 8). The sacculi too are much more abundant than in the latter species, the side plates being notched for their reception, as described on pp. 83, 127 of Part I. and shown in pl. liv. figs. 6, 7 (*ibid.*).

The ambulacra extend on to the genital pinnules as is also the case in *Antedon valida*. But the plates covering the glands are much less developed than in the species like *Antedon acœla*, which have no ambulacra on these pinnules. See Part I., pl. liv. figs. 1–3.

One of the rays in the single specimen of *Antedon incerta* is remarkable for having the second radial axillary (Pl. XVIII. fig. 4). It is smaller and more triangular than the normal axillary seen in fig. 5, so that the pair of first brachials which it bears are in close lateral contact with the axillaries of the two adjacent rays.

4. *Antedon gracilis*, n. sp. (Pl. XII. figs. 3–5; Pl. XV. figs. 1–4).

Specific formula—A.$\frac{b}{c}$.

Centro-dorsal a low hemisphere with a roughened dorsal pole. About twenty cirri which reach 30 mm. in length, and consist of fifty to fifty-five joints, a few of which are longer than wide. The remainder are shorter and begin to overlap dorsally so as gradually to develop a sharp spinous keel.

First radials scarcely visible; the second short and sharply convex and the axillaries widely hexagonal. Both joints and also the first two brachials are slightly carinate and more or less fringed with small spines. They are also somewhat wall-sided, with straight lateral edges which extend on to the hypozygals of the third brachials.

Ten arms, of elongately quadrate joints, the outer ones overlapping a little. Syzygies in the third and about the thirteenth brachials, and then at very irregular intervals.

The second brachial bears a relatively large pinnule of some twenty joints, the lowest of which are broad, with strong dorsal keels and flattened outer sides. A similar but rather smaller pinnule on the third brachial; the next pair much smaller and but slightly carinate. The following pinnules increase slowly in length, and about the twentieth brachial they become boat-shaped at the base owing to the width of the third and the next few joints.

Disk rather incised and much plated, as are also the lower parts of the arms. The pinnule-ambulacra have fairly well-developed side plates, but the sacculi are small and rare.

Colour in spirit,—brownish-white.

Disk 6 mm.; spread about 12 cm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. Five specimens.

Remarks.—The only example of this species which came into my hands with the rest of the collection was the much mutilated individual represented on Pl. XII. figs. 3, 4. But after this plate had been drawn I received three other specimens in a much better state of preservation, together with the young form shown on Pl. XV. fig. 1. Portions of the arms and pinnules are represented on figs. 2–4 of the same plate.

Antedon gracilis occupies a curiously intermediate position between *Antedon valida* and *Antedon incerta* on the one hand, and *Antedon lusitanica* and *Antedon breviradia* on the other. The cirri are slender as in these latter species, while the two outer radials are carinate, as in some forms of *Antedon breviradia* (Pl. XI. fig. 5; Pl. XII. fig. 4). This feature, however, also shows itself in the larger forms, *Antedon valida* and *Antedon incerta;* while *Antedon gracilis* further resembles these types and differs from *Antedon breviradia* and its allied species in the fact that the third brachial bears a pinnule of the same kind as that on the second, smaller in size, but with similarly carinate lower joints which are flattened on the outer side. This is not the case in *Antedon lusitanica*, *Antedon breviradia*, &c., in which the pinnule of the third brachial resembles its successor more than it does the large pinnule on the preceding joint. The fringe of small spines on the radials and lower brachials rather obscures their straight edged and wall-sided character; but it is very distinct in the smoother individuals, and the lateral flattening of the basal joints in the first pinnules indicates the position of the type very clearly.

The pinnules above the twentieth brachial till near the end of the arm are remarkable for the characters of the third and following joints (Pl. XV. figs. 2, 4). These are widely V-shaped in section, so that the lower part of the pinnule has a boat-shaped appearance when seen from the dorsal side (Pl. XV. fig. 4). This expanded part of the pinnule encloses the genital gland and recalls on a smaller scale a similar arrangement in the pinnules of *Hyocrinus* (see Part I., pl. v*c*. fig. 10; pl. vi. fig. 1).

The enlargement of the lower joints gradually disappears towards the ends of the arms (Pl. XV. fig. 2), and there is no indication of it in the pinnules of the youngest individual obtained. This shows much more of the first radials externally than is visible in the adult (Pl. XII. fig. 4; Pl. XV. fig. 1); while the pinnule on the third brachial shows hardly any trace of the enlarged and carinate basal joints which appear in the adult, but is more like its successor as in the group of species next to be described.

5. *Antedon lusitanica*, n. sp. (Pl. XXXIX figs. 1–3).

Specific formula—A.(2).$\frac{ab}{c}$.

1884. *Antedon lusitanica*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 368.

Centro-dorsal hemispherical, roughened at the dorsal pole, and bearing twelve or fifteen slender cirri. These reach nearly 30 mm. and consist of about fifty joints, of which the fifth to the fifteenth are longer than wide. The following ones have a sharp dorsal spine which is smaller again in the terminal joints.

First radials scarcely visible; the second relatively short and trapezoidal, with traces of a median ridge which is continued on to the axillaries. These are short, wide, and pentagonal, with a slight backward projection in the middle of the proximal edge. The axillaries and the first two brachials have sharp straight edges and flattened sides.

The second and the hypozygals are also sometimes flattened on their inner sides. First brachials not much incised, and the outer portions of their dorsal surface are usually much less convex than the remainder.

Ten arms, of smooth elongated joints; but in one individual there are two series of two distichals each, the axillaries not syzygies. The third and the fourteenth or fifteenth brachials are syzygial joints.

First pinnule considerably larger than the second; its lower joints stout and wide, with the outer sides somewhat flattened. The second and the three or four next joints have their inner edges produced into strong keels which are slightly folded upwards. The following pinnules are quite small and increase but slowly in length.

Disk 5 mm. in diameter, thickly covered with numerous small plates, those at the sides of the ambulacra being rather more regularly arranged than the rest.

Pinnule-ambulacra not well defined, but the sacculi moderately developed.

Colour in spirit,—brownish-white or greenish-white.

Disk 5 mm.; spread probably about 12 cm.

Locality.—H.M.S. "Porcupine," 1870, Station 17A; lat. 39° 39′ N., long. 9° 39′ W.; 730 fathoms: bottom temperature, 49°·3 F. Ten mutilated specimens.

Remarks.—This is a peculiar species in many ways, and it is very unfortunate that the ten individuals obtained by the "Porcupine" should have all been so mutilated, the arms, except in two specimens, having broken away at the syzygy in the third brachials. These two individuals are shown in Pl. XXXIX. figs. 1, 3. One is a ten-armed form with the bases of some arms preserved as far as the second syzygy; while the other is peculiar in having two distichal series, each consisting of two articulated joints, so that the number of arms is raised to twelve. No trace of this arrangement appears on any of the other nine specimens, but on the other hand there is no indication whatever of its being due to fracture and subsequent regeneration, as is sometimes the case in other Comatulæ. A similar variation from the ordinary ten-armed type towards the bidistichate group has been described by Dendy[1] in *Antedon rosacea*, and another is presented by *Antedon flexilis* (Pl. XLII.); while *Antedon anceps*, *Antedon dubia*, and *Antedon multispina* are ten-armed species which are occasionally varied by the intercalation of tridistichate series.

If the discovery of better preserved material should show that the bidistichate condition of *Antedon lusitanica* is a natural one and not a mere accidental variation, the type will be worthy of special notice as the only *Antedon* found in European Seas which has normally more than ten arms. It is already distinguished as the only European *Antedon* with a plated disk and brachial ambulacra. The condition of the specimens which I have been able to examine is not such as to afford much information respecting the character of the ambulacral plates on the pinnules; but it is sufficient at any rate to show that sacculi are present and fairly well developed, as is not always the case in species which have an ambulacral skeleton.

Antedon lusitanica was dredged at 740 fathoms in the East Atlantic, and its nearest ally is undoubtedly *Antedon breviradia*, from 630 and 1350 fathoms in the South Pacific (Pl. XIX). Both species have short and wide second and third radials, *Antedon lusitanica* especially so, while in most examples of this type the margin of the axillaries and first brachials is much less rounded than the rest of their dorsal surface, and seems to stand off from it as lateral processes, a character which is scarcely perceptible in *Antedon breviradia*. The first pinnules of the two species are also different. The keels on the inner edge of their lower joints in *Antedon lusitanica* are less prominent than in *Antedon breviradia*, but at the same time they are more distinctly separated from one another than is the case in that type; while the lower cirrus-joints are relatively longer (Pl. XIX. figs. 1, 2; Pl. XXXIX. fig. 3).

5. *Antedon breviradia*, n. sp. (Pl. III. figs. 4, 5, *a–c*; Pl. XI. fig. 5; Pl. XIX.; Pl. XX. figs. 1, 2).

Specific formula—A.$\frac{b}{c}$.

Centro-dorsal hemispherical or bluntly concave, roughened at the dorsal pole, and bearing fifteen or twenty cirri. These have forty to fifty joints, or a few more, of which

[1] Description of a twelve-armed Comatula from the Firth of Clyde, *Proc. Roy. Phys. Soc. Edin.*, 1886, vol. ix. p. 180, pl. x.

the seventh to tenth are longer than wide. The following ones are shorter and develop a well-marked spine.

First radials scarcely visible; the next two short and convex, with occasional traces of a median ridge, especially in young individuals. Axillaries short and widely hexagonal, projecting backwards into the second radials. Both joints as well as the first brachials have straight edges and flattened sides. The inner faces of the second and the hypozygals of the third brachials are also slightly flattened.

Ten arms; the lower joints triangular or quadrate, rather longer than wide; the distal ones laterally compressed and overlapping so as to become carinate.

A syzygy in the third brachial; the next between the twelfth and twenty-fifth (usually about the fifteenth), and others at intervals of from one to fifteen, usually three or four joints.

The first pinnule, which is much larger than the second, consists of about a dozen joints. The first six are wide and thick, with their outer sides somewhat flattened, and the third to the fifth have their inner edges produced into expanded processes which are slightly folded upwards. The next three or four pinnules on either side are quite small and the length gradually increases, the later pinnules becoming styliform, with elongated joints. In some arms the first two joints of the distal pinnules are rather expanded and trapezoidal, but in others they are not specially modified.

Disk and brachial ambulacra well plated. Side plates and covering plates of the pinnule-ambulacra generally well differentiated. Sacculi largely developed in some pinnules and altogether absent in others.

Colour in spirit,—light brownish-white.

Disk 6 mm.; spread probably 16 cm.

Localities.—Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. Five specimens, one much mutilated, and another with cysts of *Myzostoma murrayi.*

Station 175, August 12, 1874; near Kandavu, Fiji; lat. 19° 2′ S., long. 177° 10′ E.; 1350 fathoms; Globigerina ooze; bottom temperature, 36° F. One imperfect specimen with a cyst of *Myzostoma murrayi.*

Remarks.—This is a singular species which unites three forms that I was at first inclined to consider as distinct. Like *Antedon lusitanica* it is an exclusively abyssal type, ranging down from 630 to 1350 fathoms, and individuals from each depth were infested with the cysts of *Myzostoma murrayi*, von Graff (Pl. XIX. fig. 2).

The second radials are relatively longer than in *Antedon lusitanica* and more distinctly incised by the axillaries, which are hexagonal rather than pentagonal as in that species (Pl. XI. fig. 5; Pl. XIX. fig. 1; Pl. XX. fig. 1); while in the younger individuals both the second and the axillary radials show distinct indications of a median ridge like that which is so marked in *Antedon spinicirra* and *Antedon acutiradia* (Pl. XI. figs. 1, 3, 5). The characters of the cirri and of the first pinnules also separate *Antedon breviradia* from *Antedon lusitanica*, which was probably without such distinctly carinate outer arm-joints as occur in *Antedon breviradia* (Pl. XI. fig. 5; Pl. XIX; Pl. XX. fig. 1). Some of the later pinnules of this species have the lower joints flattened and expanded as in *Antedon valida*, while in other arms there is but little trace of this peculiarity. There is a similar variation as regards the sacculi. On some pinnules they are abundant, alternating regularly with the side plates; on others there are very few, and some pinnules are altogether without them.

The characters of the centro-dorsal and calyx of *Antedon breviradia* undergo a considerable amount of change during development, as will be seen on comparison of figs. 4 and 5 on Pl. III., which I at first took to represent distinct species. The centro-dorsal is deeper and more conical in the older form, while its more numerous cirrus-sockets are arranged in tolerably regular vertical rows. There are two of these rows under each interradial angle, each with three sockets, which alternate with those of adjacent rows, and the dorsal pole is covered with a number of short stout processes of which there is but little trace in the younger individual (Pl. III. figs. 4*b*, 5*a*). The two forms also differ in the characters of the radial pentagon. In the younger one (fig. 5*b*) its under face is tolerably flat and smooth, with the rosette rather near the surface and little or no indication of a basal star; while in the older form (fig. 4*c*) the rosette is more deeply sunk within the axial opening, and is surrounded by a fairly definite basal star. The surface of each radial is also very convex and rises to one or two sharp points near the middle of its distal edge. These are well seen in the side view (fig. 4*b*), which is considerably different from that of the younger individual (fig. 5*a*). The lower part of the muscle-fossæ is occupied by two or three strongly marked ridges with intervening furrows, which are altogether absent in the less mature form. The latter, however, has the upper end of the muscle-plates more everted than in the adult condition, so that the central opening of the calyx is relatively larger and more pentagonal in appearance (Pl. III. figs. 4*a*, 5*c*). I have now no doubt, however, that these differences are merely those of growth, and that they are not of specific value, as I supposed them to be when Pl. III. was lettered.

7. *Antedon spinicirra*, n. sp. (Pl. XI. figs. 1, 2).

Specific formula—A.$\frac{b}{c}$.

Centro-dorsal hemispherical or bluntly conical, bearing twenty to twenty-five cirri with forty to forty-five joints, a few of the lowest of which are longer than wide, while all but the basal ones have a sharp dorsal spine.

First radials just visible; the second radials and axillaries sharply convex and almost carinate. The second are partly free laterally and but little incised by the hexagonal axillaries, which are much wider than long, with a more rounded dorsal surface, but only slightly overlapping the distal angles of the second radials. Both joints, and also the first brachials, have straight edges and flattened sides. The inner sides of the second and the hypozygals of the third brachials are likewise slightly flattened.

Ten arms; the second brachials relatively short and oblong, not projecting much backwards into the first, but both joints are sharply convex at their line of junction. The next few joints are nearly square and the following ones obliquely quadrate, longer than wide. The later joints overlap slightly and become somewhat sharply carinate. Syzygies in the third and about the thirteenth brachials; others at intervals of two or three joints.

The first pinnule larger than the second. Its lower joints relatively stout, with somewhat flattened outer sides, and the inner edges of the third to the fifth joints slightly carinate. The pinnules of the third and following brachials small and increasing slowly in length, the later ones sometimes showing a faint expansion of the two basal joints.

Disk much incised and well plated, and the brachial ambulacra slightly so. Pinnule-ambulacra tolerably well defined, the side plates with intervening sacculi.

Colour in spirit,—light brownish-white.

Disk 4 mm.; spread probably about 9 cm.

Locality.—Station 164, June 12, 1874; near Port Jackson; lat. 34° 8′ S., long. 152° 0′ E.; 950 fathoms; green mud; bottom temperature, 36°·5 F. Five specimens, two much mutilated.

Remarks.—There are several points of resemblance between this species and the younger forms of *Antedon breviradia*, which show a tendency to carination of the two outer radials (Pl. XI. fig. 5; Pl. XX. fig. 1). But the radials differ considerably in their other characters, while *Antedon spinicirra* has fewer cirrus-joints than the larger *Antedon breviradia*, with the basal ones relatively shorter and more spinous than in the latter type. Another point of difference is afforded by the first pinnules, the lower joints of which are much less expanded and carinate in *Antedon spinicirra* than in equally developed forms of either *Antedon breviradia* or *Antedon acutiradia*. This last is distinguished from both the preceding species by the great relative length of the radial axillaries (Pl. XI. fig. 3).

8. *Antedon acutiradia*, n. sp. (Pl. XI. figs. 3, 4).

Specific formula—A. $\left(\frac{b}{c} ?\right)$.

Centro-dorsal hemispherical, bearing about fifteen cirri, which have the fourth and some of the following joints much longer than wide, with traces of dorsal spines.

First radials just visible ; the second partly free laterally and deeply incised by the sharp proximal angles of the axillaries, which are longer than wide. Both joints are very sharply convex and almost carinate, but the axillaries are wider and have a more rounded surface than the second radials, which are partly hidden beneath their lateral angles. Both joints and also the first brachials have straight edges and flattened sides. The inner sides of the second and the hypozygals of the third brachials are also flattened.

Ten arms; the first brachials somewhat incised for the sharp proximal angles of the second,[1] both joints rising to their line of junction. The fifth and following joints smooth and obliquely triangular, much longer than wide, the later ones becoming obliquely quadrate.

Syzygies in the third and sixteenth brachials, and then at intervals of three or four joints.

First pinnule much larger than the second ; its lower joints wide and thick, with somewhat flattened outer sides. The third to fifth have their inner edges produced into expanded processes which are slightly folded upwards. The next pair of pinnules are rather larger than their immediate successors, but the following ones are quite small and increase very slowly in length.

Disk well plated and the brachial ambulacra slightly so ; pinnule-ambulacra without very definite side plates ; the presence of sacculi uncertain.

Colour in spirit,—light brownish-white.

Disk 4 mm.; spread probably 10 cm.

Locality.—Station 175, August 12, 1874 ; near Kandavu, Fiji ; lat. 19° 2′ S., long. 177° 10′ E.; 1350 fathoms ; Globigerina ooze ; bottom temperature, 36° F. Two mutilated specimens.

Remarks.—This type is unfortunately only represented by two calyces and half a dozen arm-fragments with their pinnules mostly broken. No entire cirri are preserved, and the position which I have assigned to this species among those with thirty to fifty spiny cirrus-joints is therefore a somewhat conjectural one. But it has so many points of resemblance with *Antedon spinicirra* and the two preceding species, that I have little doubt respecting the character of its cirri.

It is most closely allied to *Antedon spinicirra* (Pl. XI. fig. 1), but differs in the sharper carination and the greater relative length of the axillaries (Pl. XI. fig. 3).

The second radials are much compressed laterally so that they appear, as it were, at a lower level than the axillaries, the lateral angles of which overlap and partly conceal them. Traces of this arrangement are visible both in *Antedon spinicirra* and in *Antedon bispinosa*. In the former species the enlargment and carination of the lower

[1] There is a considerable amount of variation in this respect.

joints of the first pinnules is less marked than in *Antedon acutiradia*, which in this respect rather resembles *Antedon breviradia*.[1]

The state of preservation of the pinnules in the two individuals under consideration is unfortunately such that it is impossible to speak positively respecting the presence or absence of sacculi. But there is no trace of them in any of the few pinnules that I have been able to examine.

9. *Antedon bispinosa*, n. sp. (Pl. XX. figs. 3, 4).

Specific formula—A.$\frac{b}{c}$.

Description of an Individual.—Centro-dorsal almost columnar, bearing about twenty-five cirri on its sides. These have thirty to thirty-five joints, the three lowest of which are almost saucer-shaped, and the next ones much longer than wide. The remainder are shorter and acquire a marked keel which becomes reduced to a spine in the terminal joints.

Three radials visible, the distal edges of the first fringed with blunt spines. Axillaries pentagonal, with a curved base, overlapping the short second radials laterally. Each joint has a rounded and spinous centre raised above the lateral portions, which meet those of adjacent radials by flattened sides.

Ten arms; the margins of the lowest brachials fringed with blunt spines. First brachials rounded and short in the middle line, but with depressed lateral portions which meet one another by flattened surfaces all round the calyx. Second brachials more square and scarcely projecting backwards into the first. The eighth and following brachials become quadrate and slightly overlapping, with two or three large curved spines near the distal edge, which become very prominent in the outer portions of the arms.

Syzygies in the third and eleventh to fourteenth brachials, with others at intervals of three or more joints.

The lower pinnules all very spiny; the first much larger than its immediate successors, with the three or four basal joints somewhat flattened on the outer side, and the second to fifth with the inner edges slightly keeled and folded upwards. The pinnule on the third brachial but little larger than that on the fourth, and the following ones become gradually longer, with overlapping spinous joints.

Disk strongly plated, and the brachial ambulacra irregularly so. Pinnule-ambulacra with large covering plates and ill-defined side plates. Sacculi rare.

Colour in spirit,—white, with dark brown patches on the calyx.

Disk 6 mm.; spread probably 10 cm.

Locality.—Station 147, December 30, 1873; lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze; bottom temperature, 34°·2 F. One specimen.

[1] This character is hardly visible in the view of the calyx which is represented in Pl. XI. fig. 3.

Remarks.—This species has such very definite characters that it is not likely to be confounded with any other. The spiny calyx and the double row of long hook-like spines along the arms distinguish it very clearly. The radial axillaries come into contact above the depressed lateral portions of the second radials just as in *Antedon acuticirra*, and there is much the same sort of relation between the first and the second brachials. It is rather a robust species for such a considerable depth (1600 fathoms). But the sacculi are poorly developed, as is so often the case in the abyssal Comatulæ.

10. *Antedon latipinna*, n. sp. (Pl. X. fig. 3).

Specific formula—A. $\frac{b}{c}$.

Description of an Individual.—Centro-dorsal subconical and marked by twenty cirrus-sockets disposed in ten vertical rows. About forty joints in the cirri, a few of them longer than wide. The remainder are shorter and begin to overlap dorsally so as to develop a sharp spinous keel.

First radials partly visible; the second rather convex, short and oblong; axillaries pentagonal, with slight backward projections, wider than the second, but barely twice as long. Both joints, together with the first two brachials and the hypozygal of the third, have straight lateral edges and small portions of the outer sides flattened.

Ten arms, of short and smooth quadrate joints. Syzygies in the third and twelfth brachials, with others at intervals of seven to nine joints.

The second brachial has a short stout pinnule of about fifteen joints, the lowest of which are short, wide, and slightly carinate, but not flattened laterally. The following pinnules diminish to about the third pair and then gradually increase, their joints becoming elongated. Disk much incised and well plated. Side plates fairly distinct on the pinnule-ambulacra; sacculi apparently absent.

Colour in spirit,—light brownish-white.

Disk about 4 mm.; spread probably about 8 cm.

Locality.—Station 232, May 12, 1875; lat. 35° 11′ N., long. 139° 28′ E., 345 fathoms; green mud; bottom temperature, 41°·1 F. One mutilated individual.

Remarks.—This species differs from all the preceding ones in the characters of the first pinnule, the lowest joints of which, though wide and slightly carinate, have no indication of the flattening on the outer side which is so characteristic of *Antedon valida* (Pl. XV. figs. 5, 6), *Antedon breviradia* and others. The first two brachials and the hypozygal of the third have the usual wall-like sides and straight edges, but these features are less marked on the two outer radials. The cirri are arranged in ten very regular rows on the centro-dorsal, which is another character of separation from the species previously described; though traces of it are apparent in *Antedon breviradia* (Pl. III. fig. 4*b*). Only a few fragments of the arms are preserved, and no traces of sacculi are visible in the broken pinnules which I have been able to examine.

11. *Antedon multispina*, n. sp. (Pl. XIII. figs. 1–3; Pl. XIV. figs. 5–7; Pl. LXIX. figs. 1–4).

Specific formula—A. $\left(3.\frac{br}{2}\right).\frac{b}{b}$.

Centro-dorsal hemispherical, bearing about twenty cirri of twenty-five to thirty joints, a few of which are longer than wide. The remainder are shorter and overlap slightly so as to develop a dorsal spine.

First radials invisible in the adult; second very short (in the adult) and axillaries widely pentagonal. The axillaries and first brachials have flattened outer sides and straight edges; and the inner sides of the second and hypozygals of the third brachials are also flattened. Numbers of small spines on the calyx and arm-bases.

Usually ten arms, but one individual has two tridistichate series. Arm-joints elongately quadrate, with tufts of numerous small spines at one or both ends. The first pair of brachials borne on the distichal axillary are united by syzygy; but above the radial axillaries the third brachial is a syzygy, the next between the ninth and fifteenth, and others at intervals of three or four joints.

The second brachial bears a pinnule of about twenty-five joints, the lowest of which are wide, with their inner edges cut away a little and the outer sides slightly flattened. The next pair of pinnules are much smaller, and the following ones gradually increase in length, with the lower joints at first broadly V-shaped, but afterwards more elongated.

Disk and arms well plated. Side plates fairly developed on the pinnule-ambulacra, with moderately abundant sacculi.

Colour in spirit,—light brownish-white.

Disk 4 mm.; spread probably about 10 cm.

Locality.—Station 344, April 3, 1876; near Ascension; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W.; 420 fathoms; volcanic sand. Four broken individuals and three Pentacrinoid larvæ.

Remarks.—This species has perplexed me a good deal, on account of the mutilated condition of the specimens, three of which are quite immature, while the fourth, which is apparently full grown, has twelve arms owing to the presence of two tridistichate series (Pl. LXIX. figs. 1, 2). I was at first inclined to regard it as a small variety of *Antedon porrecta* (Pl. LII. fig. 3) which occurs at the same station. But the tridistichate character is the only resemblance between the two forms, their cirri, arms, and pinnules being altogether different; and I am therefore forced to conclude, as with *Antedon* *lusitanica*, either that the twelve-armed condition is a monstrosity, or that *Antedon multispina* is a dimorphic species. In the latter case it is rather a curious one. For in all the four arms which are borne on the two distichal axillaries (Pl. LXIX. figs. 1, 2) the first pair of brachials are united by syzygy just as in *Antedon angusticalyx*, *Antedon distincta*, and *Antedon inæqualis* (Pl. L. fig. 1; Pl. LI. figs. 1, 2), which do not conform to the ordinary rule of a syzygy in the third brachial.

Antedon multispina differs from the species already described in the preceding pages in the small number of its cirrus-joints, which does not seem to exceed thirty. It resembles most of them, however, in having a relatively small pinnule on the third brachial, which is more like its successors (Pl. XIII. fig. 3) than its predecessor. The two outer radials, especially the second which are very short, can hardly be described as wall-sided; but this feature is very marked on the outer side of the first brachials and on the inner side of the second and the hypozygals of the third brachials (Pl. LXX. figs. 1–3), while the first pinnules of adjacent rays are flattened laterally against one another and their inner sides are slightly cut away at the base, so as to recall the condition of *Antedon incerta* and allied species (Pl. XVIII. fig. 5).

From about the twelfth brachial onwards the third and next following pinnule-joints are expanded for the protection of the genital glands, having a broadly V-shaped section, though this is less marked than in *Antedon gracilis* (Pl. XV. fig. 4).

Besides the three young individuals of *Antedon multispina*, one of which is figured on Pl. XIII. fig. 1, the Challenger also dredged three Pentacrinoid larvæ, which presumably belong to this species, as it is the only ten-armed form met with at this station. They are relatively much larger and more robust than the corresponding larval stages of any other species which I have seen, with the exception of *Antedon eschrichti*. Figs. 3–7 on Pl. XIV. represent five larvæ, all equally magnified, which belong respectively to *Antedon hystrix?* (fig. 3), *Antedon tenella* (fig. 4), and *Antedon multispina* (figs. 5–7). Figs. 3–5 illustrate almost the same developmental stage in the three different species, that namely when the first cirri make their appearance and a fair number of arm-joints have been formed. Of the three larvæ, that of *Antedon tenella* is the oldest, having pinnules on the outer parts of the young arms, but it is altogether less robust than that belonging either to *Antedon hystrix?* or to *Antedon multispina*. The latter is remarkable for the shortness of its stem, which has only thirteen joints below the centro-dorsal, the two lowest being quite short and resting on a large and expanded dorsocentral plate (Pl. XIV. fig. 5). The centro-dorsal is a thin plate, but little larger than the joints below it, and the rudiments of three cirri have appeared upon it, the positions of the other two being indicated by imperfect sockets. In the next stage (Pl. XIV. fig. 6) the first pinnules have appeared on the arms, not at their bases, but about the eleventh or twelfth brachial, and the five radial cirri which were first formed are well developed so far as can be judged from their basal joints, which is all that remains of them, while there are one or two slight indications of the second whorl of cirri, the positions of which alternate with those of the first. The centro-dorsal has increased considerably in thickness, as has also the joint below it, which has similar re-entering angles, just as is the case in the infra-nodal joint in the stem of the Pentacrinidæ. Both of these larvæ have quite low basals as compared with those of the other species figured on the same plate, and especially *Antedon hystrix?* In this respect they approach the Pentacrinidæ and the typical Apiocrinidæ rather than *Rhizocrinus* and *Bourgueticrinus*, which they resemble in the characters of the middle and lower stem-joints. In the oldest larva, however, the basals are entirely concealed by the centro-dorsal, which has now reached a considerable size, with the second whorl of cirri well developed and even traces of a third, while there is only one discoidal joint below it. (Pl. XIV. fig. 7). In *Antedon multispina*, therefore, the basals become entirely concealed before the end of the Pentacrinoid stage, as in *Antedon tenella*, though it is not the case in *Antedon rosacea*.

The youngest of the three immature forms of *Antedon multispina* is considerably more advanced than the oldest Pentacrinoid larva. Not only the basals, but also portions of the first radials are concealed, and the first two pairs of pinnules have appeared, but from the fifth to the twelfth brachials the arms are devoid of pinnules. In the still older form, shown in Pl. XIII. fig. 1, the first radials are only just visible externally, though the second are relatively much longer than in the mature form. All the arm-joints are provided with pinnules, though the lowest ones are quite small, that on the second brachial being much more like its successor than is the case in the adult; while there is but little trace of any expansion in the lower joints of the genital pinnules.

The spines of the cirri are present from the first, but those on the calyx, arms, and pinnules do not appear till after the Pentacrinoid stage, while the lateral flattening of the radials and lower brachials is one of the last characters to make its appearance. This, of course, is only to be expected, for it is only when the arms become tolerably wide that their lower portions come into close lateral contact.

In the arms of the larvæ, as in the pinnules of the adult, the covering plates are supported upon imperfect side plates. These alternate very regularly with the sacculi, which are relatively much more abundant than in the adult.

12. *Antedon echinata*, n. sp. (Pl. XXI. figs. 4, 5).

Specific formula—A.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal a low hemisphere with about twenty cirri on its sides. These have some twenty-five joints, of which the fifth is longest, with a slight dorsal projection at its distal edge which becomes a spiny keel in the short later joints. First radials just visible; the second nearly oblong, not very convex, and barely united laterally. Axillaries about twice their length, broadly pentagonal, with slight backward projections. First two brachials nearly oblong. All these pieces have sharp, straight edges fringed with spines, and very slightly flattened sides.

Ten arms, of smooth, obliquely quadrate joints, as long or longer than wide.

Syzygies in the third and about the thirteenth brachials, with others at intervals of two to four joints.

First pinnule not much larger than that on the third brachial, and consisting of about twelve joints, of which the first five are rather expanded, with the inner edges a little cut away, and all have tufts of small spines along the dorsal border. The next two pairs of pinnules decrease slowly in length and become less spinous. The later ones are long, slender, and tolerably smooth.

Disk much incised and well plated; brachial ambulacra but slightly so. The pinnule-ambulacra have fairly definite side plates, and large sacculi are occasionally present.

Colour in spirit,—light brownish-white.

Disk 3 mm.; spread probably 60 or 70 mm.

Locality.—Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. One specimen.

Remarks.—This little form clearly belongs to the group of species with spiny cirri and relatively large first pinnules; but it is distinguished from its allies by a few well-marked characters. The number of the cirrus-joints does not seem to exceed twenty-five; while the bases of the rays have but slightly flattened sides, and the accompanying peculiarities of the lower joints of the first pinnules are barely recognisable (Pl. XXI. fig. 5). It approaches *Antedon multispina* in the abundance of the spines on the radials, lower brachials and their pinnules; but it differs altogether from that species in the smoothness of the distal arm-joints as well as in the appearance of the first radials externally, and in the relatively larger size of the pinnule on the third brachial. Some of the later pinnules have a few sacculi of unusually large size, but others are entirely without them.

13. *Antedon basicurva*, n. sp. (Pl. II. figs. 2, *a-d*; Pl. XXI. fig. 3; Pl. XXII. figs. 3, 4; woodcut, fig. 3; also Part I., pl. liv. fig. 9; pl. lv. fig. 7).

Specific formula—A. $\frac{b}{ab}$.

Centro-dorsal hemispherical, with a very rough dorsal pole and small interradial processes. About twenty cirri, of eighteen to twenty very stout joints, most of which are longer than wide. The earlier joints overlap slightly, and the later ones more so,[1] especially on the dorsal side, so as to produce a blunt spine at the distal edge which is rather sharper on the penultimate.

First radials entirely concealed in the adult, and sometimes portions of the second also. These are short and band-like, in close lateral contact, with raised edges which are often somewhat crenated, and there is usually a slight tubercle in the middle of the distal border, corresponding to one on the axillary. This is short and pentagonal with a wide, open angle and more or less crenated edges. The dorsal surface is very convex, with the margins more or less flattened, and wall-like sides. First brachials short, nearly oblong and closely united; the second more wedge-shaped. Both joints rise towards their apposed edges to form a median elevation like that between the second and third radials. The first three brachials wall-sided with flattened margins like the axillaries. The following joints short till about the twelfth, after which they are longer and more triangular, gradually becoming quadrate; the terminal ones elongated and slightly compressed laterally. Ten arms of about one hundred and twenty joints. In the lower parts of the arms the distal edge of each joint stands up as a sharp crenulated ridge from which the surface slopes backwards. As the joints become longer, further out on the arms, this sudden rise disappears, and they overlap in the ordinary way.

Syzygia in the third brachials and then very variable in position. The next between the ninth and sixteenth brachials, and others at intervals of one to sixteen (usually three to seven) joints.

The second brachial has a short pinnule of about twenty-two joints, of which the six lowest are trihedral and rather broad, and much flattened on the outer side, with a marked dorsal keel which is lost in the smaller terminal joints. A similar but rather smaller pinnule on the third brachial. The next pinnule has fewer joints, but the third and fourth are relatively broader, and in the succeeding pinnules very much so, with their outer faces greatly expanded towards the ventral side. This condition is most marked about the twelfth brachial, and then gradually decreases, being traceable to the twenty-fifth or thirtieth. After this it is lost and the pinnules gradually diminish in stoutness, but do not increase much in length.

Disk much incised and completely plated, as are also the arms, both along the ambulacra and at their sides. The genital glands protected by stout anambulacral plates.

The ambulacra of the distal pinnules have well-defined side plates alternating with but often partly concealing the sacculi. These are abundant and very large, especially on the genital pinnules.

Colour in spirit,—young individuals a yellowish-brown; the older ones a dark grey-brown.

[1] This is not well shown in the only cirrus remaining on the figured specimen.

Disk 7 mm.; spread about 20 cm.

Localities.—Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. Several specimens.

Doubtful.—Station 175, August 12, 1874; near Kandavu, Fiji; lat. 19° 2′ S., long. 177° 10′ E.; 1350 fathoms; Globigerina ooze; bottom temperature, 36° F. Some arm-fragments only.

Remarks.—This species and the following one (*Antedon incisa*) are sharply distinguished from the preceding members of this group of ten-armed Antedons by their smooth, stout cirri, and the peculiar expansion of the lower joints in the proximal and middle pinnules (Pl. XXI. fig. 2). The only other *Antedon* in which the latter character

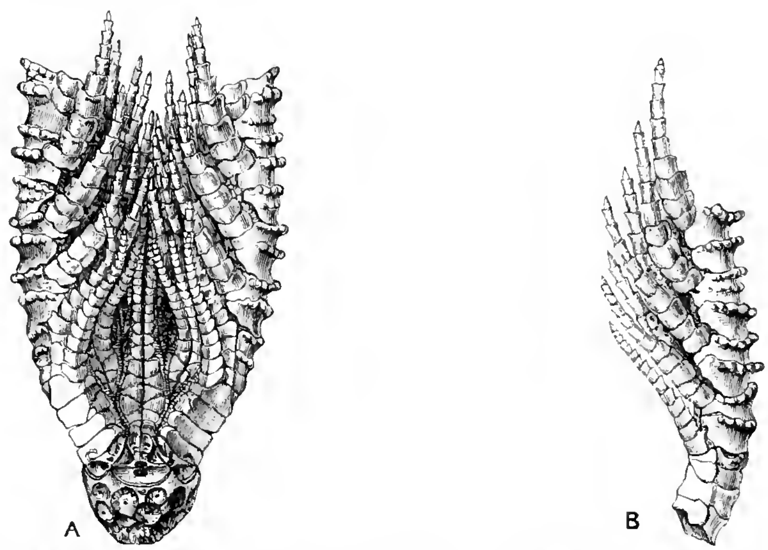

FIG. 2.—*Antedon basicurva*, × 3. A. Side view of the calyx and arm-bases after the removal of three rays, so as to show the sides and inner faces of the other two. The two outer radials, two lower brachials, and in a less degree also the third and fourth, have their outer sides flattened against one another. The genital pinnules have the third and fourth, and sometimes the fifth joints greatly expanded, but the following ones are smaller. B. The lower part of an arm from its inner side, to show the flattened inner faces of the first three brachials, including both the hypozygal and the epizygal of the third.

is similarly developed is a tridistichate species, *Antedon inæqualis* (Pl. LI. fig. 2), which occurs at the same two stations (Stations 170A and 174) as *Antedon incisa*, *Antedon basicurva* having been found at the former only. It is possible too that *Antedon basicurva* and *Antedon inæqualis* were obtained at Station 175;[1] though there appears to be much doubt upon this point. But whether this be the case or not, it is clear that the peculiarity in question is a local one and limited to this particular region of the South Pacific.

[1] Only two Comatulæ are recorded in the Station Book as having been found at this locality; and as the depth is considerable (1350 fathoms), I have little doubt that they are the two small forms of *Antedon breviradia* and *Antedon acutiradia* already described. The arms of the latter were all loose, however, and it is quite possible that the few arm-fragments of *Antedon basicurva* may have been amongst them; but no calyx of this species was obtained.

The first pair of pinnules in *Antedon basicurva* are considerably different from their successors. That on the second brachial is rather the larger of the two; but their general characters are identical (Pl. XXII. fig. 4). All the joints are quite short, but the first five or six are broad, carinate and trihedral, with their outer sides flattened, somewhat as in *Antedon valida* and allied species (Pl. XV. fig. 6). This is well seen in the woodcut (fig. 3). Traces of this lateral flattening are apparent in the pinnule on the fourth brachial, but those on the fifth and following brachials have the third and fourth joints very broad and expanded (Pl. XXII. fig. 3), though the fifth joint is smaller again and its successors very much so. These lower joints, which are so broad and almost flat on their outer side, afford support and protection to the genital glands which are situated on their inner faces. The ventral surface of the glands is covered by a pavement of anambulacral plates, often with large sacculi imbedded in them here and there as shown in *Antedon incisa* (Pl. XXI. fig. 2, *a*). But there are no side plates and covering plates as in the distal pinnules.

This expansion of the third and fourth pinnule-joints is best developed about the tenth or twelfth brachial, after which it gradually becomes less and less marked and the later joints more and more elongated. But the third and fourth joints are often distinctly broader and flatter than their successors as far out as the thirtieth brachial, after which they assume a more elongated form.

In one quite young specimen, only about one-third the size of that figured on Pl. XXII., there is comparatively little trace of this expansion of the third and fourth joints, even on the lower pinnules (Pl. XXI. fig. 3). The arms too are much smoother than in the adult, the edges of the lower brachials being but slightly raised, and showing no trace of the crenulation which is so marked in the more mature forms (Pl. XXII. fig. 3). The first radials are just visible as narrow curved bands immediately above the centro-dorsal, which are not smooth and continuous as usual, but broken here and there by pits. In a slightly older individual they are only represented by a row of irregular processes between the centro-dorsal and the second radials; while in the mature form they are altogether invisible, though traces of these processes appear after the removal of the second radials (Pl. II. fig. 2*a*).

The upper surface of the centro-dorsal is so much larger than the base of the radial pentagon (Pl. II. figs. 2, *a*, *c*, *d*) that the second radials partly rest upon it and so completely conceal the first, as in some forms of *Antedon rosacea*.

The cirrus-sockets are peculiar for having a very large articular facet in the centre, from which radiating processes extend all round to the margin of the socket, as seen in Pl. II. fig. 2*a*. The dorsal surface of the radial pentagon is marked by a well-defined basal star, the angles of which do not, however, appear externally (Pl. II. fig. 2*c*). The central funnel of the calyx (Pl. II. fig. 2*d*) is smaller than in *Antedon breviradia* (Pl. III. fig. 4*a*), as the ventral ends of the muscle-plates are less everted than in that type. There is a further resemblance between *Antedon basicurva* and the mature *Antedon breviradia*, in the presence of transverse ridges and furrows at the lower ends of the muscle-fossæ (Pl. II. fig. 2*a*; Pl. III. fig. 4*b*). I have found two radials without them, however, in one calyx of *Antedon basicurva*.

Some of the individuals of this species, including the youngest one above mentioned, are deformed by the cysts of *Myzostoma willemoesii*, and *Myzostoma tenuispinum*, von Graff.

14. *Antedon incisa*, n. sp. (Pl. II. figs. 1, *a–d*; Pl. XXI. figs. 1, 2).

Specific formula—A.$\frac{b}{a}$.

Centro-dorsal hemispherical, with a rough dorsal pole and small interradial processes. About fifteen cirri of some fifteen to eighteen rather stout, smooth joints, most of which are longer than wide. In the younger cirri the later joints overlap very slightly on the dorsal side so as to produce faint spines; this is lost in the older cirri, except in the penultimate, which bears a strong opposing spine.

Three radials visible; the first short and band-like with curved borders, meeting one another above the interradial processes of the centro-dorsal; the second somewhat longer, in close lateral contact, and rather convex in the centre, but little incised for their junction with the axillaries, which are also sharply convex, short and pentagonal, with very open angles. The axillaries and the first four or five brachials have the marginal portions of their dorsal surface flattened vertically, with sharp edges and wall-like sides.

Ten arms; the first brachials almost oblong, and very convex in the centre; the second shorter and more wedge-shaped. The following joints smooth and rather short till about the tenth, then longer and obliquely quadrate, becoming blunter and more elongated towards the end of the arm, but without any overlap.

A syzygy in the third brachial; the next frequently in the tenth, but sometimes not till the eighteenth; and others at intervals of one to nine, generally four to six, joints.

The second brachial has a longish pinnule of about thirty short joints, the lower ones rather flattened on the outer side with a sharp dorsal keel. A similar but shorter pinnule on the third brachial. The next pinnule is longer, with fewer but larger joints, the fourth and fifth of which are broad and expanded towards the ventral side. The expansion increases in the following pinnules, which have the third and fourth joints largest. This is most marked about the twelfth, but is traceable nearly to the thirtieth brachial. The remaining pinnules diminish in stoutness without increasing much in length.

Disk much incised and pretty completely plated, as are also the brachial ambulacra. The genital glands protected by stout anambulacral plates. The ambulacra of the distal pinnules have well-marked side plates, which are generally notched for the sacculi. These are large and abundant, especially on the genital pinnules.

Colour in spirit,—brownish-white, or light yellowish-brown.

Disk 7 mm.; spread about 18 cm.

Localities.—Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39·5° F. Four specimens and two fragments.

Station 174 (B, C, or D), August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms[1]; coral mud; bottom temperature (at 610 fathoms), 39° F. Two specimens.

Remarks.—This species is readily distinguished from *Antedon basicurva* by the smoothness of the arms and the appearance of the first radials externally (Pl. XXI. fig. 1). Another point of difference is that the wall-sidedness of the arm-bases extends out to the fourth, or even to the fifth, brachial, which is not the case in any of the preceding species. On the other hand the basal joints of the first pair of pinnules in the type form (from Station 170A) are less flattened and not so distinctly trihedral as in *Antedon basicurva* which occurs at the same station, so that the proximal pinnules are more like their successors than is the case in that species. It is curious, however, that in the two individuals from Station 174 (B, C, or D), where *Antedon basicurva* did not occur, the lower joints of the first pinnule show a distinct tendency towards the trihedral form characteristic of that type (Pl. XXII. fig. 4).

The first radials are completely visible in all the specimens of *Antedon incisa*, though they are shortest in those which are most mature (Pl. XXI. fig. 1), barely reaching half the length of the second radials, to which they are nearly equal in some of the younger individuals. A comparison of figs. 1 and 2 on Pl. II. will show other differences between the calyx of this type and that of *Antedon basicurva*. The former has a relatively smaller centro-dorsal, so that the radial pentagon covers it completely, and no part of it is exposed when the second radials are removed (Pl. II. figs. 1*d*, 2*d*). The under view of the radial pentagon is much the same in the two types, except for the portion of the first radial, which appears externally in *Antedon incisa* (Pl. II. fig. 1*c*). But the lower ends of the muscle-fossæ in the latter species are almost entirely without the ridge and furrow markings which are generally present in *Antedon basicurva*; the articular facet of the cirrus-socket is relatively smaller in *Antedon incisa* than in *Antedon basicurva*, and the radiating processes round the edge of the socket are less distinct (Pl. II. figs. 1*a*, 2*a*).

One of the six individuals obtained at Station 170A bore two large cysts of *Myzostoma tenuispinum*, von Graff (Pl. XXI. fig. 1), a species which also infests *Antedon basicurva* at the same station; but there is no trace of cysts on either of the two examples of *Antedon incisa* obtained at Station 174.

[1] The exact station, and consequently the exact depth, are not recorded.

15. *Antedon tuberosa*, n. sp. (Pl. XIV. fig. 9; Pl. XXIII. fig. 2).

Specific formula—A. $\frac{b}{a}$.

Centro-dorsal a thick disk with a rough dorsal surface. Fifteen to twenty cirri of thirteen to fifteen joints, of which the fifth is longest. The following ones gradually acquire a dorsal keel which passes into the opposing spine of the penultimate.

First radials concealed; second and third both short and wide, the former closely united laterally and the latter pentagonal with very open angles. The radials and the first three brachials are straight-edged and wall-sided, and more or less carinate in the middle line. Ten arms, of nearly one hundred and fifty joints; small blunt tubercles on the surface of the radials and arm-bases. First brachials oblong and closely united, the second more wedge-shaped; the third to the tenth brachials saucer-shaped, their distal edges being more or less raised and crenulated. This feature disappears in the following joints, which are more triangular, and elongate considerably towards the end of the arm. The lowest joints, especially in the younger arms, have a marked dorsal keel, which gradually dies away in the middle third, the terminal joints being quite smooth.

A syzygy in the third brachial; the next between the tenth and twenty-sixth brachials, and others at intervals of four to twelve, usually six to eight joints.

The first pair of pinnules tolerably equal, consisting of twenty to twenty-five joints, the lowest of which are broad and slightly keeled. The next pinnules slowly increase in length and in size, the third and following joints being expanded to receive the genital glands, which are protected by strong plates. The fourth and fifth are larger than the rest, but not markedly so. This ceases rather beyond the first third of the arm, and the pinnules then become more slender, with the basal joints square or longer than wide. Disk much incised and paved with small plates; the arms moderately so, and the pinnule-ambulacra have distinct side plates with intervening sacculi, which are also abundant in the plating over the genital glands.

Colour in spirit,—the young arms nearly white, the older ones a dark brownish-grey.

Disk 5 mm.; spread 25 cm.

Locality.—Station 210, January 25, 1875; off the Panglao and Siquijor Islands; lat. 9° 26′ N., long. 123° 45′ E.; 375 fathoms; blue mud; bottom temperature, 54°·1 F. One entire specimen and another much broken.

Remarks.—The absence of the first radials externally and the roughness of the arm-bases give this type a certain amount of superficial resemblance to *Antedon basicurva* (Pl. XXII. fig. 3). But it differs altogether from that species and from *Antedon incisa* in the characters of the pinnules, though the genital glands are protected by strong anambulacral plates, as in both these types. In these again the third and fourth joints of the genital pinnules are specially distinguished from the rest by the great breadth of their outer sides, which are enlarged at the expense of the inner sides (Pl. XXI. fig. 2; fig. 3 on p. 122). But the expansion of the pinnule-joints is much more uniform in *Antedon tuberosa*, as they increase and then decrease gradually from the base to the end of the pinnule, while both sides of each joint are enlarged, though the outer is slightly more so than the inner one. In these characters *Antedon tuberosa* resembles the smoother *Antedon parvipinna* and the ten-armed variety of *Antedon flexilis*; but apart from its occasional bidistichate character (Pl. XLII.), the latter form is readily distinguished by its longer cirri, the appearance of the first radials externally, and by the smoothness of the arm-bases.

All three species are remarkable for the great development of the sacculi, which are found not only between the side plates of the distal pinnules, but also along the medio-ventral line of the plated genital pinnules as in *Antedon incisa* (Pl. XXI. fig. 2*a*); but they are often absent in this position in other species, as, for example, *Antedon acœla* (see Part I. pl. liv. figs. 1–3).

A young larva was obtained at Station 210, which must belong either to *Antedon tuberosa* or to *Antedon distincta* (Pl. LI. fig. 1), the only two species found at this station. The latter, however, is a multibrachiate form with both distichal and palmar series, and from the appearance of the larva I think that it should most probably be referred to *Antedon tuberosa*. It is represented in Pl. XIV. fig. 9, and is so very similar to the corresponding stage of the Pentacrinoid of *Antedon rosacea*, except perhaps for being a trifle more robust, that little need be said about it. The centro-dorsal is still small and without any indication of its subsequent enlargement for the development of cirri, and but very few arm-joints have appeared above the radial axillaries.

16. *Antedon parvipinna*, n. sp. (Pl. XV. fig. 9).

Specific formula—$A.\frac{b}{a}$.

Description of an Individual.—Centro-dorsal discoidal, bearing some fifteen marginal cirri. These have about fifteen stout joints, of which the fifth and sixth are slightly longer than wide.

Minute plates, probably the basal rays, rest upon the interradial angles of the centro-dorsal and separate the bases of the nearly oblong second radials, the outer parts of which are in close lateral contact. Axillaries short and wide with very open angles, and also in close apposition. Both these joints have traces of a median keel which is continued on to the arm-bases. The first brachials nearly oblong, with their outer sides flattened; the inner sides of the second and hypozygals of the third brachials also flattened.

Ten arms; the joints after the eighth triangular, at first considerably shorter than wide, but gradually becoming more nearly equilateral and finally quadrate. A syzygy in the third brachial, the next between the eighth and twelfth, and others at intervals of five to nine joints.

The first pair of pinnules are relatively small and of tolerably equal size, consisting of little over a dozen short joints. The second pair have longer joints, and those of the sixth and following brachials have the third and the two or three next joints considerably expanded so as to enclose the genital glands, which are protected by plates. The fourth joint is larger than the rest, but not markedly so.

Disk and arms distinctly but not extensively plated; the pinnule-ambulacra have fairly defined side plates with intervening sacculi, which are also abundant in the plating over the genital glands.

Colour in spirit,—white.

Disk about 4 mm.; spread probably 12 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

Remarks.—This species comes very near to *Antedon tuberosa* (Pl. XXIII. fig. 2), but is quite free from the numerous blunt spines which are so characteristic of that species, its calyx and arms being almost completely smooth. Furthermore, the first pinnules are relatively shorter and much less flagellate than in *Antedon tuberosa*, consisting of a smaller number of joints and having an altogether stiffer appearance.

17. *Antedon flexilis*, n. sp. (Pl. XLII.).

Specific formula—A.(2).$\frac{b}{ab}$.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ N., long. 132° 14′ 15″ E.; 140 fathoms; blue mud.

Remarks.—This species will be described in the bidistichate group;[1] but its ten-armed variety finds a place here. It resembles *Antedon tuberosa* in the uniform expansion of the lower joints in the genital pinnules; but it differs altogether from that species in the appearance of the first radials externally and in the absence of spines on the arm-bases, while the cirri are stouter and have a larger number of joints than in either that type or *Antedon parvipinna*.

18. *Antedon aculeata*, n. sp. (Pl. XXIII. fig. 3).

Specific formula—A.$\frac{b}{a}$.

Description of an Individual.—Centro-dorsal subconical, bearing about fifteen cirri in five irregular rows which are radial in position. The cirri have about eighteen joints,

[1] See p. 217.

most of which are longer than wide and sharply compressed along the dorsal edge, the penultimate with an inconspicuous spine.

Three radials visible; the first short and band-like, marked by occasional grooves and projections. The second longer, with flattened lateral borders but sharply convex in the centre, where they rise to meet the backward projections of the axillaries. These and the first three brachials have a high centre and depressed margins like the second radials, with sharp lateral edges and flattened sides. Ten arms; the basal joints rather short, with a sharp medio-dorsal line; the following joints obliquely quadrate and more distinctly carinate, so as to overlap. Syzygies in the third and about the fourteenth brachials; others at intervals of five to eight joints.

The first pinnule rather larger than its immediate successors; their basal joints short and laterally compressed, with a sharp dorsal edge. In the pinnules of the tenth and following brachials the third joint and its successors are not expanded, but gradually become longer than wide, and in the terminal pinnules are much elongated.

Disk invisible; covering plates of the pinnule-ambulacra supported on a limestone band which is not distinctly segmented. Sacculi variable, but not very common.

Colour in spirit,—light brownish-white.

Spread probably 15 cm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. One specimen.

Remarks.—This species has straight-edged and wall-sided arm-bases, just as in *Antedon basicurva* and *Antedon incisa.* But it differs altogether from these types in the characters of the pinnules on the proximal third of the arm. So far as I have been able to make out, without mutilating the specimen, the proximal pinnules have somewhat of the trihedral form with flattened outer sides which is characteristic of *Antedon basicurva* (Pl. XXII. fig. 4). Their next successors are altogether different, however, the third and following joints gradually becoming relatively longer until they attain the usual elongated shape which is characteristic of the middle and terminal pinnules. But they acquire this shape at about the tenth or twelfth brachial, so that they differ from the broad and expanded pinnule-joints in the corresponding part of the arm of *Antedon tuberosa* (Pl. XXIII. figs. 2, 3), and the genital glands are unprotected by plates. The side plates of the pinnule-ambulacra are not well differentiated, and the sacculi are variable in their distribution, being moderately abundant in some pinnules and rare in others.

The arrangement of the cirri is peculiar. There are none upon the interradial portions of the centro-dorsal; but beneath each ray there is a somewhat irregular vertical row of two, three, or occasionally four sockets, all the rows converging on the apex of the subconical centro-dorsal.

19. *Antedon denticulata*, n. sp. (Pl. XXII. figs. 1, 2).

Specific formula—A.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal hemispherical, with a denticulate rim. Twenty to twenty-five rather slender cirri, of twenty-five to thirty smooth joints, nearly all of which are longer than wide, the fifth and sixth longest.

First radials not visible; second short and rather convex in the centre; axillaries short and widely pentagonal with slight backward projections. Both the radials and the first two brachials are wall-sided, with straight edges and the margins of the dorsal surface flattened.

Ten arms; the lower joints nearly oblong and the following ones smooth, short, and bluntly wedge-shaped, gradually becoming more oblong about the middle of the arm. Syzygies in the third and twelfth or thirteenth brachials; others at intervals of four to six joints.

The pinnule on the second brachial is rather longer than that on the third, and the length increases to the third pair (on sixth and seventh brachials). These consist of about a dozen joints, the lowest of which are broad and slightly carinate. The next pair are smaller with relatively longer joints and the following ones increase slowly in length.

Pinnule-ambulacra not plated; sacculi apparently absent.

Colour in spirit,—very light brown.

Spread, perhaps 14 cm.

Locality.—Station 190, September 12, 1874; lat. 8° 56′ N., long. 136° 5′ E.; 49 fathoms; green mud. One specimen.

Remarks.—This species and the following one are readily distinguished from all those previously described with wall-sided arm-bases by the entire absence of any ambulacral skeleton on the pinnules; but they differ altogether from one another, especially in the characters of the pinnules and of the arm-joints. *Antedon denticulata* has quite short arm-joints, the lower ones obliquely quadrate and their successors more nearly oblong, but always much wider than long (Pl. XXII. fig. 1), and the third pinnule is the largest. But in *Antedon pusilla* the arm-joints are as long or longer than wide (Pl. XXIII. fig. 1), and the first pinnule is the largest.

There appear to be no sacculi in *Antedon denticulata*, or at any rate I have been unable to find them. Their absence is remarkable in a form with unplated ambulacra, especially as they are abundant in four individuals of *Antedon fluctuans*, which were dredged at the same station.

20. *Antedon pusilla*, n. sp. (Pl. XXIII. fig. 1).

Specific formula—A. $\frac{b}{b}$.

Description of an Individual.—Centro-dorsal a low hemisphere bearing about fifteen cirri with some twenty-eight joints, few of which are longer than wide, the distal ones with a slight dorsal keel.

First radials partially visible; the second short and oblong with the centre of the distal edge raised to meet the proximal edge of the axillary and form a tubercle. A similar but smaller tubercle at the junction of the first two brachials. All four joints are wall-sided and straight-edged, with the margins of the dorsal surface flattened.

Ten arms of smooth and elongated obliquely quadrate joints; syzygies in the third and then generally in the eighth or ninth brachials, with others at intervals of one to five, usually three joints.

The first pinnule consists of about a dozen elongated joints and is considerably longer and stouter than its successors, which decrease to about the fourth pair and then gradually increase. The two lowest joints of the later pinnules are expanded and trapezoidal, but the following joints are slender.

Pinnule-ambulacra not plated; sacculi abundant.

Colour in spirit,—light brownish-white.

Spread about 7 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

Remarks.—This is an elegant little form with long arm-joints and the first radials visible externally, both of which characters are frequently indicative of immaturity. But the great development of the genital glands, which are often found as far out on the arms as the sixtieth brachial, seems to negative this idea in the present case. The two characters just mentioned distinguish *Antedon pusilla* from *Antedon denticulata*, from which it also differs in the presence of tubercles on the rays and arm-bases, in the much shorter cirrus-joints, and in the fact that the first and not the third pinnule is the largest. The distal pinnules are very delicate and their two basal joints altogether different from the rest, being expanded and trapezoidal, with their apposed edges much curved, as in many of the Circumpolar species, while there are large and abundant sacculi on both arms and pinnules.

2. The *Acœla*-group.

This group includes, at present, only two species, which differ from one another in nearly all the characters of the cirri, arms, and pinnules, but are allied to the *Basicurva*-group in the presence of a plated disk and of a well-defined ambulacral skeleton, characters which appear in no other ten-armed Comatulæ.

Pinnule-ambulacra well plated.
Less than twenty smooth cirrus-joints; genital pinnules with broadly expanded joints and strong protecting plates, ... 1. *acœla*, n. sp.
Forty or more spiny cirrus-joints; no enlargement of the genital pinnules; first joint of lower pinnules much expanded, ... 2. *discoidea*, n. sp.

1. *Antedon acœla*, n. sp. (Pl. II. figs. 3, *a–d*; Pl. XVI.; also Part I., pl. liv. figs. 1–4; pl. lv. fig. 5).

Specific formula—A.$\frac{b}{a}$.

Centro-dorsal subconical or hemispherical, bearing twenty-five to thirty cirri. These have fifteen to eighteen smooth joints, nearly all of which are longer than wide. Terminal claw sharp, with but little trace of an opposing spine.

First radials only visible in young specimens; the second somewhat flattened, with a convex proximal and concave distal border. Axillaries more convex, broadly pentagonal or almost rhombic, with a wide distal angle, and sometimes projecting deeply backwards into the second radials. The dorsal surfaces of both radials, with the two lowest brachials and the hypozygals of the third, project beyond their faces and sides, especially the latter, which fall away rapidly from the dorsal towards the ventral border.

Ten arms. First brachials nearly oblong with rounded outer edges; the second convex and irregularly pentagonal. About one hundred smooth triangular joints, as long as or longer than wide. Syzygies in the third and then about the eleventh or twelfth brachials, with others at intervals of two to five, usually three or four joints.

The first pair of pinnules have about thirty short joints, the lowest of which is a good deal wider than the rest. From the fourth to the twenty-fifth brachials about three to five of the pinnule-joints are greatly expanded laterally to enclose the genital glands, and the first joint is much wider than its successors, especially in the lower pinnules. The later pinnules have longer and more trihedral joints, the lowest of which are flatter.

Disk rather incised and completely covered with irregular plates bearing short and blunt rod-like spines. Brachial ambulacra and interarticular spaces well plated, and the expanded parts of the genital pinnules are completely enclosed in an arched pavement of flat plates, very regularly arranged and devoid of ambulacra. The ambulacra of the later pinnules have very well-defined side plates, sometimes covering the sacculi and sometimes notched for them. These are very abundant, except on the non-tentaculiferous genital pinnules.

Colour in spirit,—young individuals straw-coloured; the older ones a dense brownish-grey, becoming a dark grey in the most mature.

Disk 5 mm.; spread probably 20. mm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. Several specimens.

Remarks.—This is a peculiar species for many reasons. In its general characters it has many points of resemblance with *Antedon basicurva*, *Antedon incisa*, and *Antedon tuberosa*; but the sides of the basals and lower radials are not in close apposition and flattened laterally against each other as in those types, for they fall away very rapidly from the dorsal towards the ventral surface, so that there is a considerable space between every two rays, especially at the level of the articulations (Pl. XVI. fig. 1).

This is smaller on the surface than it is deeper down, for the lateral edges of the joints are produced outwards like the projecting eaves of a roof. This condition is extremely marked in the case of the second radials, which have the proximal edge similarly produced so as to overlap the minute portion of the first radials which appears externally. The relative shapes of the two outer radials vary extremely. Their usual appearance is represented in Pl. XVI. fig. 1; but in some individuals the second radials are rather more oblong and show hardly any indication of an incised distal edge, while the axillaries are widely pentagonal. On the other hand the axillaries sometimes project far backwards into the second radials, which thus have a deeply incised distal edge, while the proximal edge is also much curved.

In young specimens, such as that shown in Pl. XVI. fig. 2, a considerable portion of the first radials is visible, but the projection of the edges of the next following joints is almost as marked as it is in the mature individual. In the youngest specimen, with a spread of about 80 mm., the external surface of the first radials is rather less wide than that of the second, and a trifle more than half its length. It does not, however, increase in size along with the corresponding parts of the two outer radials, but remains undeveloped and is sometimes marked by small tubercular elevations like those on the centro-dorsal, from which it is with difficulty distinguishable. These are situated in the gap between the ventral edge of the centro-dorsal and the proximal edges of the second radials, which project backwards so as to overlap and conceal them.

The most striking character of *Antedon acœla*, and the one which allies it most closely to the *Basicurva*-group, is the great size, both of the pinnule-joints and of the protecting plates on the genital pinnules. Even the second pair of pinnules are enlarged for the reception of the genital glands, three of their middle joints being expanded; and a little further from the disk the fifth and the four or five following joints are flattened and produced laterally, as shown in Pl. XVI. fig. 2, the proximal joint being often much enlarged at the same time. This expansion is not almost entirely limited to the outer side only as in *Antedon incisa* (Pl. XXI. fig. 2), but it is equal on both sides of the medio-dorsal line; and the ventral portion of these expanded joints is covered by an arched pavement of strong plates, few in number but of large size, and often very regularly arranged, as seen in figs. 1–3 of pl. liv. in Part I. These protecting plates are much larger and better developed than in either *Antedon incisa* or *Antedon tuberosa*, and they often alternate more or less regularly on opposite sides of the medio-ventral line of the pinnule, where there is an opening in one of them for the exit of the genital products.

In the young individuals obtained, even in those with a spread of 12 cm., there is no trace of the enlargement either of the pinnule-joints or of the protecting plates (Pl. XVI. fig. 5), although both are visible in the older forms, which still show a considerable part of the first radials externally. In the regenerated arms too the lower pinnules are for some time quite small and inconspicuous, and altogether different from those of the uninjured mature individuals. This is the case even when the arm has attained almost its full size, and is absolutely larger than those of other individuals not yet quite mature, but with comparatively large genital glands.

All these greatly enlarged genital pinnules are devoid of ambulacra, like the non-tentaculiferous posterior arms of *Actinometra;* but at about the position of the twenty-fifth brachial there is a sudden diminution in size both of the pinnule-joints and of the protecting plates, more especially of the latter. They become much smaller and relatively more numerous, while the sacculi which are absent in the large lower pinnules begin to appear, just as they show themselves in the genital pinnules of *Antedon angusticalyx* from the same station;[1] while eventually the ambulacral skeleton shows itself above the small protecting plates, as in *Antedon incerta.*[2] A little further out on the arms these protecting plates disappear, and the ambulacral skeleton comes to rest directly upon the pinnule-joints, as shown in Pl. XVI. fig. 4. The side plates are very well differentiated and are often notched for the reception of the sacculi or of portions of them; but in other cases, when the sacculi are large, they are altogether covered and concealed by the side plates.

2. *Antedon discoidea*, n. sp. (Pl. X. figs. 1, 2).

Specific formula—$A.\frac{a}{c}$.

Centro-dorsal a thick disk, bearing fifteen to eighteen cirri in a single or partially double row, with the dorsal surface free. The cirri reach 27 mm. in length and consist of forty or fifty joints, a few of which at the base are longer than wide, and the following ones gradually develop a sharp dorsal keel.

Three radials visible; the first short, except at the angles of the calyx, where the ends of the basal rays sometimes appear. Second radials short, wide and oblong, and the axillaries barely pentagonal.[3] Both joints have large muscle-plates, and their dorsal surfaces rise towards the middle of their apposed edges. Rays well separated.

[1] See Part I., pl. liv. fig. 5. [2] See Part I., pl. liv. fig. 6.

[3] The above description applies to the joints as seen in full face view. They have a very different shape in the figure of the entire animal, owing to the angle at which the rays are set on the calyx (Pl. X. fig. 1).

Ten arms. First brachial almost oblong; the second bluntly triangular, with a large lateral process bearing the pinnule-facet. The next few segments each have a process of the same kind, but gradually decreasing in size. Arm-joints after the tenth, triangular, as long as wide, and slightly overlapping, but more quadrate towards the end. Syzygia in the third and beween the tenth and fourteenth brachials; others at intervals of two to five, usually three, joints.

The first two pairs of pinnules have twenty or more short joints, the first of which is much expanded dorsally and the next two slightly so. This expansion gradually dies away in the following pinnules, which increase in size, becoming stiff and rod-like, and composed of long cylindrical joints, after the first two, which are laterally compressed.

Disk and brachial ambulacra much plated. Covering plates of the pinnule-ambulacra supported on a well-developed limestone band, which is not clearly divided into side plates; the sacculi concealed by it are very large and closely set.

Colour in spirit,—yellow or yellowish-white, with occasional brown or purplish bands.

Disk 6 mm.; spread about 16 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. Four specimens.

Remarks.—This is a singular species in many ways and is readily distinguished by the characters of the lower arm-joints and of the pinnules which they bear. The broader end of each joint projects considerably from the general lateral line of the arm, so as to form a large pinnule-facet; and the dorsal part of the first pinnule-joint is expanded into a large curved plate which covers in this facet. This plate, which is well shown in Pl. X. fig. 2*a*, is sometimes so large that the whole arrangement looks as if it were a malformation due to the action of an encysting *Myzostoma* which had taken up its abode in the pinnule-socket. It is largest in the first two pairs of pinnules, the remaining joints of which are relatively quite short, especially in the first pair (Pl. X. fig. 2*a*), but by the fourth pair (Pl. X. fig. 2*b*) the two basal joints are less expanded, though the third is slightly so, while the following joints are much longer and somewhat carinate. In the middle and distal pinnules this tendency disappears and the two lower joints have the usual somewhat flattened appearance.

The lateral projection of the arm-joints to form large pinnule-sockets is a point of some interest because it occurs in some forms of the Jurassic *Antedon costata*, as for example that figured by Walther on taf. xxv. fig. 6 of his memoir. He describes the arm-joints as follows "Das dickere Ende trägt einen dorsalen Knoten und einen seitlichen Fortsatz zur Insertion der Pinnula."[1]

The sacculi are fairly developed on the arms of *Antedon discoidea*, and in the pinnules they are large and extraordinarily abundant. They are covered, however, by the

[1] *Loc. cit.*, p. 172.

substantial limestone band which supports the covering plates but is not properly segmented into side plates. The ambulacral skeleton does not extend to the end of the pinnules, several joints of which are entirely without it, as in *Antedon longicirra* from the same station, and in many Pentacrinidæ.

3. The *Eschrichti*-group.

This group is very well defined both in its zoological characters and in its geographical and thermal distribution. Of the seven species which it at present contains, three are Arctic and the remaining four Antarctic. *Antedon eschrichti* and *Antedon quadrata* are widely distributed through the Arctic Ocean, reaching a latitude of 79° N., and 81° N. respectively in Smith's Sound. They extend across the North Atlantic into the Barents Sea, and *Antedon eschrichti*, at any rate, was dredged by Nordenskjöld in the "Vega" as far east as long. 92° 20′ E.. In the East Atlantic both species are found as far south as the parallel of 60° in the cold area of the Færoe Channel; but the Challenger dredged them both off Halifax in lat. 43° 2′ N. This is their furthest southern limit, and the third Arctic species belonging to this group (*Antedon barentsi*) has as yet only been found near Vardö in the Barents Sea.

Two of the four Antarctic species occur in the Straits of Magellan, while the other two were obtained by the Challenger at Stations 150 and 151, between Kerguelen and Heard Island. The only species found at depths exceeding 200 fathoms are *Antedon eschrichti* and *Antedon quadrata*, both of which extend downwards from the littoral fauna, the former descending to 632 and the latter to 466 fathoms. The temperature limits of this group are very well defined. There is no record of any of them having been found in water of a higher temperature than 36° F. *Antedon quadrata* was obtained at 29° and *Antedon eschrichti* at 30° in the cold area of the Færoe Channel; while *Antedon australis* was dredged from a temperature of 35°·2 at Station 150. I do not imagine that this is likely to have been greatly exceeded at any of the shallow water localities, either in the Arctic or in the Antarctic Seas, where species of this group have been obtained. They are not, however, the only Comatulæ which occur in the colder seas of the globe. *Antedon prolixa* was obtained in 25 fathoms at Discovery Bay (lat. 81° 41′ N.) together with *Antedon quadrata*, and has since been dredged in abundance near Spitzbergen by the Norwegian North-Atlantic Expedition, from a depth of 743 fathoms; while the "Varna" found it at 50 fathoms in the Kara Sea.

The "Porcupine" and "Triton" met with *Antedon hystrix* in the cold area of the Færoe Channel where *Antedon eschrichti* and *Antedon quadrata* also occur; while *Antedon tenella*, which reaches a latitude of 79° near Franz Joseph Land, is common in the Barents Sea and on both sides of the Atlantic down to 740 fathoms, with a thermal range of from 30° to 50° F.

Apart from the absence of any lateral flattening of the rays and arm-bases and of an ambulacral skeleton, the special character distinguishing the *Eschrichti*-group is the flagellate appearance of the proximal pinnules. The two first pairs (on second to fifth brachials), and sometimes also the third pinnule on the outer side of the arm (on sixth brachial), consist of a large number of short and wide joints, the later ones of which are often somewhat serrate (Pl. XXIV. figs. 1, 2, 7, 8; Pl. XXV. figs. 1, 2; Pl. XXVII. figs. 8, 9, 11, 12, 14, 15). The cirri are always numerous and composed of thirty to fifty joints; while the long arms bear numerous closely set pinnules, so as to give a very feathery appearance to the general plume. The regular arrangement of the syzygies too is very striking as compared with the *Basicurva*-group, the members of which exhibit hardly any regularity in the grouping of the syzygies, except for the presence of one in the third brachial as in most Comatulæ with articulated radials. In the *Eschrichti*-group, however, as also in *Antedon phalangium*, *Antedon rosacea*, and allied species, the syzygies are situated with great uniformity in the third, eighth, and twelfth brachials, and afterwards at intervals of two or three joints. The position of the third syzygy is less constant than that of the second, but does not vary to any great extent (Pl. XXIV. fig. 11; Pl. XXV. fig. 12; Pls. XXVI., XXVIII.).

It will be seen from the following table that the differences between the individual species mostly turn upon the characters of the third pinnule, the relative shape of the arm-joints, and the number of the cirrus-joints. *Antedon rhomboidea* and *Antedon barentsi* are species based upon single individuals; but I have seen seven examples of *Antedon australis*, and a considerable number of each of the other four species, those of *Antedon eschrichti* and of *Antedon quadrata* being from several different localities. Neither *Antedon barentsi* nor *Antedon magellanica* were obtained by the Challenger at all, the former living in the Barents Sea,[1] while *Antedon magellanica* was obtained by H.M.S. "Alert," and was described as a variety of *Antedon eschrichti* by Bell.[2] I have pointed out elsewhere,[3] however, that it is altogether separated from *Antedon eschrichti* by the characters of its arm-joints, a point to which Bell did not refer, and I have since examined several individuals of it which were dredged by the Italian corvette "Vettor Pisani," and have no doubt whatever as to its being a good species. Although not Challenger species, these two are included in the following list for the sake of completeness.

[1] The Comatulæ of the "Willem Barents" Expeditions, 1880 and 1881, *Bijdragen tot de Dierkunde*, 1886, 13 Aflevering, vi. pp. 1–12.

[2] Note on a Crinoid from the Straits of Magellan, *Proc. Zool. Soc. Lond.*, 1882, p. 651.

[3] *Bijdragen tot de Dierkunde*, 1886, 13 Aflevering, vi. p. 4.

The first two or three pairs of pinnules long and flagellate, with numerous short and wide joints.

A. Third pinnule equal to, or not much shorter than the second.
  I. Joints of the third pinnule mostly wider than long, as in the first and second. Arm-joints triangular, but quite short.
    a. Forty or more cirrus-joints. Axillaries as wide as long. Arms smooth. Third pinnule most like the second, . . . 1. *eschrichti*, Müll., sp.
    b. Less than forty cirrus-joints. Axillaries wider than long. Arm-joints overlap. Third pinnule most like the fourth, . . . 2. *antarctica*, n. sp.
  II. Third pinnule has fewer but much longer joints than the first and second.
    a. Less than forty cirrus-joints. Arm-joints triangular.
      1. Arm-joints short and much wider than long, . . . 3. *australis*, n. sp.
      2. Arm-joints as long as or longer than wide, . . . 4. *rhomboidea*, n. sp.
    b. Over forty cirrus-joints. Arm-joints quadrate, and as long as or longer than wide, ... *magellanica*, Bell.
B. Third pinnule composed of a few elongated joints, and much shorter than the second.
  I. About forty cirrus-joints. The middle arm-joints quadrate, . . 5. *quadrata*, n. sp.
  II. Twenty-five to thirty cirrus-joints. The middle arm-joints triangular; genital pinnules plated, ... *barentsi*, Carpenter.

1. *Antedon eschrichti*, Müll., sp. (Pl. I. figs. 8, *a–d*; Pl. XXIV. figs. 4–14, woodcut, figs. 4, C, D, on p. 154).

Specific formula—A.$\frac{c}{c}$.

1841. *Alecto Eschrichtii*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 183.
1849. *Comatula (Alecto) Eschrichtii*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1847 [1849], p. 254.
1854. *Alecto Eschrichtii*, Stimpson (?), Mar. Invert. Grand Manan, 1853 [1854], p. 12.
1857. *Alecto Eschrichtii*, Lütken, Vidensk. Meddel. nat. Foren. Kjobenhavn, 1857, p. 55.
1860. *Alecto glacialis*, Walker, Journ. Dublin Soc., 1860 [1862], vol. iii. p. 70.
1862. *Comatula Eschrichtii*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Echinodermes Paris, 1862, p. 199.
1866. *Antedon Eschrichti*, Lovén, Öfversigt k. Vetensk.-Akad. Förhandl., 1866, No. 9, pp. 224, 230, figs. *i–m*.
1866. *Antedon Eschrichtii*, Verrill, Proc. Boston Soc. Nat. Hist., 1866, vol. x. p. 343.
1872. *Antedon escrichtii*, Wyville Thomson, Proc. Roy. Soc. Edin., 1872, vol. vii. p. 764.
1876. *Comatula Eschrichtii*, Quenstedt, Petrefactenkunde Deutschlands, 1876, Bd. iv. Asteriden und Encriniden, p. 165, Tab. 96, fig. 16.
1879. *Antedon Eschrichtii*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1880. *Antedon Eschrichtii*, d'Urban, Ann. and Mag. Nat. Hist., 1880, ser. 5, vol. vi. p. 261.
1881. *Antedon Eschrichtii*, Duncan and Sladen, Memoir Arctic Echinodermata, London, 1881, p. 73, pl. vi. figs. 1–4.
1882. *Antedon Eschrichtii*, Hoffmann, Niederländ. Arch. Zool., 1882, Supplement Bd. i., Lief 3, p. 1.
1882. *Antedon eschrichti*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1882. *Antedon eschrichti*, P. H. Carpenter, *Ibid.*, p. 746.

1884. *Antedon eschrichti*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. pp. 364, 374.
1886. *Antedon Eschrichti*, P. H. Carpenter, Bijdragen tot de Dierkunde, 1886, 13 Aflevering, vi. p. 5, pl. i. figs. 7–10.
1886. *Antedon Eschrichtii*, Levinsen, Dijmphna-Togtets zoologisk-botaniske Udbytte, Kjøbenhavn, 1886, p. 410, Tab. xxxv. figs. 7, 8.
1886. *Antedon Eschrichtii*, Stuxberg, Vega-Expeditionens Vetenskapliga Arbeten, Stockholm, 1886, Bd. v. p. 162.
1886. *Antedon Eschrichtii*, Fischer, Die Österreichische Polarstation Jan Mayen, Bd. iii., Wien, 1886, Echinodermen, p. 3.

Centro-dorsal hemispherical, bearing a very large number of cirri, reaching a hundred in old specimens. The dorsal pole, which is somewhat flattened, is free, but elsewhere they are very closely set and may reach over 70 mm. in length, consisting of forty to sixty joints, but few of which are longer than wide. The later joints project slightly, but do not form definite spines.

First radials almost entirely invisible in the adult; second quite short, oblong or crescentic, according to the amount of incision by the axillaries, and almost free laterally, with large muscle plates. Axillaries more than twice their length, triangular or rhombic, with incurved sides. They are about as long as wide, and have a sharp distal angle.

Ten arms, with over three hundred joints in a large specimen. First brachial deeply incised, with a short inner and much longer outer edge. The second irregularly quadrate, and the succeeding joints to the eighth nearly triangular, with the pinnules on their shorter sides and their apposed edges rising to tubercular prominences alternately on the outer and inner sides of the arm. The following joints smooth and triangular, much wider than long, becoming quadrate towards the end of the arms. Syzygies in the third, eighth, and twelfth brachials, with others at intervals of two or three joints.

The lower pinnules long and flagellate, composed of numerous short joints, rather wide at the base. The second (on the fourth brachial) is usually the longest, reaching nearly 40 millimetres in length and consisting of about seventy joints. The third pinnule is of variable length, but its lower joints are larger than those of the second, though distinctly wider than long. In the first three or four pairs of pinnules the dorsal edges of the lower joints are sharp and cut away at the ends, so as not to meet their fellows, and in the small terminal joints this sharpened edge is produced into a bluntly angular process, making the end of the pinnule somewhat serrate. The following pinnules are shorter and more massive, with large lower joints, which are nearly square in outline and gradually become longer than wide. The middle pinnules reach 30 millimetres with about forty joints, the two lowest of which are flattened and somewhat trapezoidal, with their apposed edges incurved. Genital glands long and fusiform. Disk and arms not plated; sacculi extremely abundant.

Disk 25 mm.; spread 50 cm. (maximum).

Colour in spirit,—light reddish-brown.

Localities.—H.M.S. "Porcupine," 1869, Station 57; lat. 60° 14′ N., long. 6° 17′ W.;

632 fathoms; bottom temperature, 30°·5 F. Three (or more) specimens. Also at other unrecorded localities in the "cold area."

H.M.S. Challenger, Station 48, May 8, 1873; on the Le Have Bank; lat. 43° 4′ N., long. 64° 5′ W.; 51 fathoms; rock. Several specimens.

H.M.S. "Valorous," Station 1, July 22, 1875; off Hare Island, in Davis Strait; lat. 70° 30′ N., long. 54° 41′ W.; 85 fathoms; sand and mud. One specimen.

H.M.S. "Alert," 1875; Franklin-Pierce Bay in Smith's Sound; lat. 79° 25′ N.

Other Localities.—Melville Bay; Jan Mayen; Spitzbergen Sea: Barents Sea; Kara Sea; Coast of Siberia to long. 92° 20′ E. (Stuxberg); Bay of Fundy? (Stimpson).[1]

Remarks.—Although described by Müller in 1841, this species was never figured till 1876, when Quenstedt gave a rough, but very characteristic sketch of it in the Atlas of the Petrefactenkunde Deutschlands.[2] Five years later it was again figured and minutely described by Duncan and Sladen in their well known monograph of Arctic Echinoderms. The numerous examples of it which were dredged by the Challenger off Halifax (Station 48) are by no means so large and well developed as individuals which I have examined from higher latitudes, and notably those obtained in the Barents Sea by the Dutch Arctic Expeditions, which are the finest examples of the type that I have seen. The spread of these Atlantic specimens does not exceed about 40 cm., and there are not more than two hundred arm-joints. The cirri and the lower pinnules are also fewer-jointed and shorter in proportion, while the arm-bases are much less tubercular than in the more northern forms. In these last the junction of the first two brachials forms a somewhat prominent knob in the middle line of the arm, and there is another at the outer end of the line of articulation between the second and third. The next is at the inner end of the articulation between the third and fourth, the one joint projecting forwards and the other backwards to form a knob-like elevation. This usually disappears at the second syzygy (on the eighth brachial), but may be continued out for three or four joints further, and the result of it is that the fourth to the seventh joints are altogether different from their successors in bearing their pinnules on their shorter sides (Pl. XXIV. figs. 10, 11). Beyond the third syzygy the joints are very distinctly triangular, but they are considerably wider than long, and this disproportion increases in the middle and outer parts of the arms, so that the successive pinnules are very closely set (Pl. XXIV. fig. 13); and it is only quite at the extremities that the joints become at all quadrate (Pl. XXIV. fig. 12). This is one of the best characters for distinguishing *Antedon eschrichti* from *Antedon quadrata* (Pl. XXVI. figs. 1–3; Pl. XXVII. figs. 5–7; fig. 4 on p. 154), which is commonly found associated with it, though it is shared with *Antedon antarctica*, as seen in Pl. XXV. fig. 12.

[1] Stimpson had some hesitation in referring his single specimen to *Antedon eschrichti*, on account of its small size, and it may not improbably belong to *Antedon quadrata*.

[2] Encriniden, tab. 96, fig. 26.

The middle and outer pinnules of *Antedon eschrichti* exhibit a modification of the first two joints of essentially the same character as that which has already been noticed in *Antedon valida* (Pl. XV. fig. 2). The first joint is irregularly trapezoidal, or in some cases almost crescentic, its distal edge being more or less concave, while the proximal edge of the larger and more trapezoidal second joint is similarly incurved and only meets that of the first near its ventral end, so as to leave a large gap on the dorsal side, which is occupied by ligament (Pl. XXIV. fig. 13). This feature is very characteristic of nearly all the Comatulæ from Arctic and temperate seas, and also of some abyssal forms (Pl. XXVII. figs. 26, 27; Pl. XXVIII. fig. 4; Pl. XXXII. figs. 5, 7), while it likewise presents itself in certain tropical species; but it never appears in *Actinometra*.

The axillaries of *Antedon eschrichti* vary considerably in their shape from triangular to rhombic, according to the extent of their backward projection into the second radials. In a few instances I have found them to be longer than wide; but in most cases the width is equal to or a trifle greater than the length, more than half of which is on the distal side of the line joining the lateral angles. This is chiefly due to the acuteness of the distal angle (Pl. XXIV. figs. 10, 11). The axillaries of *Antedon antarctica* have much the same shape, but they are usually considerably wider than long (Pl. XXV. figs. 8–12).

There is much variation both in the relative and in the absolute size of the flagellate lower pinnules of *Antedon eschrichti.* Those figured on Pl. XXIV. figs. 7–9, are the three first pinnules on the outer side of the arm of a specimen from Station 48, *i.e.*, those borne by the second, fourth, and sixth brachials. The same three pinnules of *Antedon rhomboidea*, *Antedon antarctica*, *Antedon australis*, and *Antedon quadrata* are figured on Pls. XXIV., XXV. and XXVII., and in all but the last (Pl. XXVII. figs. 8–13) the third pinnule is but little smaller than its predecessors. In *Antedon eschrichti* it has fewer joints than the first and second pinnules, but the basal ones are somewhat larger, though still wider than long, and a few of the outer joints become longer than wide, which is not the case in the first two pinnules (Pl. XXIV. figs. 7–9). The third and fourth pinnules are in fact the transitional stages between the flagellate basal pinnules and the larger genital ones which follow them. In *Antedon antarctica*, however, the change is much more sudden (Pl. XXV. figs. 1–3).

Fig. 10 on Pl. XXIV. represents a small but very interesting example of *Antedon eschrichti* which was dredged by the "Triton" in the Færoe Channel. The cirri are small and comparatively delicate, not exceeding 20 mm. in length, and the arm-bases are but slightly tubercular. All the arms have been broken and regenerated either at the second (eighth brachial) or third syzygy (twelfth or thirteenth brachial). In one arm there are two distinct changes of diameter, showing that the first regenerated part had undergone a subsequent fracture which has been again made good. One can therefore study the appearances presented by the new arm-joints in various stages of growth. The lowest and therefore oldest of these new joints are most like those of the corresponding part of the arm in the adult, *i.e.*, triangular or very slightly quadrate, but relatively wide in proportion to their length. These characters, however, do not disappear as they do in the adult, where the joints become gradually shorter and shorter, with a markedly triangular outline. But throughout the remainder of the restored arm the joints are quadrate and comparatively long; while the two lowest pinnule-joints show but few traces of the flattening and peculiarities of outline which are so characteristic of the adult. It is just in these characters, besides the smaller size of the first pair of pinnules, that *Antedon quadrata* differs from *Antedon eschrichti*, and it is therefore to be regarded as a permanently immature form of the latter species. Levinsen, indeed, considers the two species as identical, a point which I shall discuss when treating of *Antedon quadrata*.

Two Pentacrinoids, besides that of *Antedon tenella*, were dredged by the "Porcupine" in the cold area of the Færoe Channel; but I doubt whether either of them can be the one referred to by Sir Wyville Thomson[1] in the following passage:—"A single example of a pentacrinoid in an early stage was found associated with *Antedon escrichti*. It resembles closely the larva of *Antedon sarsii*, but the specimen was not sufficiently preserved for a critical examination."

The larva mentioned in the above passage is possibly that which I have represented on Pl. XIV. fig. 2. Its developmental condition is intermediate between the second and third stages of the larva of *Antedon tenella*, though I do not think that it can be referred to that type, on account of its greater robustness, and for other reasons. But, on the other hand, I do not imagine it to be the larva of *Antedon eschrichti*, to which species I referred it conjecturally in 1884,[2] together with the larva represented on fig. 3 of the same plate.

The Danish exploring vessel "Dijmphna" dredged forty-five individuals of *Antedon eschrichti* in the Kara Sea. They were of all sizes from a length of 25 mm. upwards. One Pentacrinoid was also obtained and has been figured by Levinsen.[3] It is considerably younger than the smaller of two Pentacrinoids which were obtained by the Dutch ship "Varna," in the Kara Sea, during the summer of 1883, and were sent to me for examination.[4] I had been unable to definitely refer them to any specific type, but they are so closely similar to that figured by Levinsen that I have now no doubt of their belonging to *Antedon eschrichti*. It is equally clear to me, however, that the larva which is represented on Pl. XIV. fig. 2 cannot belong to *Antedon eschrichti*, as seemed possible in 1884; while it is too large for the corresponding stage of *Antedon tenella*, so far as I can judge from the figures and dimensions of the latter which are given by Sars.

[1] *Proc. Roy. Soc. Edin.*, 1872, vol. vii. p. 764.
[2] *Proc. Roy. Soc. Edin.*, 1884, vol. xii. p. 364.
[3] Kara-Havets Echinodermata, Dijmphna-Togtets zoologisk-botaniske Udbytte, Kjøbenhavn, 1886, p. 34 (414) Tab. xxxv. fig. 8.
[4] The proofs of this Report were corrected early in 1885, but for some reasons with which I am not acquainted, it has not yet been published.

It may perhaps be only a younger stage of the larva shown on Pl. XIV. fig. 3, which I formerly referred to *Antedon eschrichti* on account of its extremely robust character. I am now satisfied, however, from Levinsen's observations, that the latter supposition is incorrect. The stem and the bases of the arms are nearly as well developed as in his larva of *Antedon eschrichti*, and the cirri of the first whorl have rather fewer joints; but the basals are relatively much higher than in the *Eschrichti*-larva, the axillaries of which are of an altogether different shape from those of the larva dredged by the "Porcupine." The latter is not likely to belong to *Antedon quadrata*, which must have a larva very like that of *Antedon eschrichti*, if indeed the two species are not identical; and I conclude therefore that the "Porcupine" larva should be referred to *Antedon hystrix*, the only other *Comatula* found in the cold area of the Færoe Channel.

The cirri of *Antedon eschrichti* resemble those of *Antedon rosacea* and *Antedon phalangium* in the dimorphic characters of their younger stages. Fig. 6 on Pl. XXIV. represents an immature cirrus of the normal developmental type. The lower joints are relatively longer than in the full-grown cirrus shown in fig. 4, and its outer part consists of a large number of short and wide joints with a strong terminal claw. On the other hand, fig. 5 represents a "small mature" cirrus which is shorter and composed of fewer joints than the immature one just mentioned; but the small terminal joints, instead of being short, wide and smooth, are much more like those of the adult cirrus and have slight dorsal projections, though there is only a very small terminal claw. The cirri are very numerous and the centro-dorsal proportionately large, so that it hides the first radials completely, only very small portions of them appearing on the exterior of the isolated calyx (Pl. I. fig. 8*a*). The rosette of *Antedon eschrichti* is near the dorsal surface of the radial pentagon and very well defined, with ten distinct spout-like processes, of which the interradial ones are a trifle the smallest (Pl. I. fig. 8*c*), but there is no indication of a basal star around it, the dorsal interradial furrows being simple and not provided with lateral folds, so that the interradial markings on the upper surface of the deeply hollowed centro-dorsal simply indicate the boundaries of the radial fossæ.

The articular faces of the radials of *Antedon eschrichti* are very characteristic. In a full-grown calyx the muscle plates stand up nearly vertically, but the lower parts of the faces are less steeply inclined (Pl. I. fig. 8*a*), so that the lower fossæ are pretty completely visible in a top view, while the muscular fossæ are mostly concealed (Pl. I. fig. 8*b*). They are separated from the pair of fossæ below them by slanting ridges which run upwards and outwards from the thickened lower end of the intermuscular ridge immediately above the opening of the central canal. The lower pair of fossæ above the articular ridge are thus but little smaller than the upper pair which lodge the great ventral muscles (Pl. I. fig. 8*a*). In smaller individuals, however, they are more unequal, the upper fossæ being considerably larger than the lower ones.

At the most of the localities where *Antedon eschrichti* is known to occur it is infested by the parasitic *Myzostoma gigas*, Lütken. Station 48 also yielded *Myzostoma fimbriatum*, von Graff.

2. *Antedon antarctica*, n. sp. (Pl. I. figs. 6, *a–d*, 7, *a*, *b*; Pl. XXV.).

Specific formula—A. $\frac{c}{b}$.

Centro-dorsal hemispherical, thickly covered with cirrus-sockets. Eighty or more cirri, reaching 35 mm. in length, and consisting of twenty-five to thirty-five joints, several of which are longer than wide. The later joints project slightly beyond the bases of their successors, and the penultimate has a well-developed terminal claw.

First radials invisible, except at the angles of the calyx, where they are sometimes separated by the ends of the basal rays; the second quite short and band-like, very convex in the centre and deeply incised. Axillaries usually rather wider than long, subtriangular, with a backward process of variable size in the middle of the base, sometimes so large as to give the plate an unequally rhombic appearance; first brachial much incised, with a short inner and long outer edge.

Ten arms, but slightly tubercular at the base, the joints after the third syzygy being quite short, triangular and slightly overlapping. They become slowly quadrate towards the ends of the arms, but always remain wider than long. Syzygies in the third, eighth, and twelfth brachials, and then usually at intervals of three joints.

Lower pinnules long and flagellate, with a serrate dorsal edge, reaching 25 mm., and composed of about sixty short joints, the basal ones rather wide.

The first two pinnules are nearly equal; but the third, though of about the same length, consists of fewer and larger joints, some of the lower ones being as long or longer than wide. The following pinnules shorter and more massive,with large lower joints, which are nearly square in outline and overlap considerably. The middle and outer pinnules of more elongated but still overlapping joints, the two lowest broader and more flattened, with their apposed edges incurved.

Disk and ambulacra naked; sacculi abundant.

Colour in spirit,—light brown.

Disk 17 mm.; spread about 25 cm.

Locality.—Station 151, February 7, 1874; near Heard Island; lat. 52° 59′ 30″ S., long. 73° 33′ 30″ E.; 75 fathoms; volcanic mud. Several specimens.

Remarks.—This is no doubt the species to which Sir Wyville Thomson referred when he stated that *Antedon eschrichti* had been obtained in the Southern Ocean.

The two types are unquestionably very closely similar in their general appearance; but at the same time they differ considerably in points of detail. The cirri of *Antedon* *antarctica* are much smaller than those of *Antedon eschrichti*, even in individuals of equal size, not having more than thirty-five joints, a considerable proportion of which are longer than wide, while the later joints project considerably more on the dorsal side than is the case in *Antedon eschrichti* (Pl. XXIV. fig. 4; Pl. XXV. fig. 6). This is especially marked in the younger cirri which are of the "small mature" type (Pl. XXV. fig. 7), while those which develop in the usual way, though both relatively and absolutely larger, are much more smooth-jointed (Pl. XXV. figs. 4, 5).

Rather more of the first radials is visible on the exterior of the calyx in *Antedon antarctica* than in *Antedon eschrichti* (Pl. XXIV. figs. 10, 11; Pl. XXV. figs. 10–12), and in some instances the ends of the basal rays appear between their lower angles (Pl. I. fig. 6*a*). As in *Antedon eschrichti* the shape of the second radials depends considerably upon that of the axillaries. These are always wider than long (Pl. XXV. figs. 8–11), but vary considerably in shape, even in the same individual. They are almost triangular in some cases, and widely rhombic in others, owing to the strong backward projection, which forms a sort of tubercle together with the very convex centre of the second radial. There is a similar variation in the shape of the first pair of brachials (Pl. XXV. figs. 10–12), and the junctions of the following joints are by no means so tubercular as in the largest variety of *Antedon eschrichti*, though more so than in the smaller and smoother Atlantic specimens, which have about the same size as the largest individuals of *Antedon antarctica* that were obtained. In both species alike, however, as in all the members of this group, the fourth to the eighth brachials bear pinnules on their shorter sides. Beyond the third syzygy the arm-joints of *Antedon antarctica* are even shorter relatively to the width than they are in *Antedon eschrichti* (Pl. XXIV. fig. 11; Pl. XXV. fig. 12), and they have a very decided tendency to overlap which is absent in that species, the arms of which are unusually smooth (Pl. XXIV. figs. 13, 14). The same may be said of the pinnule-joints, especially of the genital pinnules nearest the calyx; while the long flagellate pinnules on the arm-bases are serrate from end to end in *Antedon antarctica* (Pl. XXV. fig. 1–3), whereas in *Antedon eschrichti* the middle joints are smooth with sharp edges but nothing more. The third pinnule of *Antedon antarctica* is much more like its successor than is the case in *Antedon eschrichti*. Its lower joints are considerably stouter than those of the second pinnule, some of them being as long as or longer than wide (Pl. XXV. figs. 2, 3), whereas in *Antedon eschrichti* they are distinctly wider than long. In fact the third pinnule of *Antedon antarctica* resembles the fourth pinnule of *Antedon eschrichti* rather than its fellow, the third pinnule. In the middle and outer pinnules there is a good deal of variation in the extent of modification in the two basal joints; but they are never so much flattened and so nearly trapezoidal in form as they are in the larger *Antedon eschrichti*.

The centro-dorsal of *Antedon antarctica* is somewhat more conical than that of *Antedon eschrichti* (Pl. I. figs. 6*a*, 8*a*), and the axial opening on the ventral surface is relatively much larger than in that type (Pl. I. figs. 6*d*, 8*d*), so as to reveal a large number of the internal ridges which separate the inner openings of the cirrus-canals. Five of these, interradial in position, are much more prominent than the rest, as is well seen in the figure (Pl. I. fig. 6*d*). The basal grooves on the ventral surface of the centro-dorsal are scarcely more distinct than they are in *Antedon eschrichti* (Pl. I. fig. 8*d*). But on the other hand the dorsal surface of the radial pentagon bears a very well-defined basal star, of which there is rarely any trace in that species (Pl. I. figs. 6*c*, 8*c*). The rosette lies deeper than it does in *Antedon eschrichti*, and the basal rays connected with it are unusually stout. This is most noticeable in their isolated condition (Pl. I. figs. 7, *a*, *b*; compare Pl. III. fig. 2, and Pl. IV. figs. 4–6, all equally magnified). In some cases their distal ends appear on the exterior of the calyx, as seen in Pl. I. fig. 6*a*. This figure too shows the difference between the articular faces of the radials in *Antedon eschrichti* and *Antedon antarctica* respectively. Their slope is more uniform in the latter species, as there is much less of an angle between the upper and lower parts of each face than in *Antedon eschrichti* (Pl. I. fig. 8*a*), and the consequence is that more of the large muscular fossæ is visible in the ventral aspect of the calyx (Pl. I. figs. 6*b*, 8*b*). The ridges which separate them from the lower pair of fossæ are much more horizontal than in *Antedon eschrichti*, so that the two pairs of fossæ are of very unequal size (Pl. I. fig. 6*a*, 8*a*).

A detailed comparison of the two outer radials and of the lower brachials in the two species respectively reveals a number of similar points of difference between them; and though they are so very closely similar in habit and in general appearance, as also in the conditions of their existence, there can, I think, be no question that they are distinct.

3. *Antedon australis*, n. sp. (Pl. XXVI. figs. 4, 5; Pl. XXVII. figs. 14–20).

Specific formula—$A.\frac{c}{b}$.

Centro-dorsal hemispherical, thickly covered with about fifty cirri. These have twenty-five to thirty joints, nearly all of which are longer than wide. The later joints are laterally compressed, and their dorsal edges project considerably beyond the bases of their successors, thus giving rise to a strong spine in the last few joints. The young cirri round the dorsal pole resemble the mature form, but have fewer joints; those round the margin may have thirty smooth and elongated joints which only develop spines quite late.

First radials just visible; the second short and nearly oblong, but little incised for the axillaries, which are broadly pentagonal or triangular with a slight backward projection in the middle of the base.

Ten arms, of somewhat overlapping joints, but not tubercular at the base. The arm-joints after the second syzygy are shortly triangular, gradually becoming quadrate, but always much wider than long. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of two or three joints.

The first pair of pinnules (on second and third brachials) flagellate, about 12 mm. long, and consisting of forty-five short joints, the basal ones of which are broad, flattened, and somewhat carinate. The next pair sometimes nearly equal to and sometimes shorter than the first. The third pair also shorter, with stouter joints, most of which are distinctly longer than wide, and they generally bear fusiform genital glands. The following pinnules more massive, with squarer joints, which become elongated further out, while the two basal ones become flattened and trapezoidal, with their apposed edges incurved.

Disk and ambulacra naked. Sacculi abundant in some pinnules, but less so in others.

Colour in spirit,—white, with purplish or brownish patches.

Disk 10 mm.; spread about 12 cm.

Locality.—Station 150, February 2, 1874; lat. 52° 4′ S., long, 71° 22′ E.; 150 fathoms; coarse gravel; bottom temperature, 35°·2 F. Seven mutilated specimens and one very young.

Remarks.—This is a smaller and more delicate species than *Antedon antarctica*, which it resembles in the shortness of the arm-joints; but the arms generally are much smoother, and there are fewer cirrus-joints, while the third pinnule is much less like the second than is the case in that species (Pl. XXV. figs. 2, 3; Pl. XXVII. figs. 15, 16). The three lowest joints are by no means so wide as in *Antedon antarctica*, but more nearly square, while the following joints till quite near the end are very distinctly longer than broad, which is not the case in *Antedon antarctica*. Even the first two pinnules of *Antedon australis* have a tendency in this direction, as compared with the much longer ones of *Antedon eschrichti* and *Antedon antarctica* (Pl. XXIV. figs. 7, 8; Pl. XXV. figs. 1. 2).

Like both these last mentioned types and the other Arctic species as well (*Antedon quadrata*, *Antedon hystrix*, and *Antedon prolixa*), *Antedon australis* affords an excellent illustration of the dimorphic mode of development of the cirri. Its full-grown cirri consist of some twenty-five to thirty-five joints, the first half of which, except those just at the base, are considerably longer than wide. As they get shorter their dorsal edges come to project more and more definitely beyond the bases of the succeeding joints, so that the compressed terminal segments are distinctly spinous (Pl. XXVII. fig. 20). There are numerous young cirri of this type round the dorsal pole. They consist of twenty joints, all of which, except the two or three short ones at the base, have a forward projecting dorsal edge (Pl. XXVII. fig. 18). But on the other hand, the margin of the centro-dorsal bears several young cirri of an altogether different type in various stages of development (Pl. XXVII. figs. 17, 19). One of them has thirty elongated joints, all of which are perfectly smooth and without any traces of the dorsal projections which are so characteristic of the joints composing the shorter and more centrally placed cirri. These long marginal cirri eventually develop spines and only differ in their greater length from those nearer the dorsal pole.

Besides seven individuals of *Antedon australis* found at Station 150, which are all pretty equally developed, the Challenger also obtained a mutilated calyx of much smaller size, from which all the arms had broken away at the syzygies in the third brachials (Pl. XXVI. fig. 5). It may belong to this same species, but if so, it is remarkable in not showing more of the first radials externally than is visible in the more mature forms, though, on the other hand, the axillaries are relatively longer, as would be expected in a young individual. This may also account for the elongated shape of the joints of the first pinnule, and for the present it will be safest to regard this form, which has numerous cirrus-sockets on the centro-dorsal, though barely 4 mm. in diameter, as a young example of *Antedon australis*.

4. *Antedon rhomboidea*, n. sp. (Pl. XII. figs. 1, 2; Pl. XXIV. figs. 1–3).

Specific formula—A.$\frac{c}{b}$.

Description of an Individual.—Centro-dorsal hemispherical, with a flattened and cirrus-free dorsal pole. Sixty or more cirri, of thirty to thirty-five segments, several of which are longer than wide. The middle joints project beyond their successors on the dorsal side, and in the shorter terminal joints this projection develops into a blunt keel.

First radials just visible; the second trapezoidal, rather deeply incised and rising to tubercles at the junction with the rhombic axillaries, which are much wider than the distal ends of the second radials.

Ten arms, with a median knob at the junction of the first two brachials, and others alternating on the outer and inner sides till the ninth or tenth joint. The first brachials deeply incised, with very short inner ends, which barely meet above the sharp angles of the axillaries. Middle arm-joints triangular, soon becoming quadrate, as long as or longer than wide, and slightly overlapping. Syzygies in the third, eighth, and fourteenth brachials, and then at intervals of two or three joints. The first two pinnules on each side about 22 mm. long, flagellate, and composed of fifty short joints, the basal ones broad, flattened, and slightly carinate, and the later joints serrate. The third pinnule of about the same size but with fewer joints, the basal ones being stouter and the middle ones longer than wide. The following pinnules are more massive, with square joints, which soon become elongated, the two basal ones but little modified.

Mouth subcentral, with rather large calcareous concretions round the peristome and at the sides of the ambulacra on the disk and arm-bases. Sacculi very abundant.

Colour in spirit,—light brownish-white.

Disk 12 mm.; spread at least 25 cm.

Locality.—Station 308, January 5, 1876; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W.; 175 fathoms; blue mud. One specimen.

Remarks.—This species resembles *Antedon australis* in the length of the middle joints of the third pinnule, but it is altogether a much larger form, with considerably longer arm-joints than occur in that species. In this respect *Antedon rhomboidea* and *Antedon magellanica* have the same relation to *Antedon australis* and *Antedon antarctica* that the northern species *Antedon quadrata* has to *Antedon eschrichti*. *Antedon magellanica* has never yet been properly described, the type specimen having been regarded merely as a variety of *Antedon eschrichti*,[1] although its arm-joints are mostly quadrate and as long as or longer than wide. It has many points of resemblance with *Antedon rhomboidea*, but there may be over fifty cirrus-joints, while some of the middle joints of the second pinnule are longer than wide. It is nearly half as long again as the corresponding pinnule in an equal sized specimen of *Antedon rhomboidea*, while the third pinnule is considerably shorter than the second. Several examples of the type were obtained by the Italian corvette "Vettor Pisani," and I hope soon to be able to describe them at length.

5. *Antedon quadrata*, n. sp. (Pl. XXVI. figs. 1–3; Pl. XXVII. figs. 1–13; woodcut, figs. 4, A, B, on p. 154).

Specific formula—$A.\frac{c}{b}$.

1878. *Antedon celticus*, von Marenzeller, Denkschr. d. k. Akad. d. Wiss. Wien, 1877 [1878], Bd. xxxv. p. 380.
1880. *Antedon celticus*, d'Urban, Ann. and Mag. Nat. Hist., 1880, ser. 5, vol. vi. p. 380.
1881. *Antedon celtica*, Duncan and Sladen, Memoir Arctic Echinodermata, London, 1881, pp. 75–77, pl. vi. figs. 5, 6.
1881. *Antedon celtica*, P. H. Carpenter, Zool. Anzeiger, 1881, Jahrg. iv. p. 521.
1882. *Antedon celtica*, Bell, Proc. Zool. Soc. Lond, 1882, p. 534.
1882. *Antedon celtica*, P. H. Carpenter, *Ibid.*, p. 746.
1884. *Antedon quadrata*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, pp. 375–377.
1886. *Antedon quadrata*, P. H. Carpenter, Bijdragen tot de Dierkunde, 1886, 13 Aflevering, vi. p. 7, pl. i. fig. 6.
1886. *Antedon Eschrichtii*, Levinsen (*pars*), Dijmphna-Togtets zoologisk-botaniske Udbytte, Kjøbenhavn, 1886, p. 410.
1886. *Antedon quadrata*, Fischer, Die Österreichische Polarstation Jan Mayen, Bd. iii., Wien, 1886, Echinodermen, p. 3.

Centro-dorsal hemispherical, bearing fifty to seventy cirri, with about thirty to thirty-five joints, several of which are longer than wide; the later joints sharpened dorsally but not distinctly carinate.

[1] See *Proc. Zool. Soc. Lond.*, 1882, p. 650.

First radial very short; the second longer and trapezoidal, somewhat incised by the rhombic axillary and forming with it a slight prominence. Axillary as wide as or wider than long, with a fairly open distal angle.

Ten arms, of some two hundred smooth joints. First brachial rather deeply incised, with a short inner and much longer outer edge; the second irregularly quadrate, and the six following joints more oblong or obliquely quadrate, with the pinnule on the shorter side. The first three joints above the third syzygy are sometimes nearly triangular and as wide as long, but the following ones are distinctly quadrate and gradually become longer than wide; the terminal joints somewhat elongated. Syzygies in the third and eighth brachials and then at intervals of two to four joints.

The first two pinnules long and flagellate, composed of numerous short joints, the basal ones wide and slightly carinate, sometimes with dorsal processes, and the later joints serrate. The third pinnule little more than half as long as the second, with much fewer joints, the basal ones stouter, and the remainder mostly much longer than wide. The following pinnules more massive, with square joints which gradually become elongated. The two lower joints of the distal pinnules flattened and trapezoidal in some forms, but only slightly modified in others.

Ambulacra not plated, but the disk sometimes bears a number of small calcareous granules.

Colour in spirit,—white or brownish-white.

Disk 15 mm.; spread may reach 30 cm.

Localities.—H.M.S. Challenger, Station 48, May 8, 1873; on the Le Have Bank; lat. 43° 4′ N., long. 64° 5′ W.; 51 fathoms; rock. Several specimens.

H.M.S. "Valorous," Station 6, August 10, 1875; Davis Strait; lat. 64° 5′ N., long. 56° 47′ W.; 410 fathoms; sand and mud; bottom temperature, 34°·6 F. One specimen.

H.M.S. "Alert," 1875; Franklin-Pierce Bay (in Smith's Sound); lat. 79° 25′ N.; and Discovery Bay (in Robeson Channel), lat. 81° 41′ N.; 25 fathoms; hard bottom.

H.M.S. "Triton," 1882, Station 4; lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W. and 8° 14′ W.; 327 to 430 fathoms; stones, mud; bottom temperature, 31°·5 to 30° F.

Station 6; lat. 69° 8′ 0″ N., long. 7° 26′ 30″ W.; 466 fathoms; stones; bottom temperature, 29°·5 F.

Other Localities.—Barents Sea ("Tegetthoff" and "Willem Barents"); Kara Sea ("Varna"); Jan Mayen (Fischer).

Remarks.—This species has a curious history and has caused me no little trouble. I have no doubt that it was dredged by the "Porcupine" in 1869 in the cold area of the Færoe Channel, together with *Antedon eschrichti*, which was met with in comparative abundance; but it is not now to be found among the remains of the "Porcupine" collection which have come into my hands. Three years later (1872) it was obtained by the ill-fated "Tegetthoff" 5° west of Nova Zembla, and was minutely described by von Marenzeller[1] who referred it to *Antedon celticus*, Barrett, sp. Little was then known of the latter form, except for the very incomplete description of it which had been given by Barrett, and for Sir Wyville Thomson's incidental references to the numerous examples of it which had been dredged off the north coast of Scotland by the "Lightning" and "Porcupine."

Von Marenzeller, regarding his Arctic specimen as identical with Barrett's type, gave a careful description of them which enabled Duncan and Sladen to recognise the same form among the Comatulæ dredged by Sir George Nares's Arctic Expedition of 1875–76. These were well and carefully described by Sladen,[2] who was the first to figure the type, though still under Barrett's specific name "*celtica*." He used this designation with some hesitation, however, owing to the prevalent want of knowledge respecting Barrett's species; and after writing his description of the more northern form he saw for the first time some examples of the true *Antedon celtica*, which he recognised as altogether distinct from the Arctic type. He therefore inserted a note to this effect, but did not alter the name under which the latter had been described by both von Marenzeller and himself. It will be shown further on that Barrett's species has proved to be identical with the long but little known *Antedon phalangium*, Müller, sp., of the Mediterranean, and the specific name *celtica* being therefore unoccupied, I thought at first[3] that it might conveniently be retained for the type described under this name by von Marenzeller and Sladen respectively. This course, however, has seemed undesirable for many reasons; and in compliance with the wishes of both the above named naturalists I propose to give it a new name altogether. I have therefore chosen one indicative of the character by which the species is most easily distinguished from *Antedon eschrichti*, viz., the markedly quadrate shape of the middle and outer arm-joints, as seen in Pl. XXVII. figs. 5–7, and in the woodcut, fig. 4 on p. 154.

Thanks to the kindness of Dr. von Marenzeller I have been able to examine the single individual dredged by the "Tegetthoff," and I am satisfied that Sladen was right in identifying it with those which he described from Smith's Sound and Robeson Channel. Another example was dredged by the "Valorous" in Davis Strait in 1875, and when the Challenger Comatulæ came into my hands I found the same type among a quantity of specimens of *Antedon eschrichti* from Station 48 on the Le Have Bank (51 fathoms). The species was twice taken by the "Triton" (1882) in the cold area of the Færoe Channel. The "Willem Barents" met with it in 1880 near the locality of the "Tegetthoff" dredging; and it was twice obtained by the "Varna" in the Kara Sea

[1] Die Cœlenteraten, Echinodermen, und Wurmer der k. k. Österreichisch-Ungarischen Nordpol. Expedition. *Denkschr. d. k. Akad. d. Wiss. Wien*, 1877 [1878], Bd. xxxv. p. 380.

[2] *Op. cit.*, p. 75.

[3] Note on the European Comatulæ, *Zool. Anzeiger*, 1881, Jahrg. iv. p. 521.

(1883). Not improbably too it may have been among the collections made by the earlier "Willem Barents" Expeditions and by the "Vega"; though, as in the case of the "Porcupine" specimens, it was not distinguished from immature individuals of *Antedon eschrichti*.

A careful study of all this material has convinced me, however, that the two forms are very different in reality; though, as I have pointed out above, *Antedon quadrata* may in some sense be regarded as a permanent larval form of *Antedon eschrichti*. Its first radials are not entirely concealed by the centro-dorsal, but appear above it as short band-like plates (Pl. XXVI. figs. 1–3). The second radials have more sloping sides than in the smaller forms of *Antedon eschrichti*, so as to be trapezoidal in general outline; and the axillaries have a blunter distal angle than in that type (Pl. XXIV. figs. 10, 11). The arm-bases are not tubercular, though the joints between the first and second syzygies have the same backward projections on the sides which do not bear the pinnules that occur in *Antedon eschrichti*. The relatively long quadrate shape of the arm-joints immediately after the third syzygy is less marked in the Challenger specimens of *Antedon quadrata*, the southernmost ones known (Pl. XXIV. fig. 2), than it is in the two obtained further north by the "Triton" (Pl. XXIV. fig. 3), and in those from the Arctic Ocean which have been figured elsewhere by Sladen[1] and myself.[2] But the middle and outer arm-joints of the two species are always distinguishable, those of *Antedon eschrichti* being short, generally triangular, and much wider than long, till quite near the end of the arm; while the brachials of *Antedon quadrata* are obliquely quadrate and the length is more nearly equal to the width. This is especially marked in the "Valorous" specimen, and is no doubt partly due to its not being quite mature, as in the young forms obtained by the Challenger (Pl. XXVI. fig. 1); but it is also very distinct in the larger examples from the Barents and the Kara Seas.

The other special mark of *Antedon quadrata* is the disproportion between the second and the third pinnule, which has already been noticed by Sladen as distinguishing the type from *Antedon eschrichti* (Pl. XXVII. figs. 9, 10, 12, 13). In the individuals of the latter species which were obtained by the Challenger at Station 48, the third pinnule is relatively much shorter than in the more northern forms. In large examples of *Antedon eschrichti* from the Arctic Ocean it is of almost exactly the same length as the second pinnule, as described by Sladen; but in the West Atlantic representatives of the type it is distinctly shorter (Pl. XXIV. figs. 8, 9). The southern forms of the two species therefore approach one another in the characters of the pinnules, just as in those of the arm-joints; although the more northern varieties are entirely distinct in both respects.

Not only is the third pinnule of *Antedon quadrata* altogether smaller than the second, but its component joints, while fewer in number, are also different in their

[1] *Op. cit.*, pl. vi. figs. 5, 6.

[2] *Bijdragen tot de Dierkunde*, 1886, 13 Aflevering, vi., pl. i. fig. 6.

relative proportions. The basal joints are stouter as in the following genital pinnules, and their successors are distinctly longer than wide, indications of which appear in the second pinnule (Pl. XXVII. figs. 9, 10, 12, 13). There is no sign of this, however, in *Antedon eschrichti*, the joints of the third pinnule being as wide or wider than long (Pl. XXIV. figs. 8, 9). Furthermore there is generally less trace in *Antedon quadrata* of the modification of the two lowest joints in the outer pinnules, which is usually so marked in *Antedon eschrichti* (Pl. XXIV. fig. 13), though it is extremely well developed in an example brought by the "Varna" from the Kara Sea.

Levinsen[1] has recently united *Antedon quadrata* with *Antedon eschrichti*, on the ground that the characters of this latter species as stated by von Marenzeller, Sladen, and myself, all present themselves in immature examples of *Antedon eschrichti*. The possibility of this being the case had of course naturally occurred to me; but I decided against it for various reasons.

Levinsen is not personally acquainted with *Antedon quadrata*, but only knows it from the descriptions of Sladen and von Marenzeller, and from my own preliminary account of its special marks, characters which, as I am fully aware, do occur in young individuals of *Antedon eschrichti*, though not, I think, to the same degree that they do in *Antedon quadrata*. Had Levinsen been able to compare an example of *Antedon quadrata* with an equal-sized but immature individual of *Antedon eschrichti*, I believe that he would have found differences between them which he would recognise as of specific value.

One of the "special marks" which I mentioned as distinctive of *Antedon quadrata* when the type was rebaptised, was the very definite quadrate shape of the middle and outer arm-joints (Pl. XXVII. figs. 5–7) as compared with those of *Antedon eschrichti* (Pl. XXIV. figs. 11, 14), which are much shorter than wide, with their sutures less oblique than in *Antedon quadrata*. The young *Antedon eschrichti* also has relatively long and quadrate arm-joints with oblique sutures, and Levinsen assigns this as one of his reasons for uniting the two species. I was of course perfectly aware of this fact when I named *Antedon quadrata*, and described it as a permanently immature form of *Antedon eschrichti*.[2] Since the publication of Levinsen's memoir, which only reached me after the preceding pages were written, I have gone into the subject again in the only way which can possibly give a satisfactory result, namely, the comparison of the corresponding arm-joints in equal-sized individuals of the two species.

Figs. 4, A and B, on the next page, represent the portions of the arms between the fiftieth and sixtieth brachials of two individuals of *Antedon quadrata* from different localities. In both cases the joints are of an obliquely quadrate shape and nearly as long as wide. But in the corresponding part of the arm of a young *Antedon eschrichti* of equal size the joints are more nearly triangular and considerably wider than long (fig. 4, C),

[1] *Loc. cit.*, p 413.
[2] *Proc. Roy. Soc. Edin.*, 1884, vol. xii. pp. 374–376.

and in full grown individuals this character is still more marked. This is shown in fig. 4, D, which represents a portion of the third quarter of an arm in the largest specimen of *Antedon eschrichti* that I have seen. It is drawn of the same size as the three other arm-fragments, so that their differences may be the more readily compared. The extreme shortness of the arm-joints is one of the most striking characters of *Antedon eschrichti*, though it occurs also in *Antedon antarctica* (Pl. XXV. fig. 12); and it manifests itself in individuals which have not attained half their full size, while it does not appear in

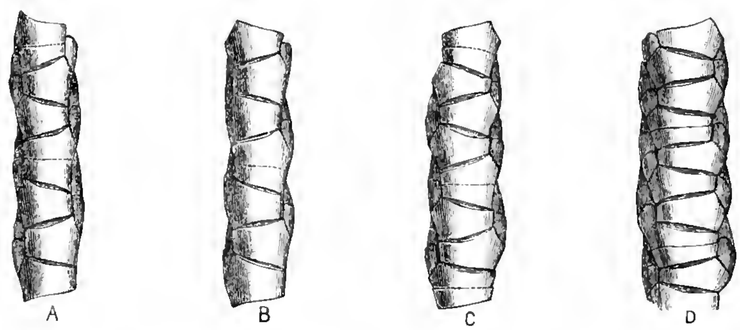

FIG. 4.—A, B, The fiftieth and next following brachials of *Antedon quadrata*; ×6. C, The same joints in a young *Antedon eschrichti* of equal size; ×6. D, Arm-joints of a mature individual; ×4.

examples of *Antedon quadrata* which have the same dimensions, as shown in figs. 4, A, B, C. The difference may seem but a slight one in small pieces of arms like those figured; but it produces a very decided effect on the general facies of the whole plume of arms, on account of the greater or less separation of the successive pinnules from one another.

A second point of difference between the two species is the relatively small size of the third pinnule in *Antedon quadrata*, as compared with that of *Antedon eschrichti*, (Pl. XXIV. figs. 8, 9; Pl. XXVII. figs. 9, 10, 12, 13). Levinsen[1] has pointed out that as the second pinnule appears before the third, there is necessarily a period of growth at which the third pinnule will be only about half the size of its predecessors, as is the case in *Antedon quadrata*.

This of course is perfectly true; but as I have pointed out above, the relative proportions of its component joints are not the same in the two types. The difference is similar to that which shows itself in the arms, *i.e.*, the joints are relatively longer in the lower pinnules of *Antedon quadrata* than in those of *Antedon eschrichti*. The following measurements of the second and third pinnules in *Antedon quadrata* and in a young *Antedon eschrichti* of equal size will make this point clear.

	Second pinnule.		Third pinnule.	
	Length.	Number of joints.	Length.	Number of joints.
Antedon quadrata, . .	14	31	8	17
Antedon eschrichti, .	15	39	12	28

[1] *Loc. cit.*, pp. 32, 33.

Thus then the third pinnule of *Antedon quadrata* is only $\frac{4}{7}$ as long as the second; whereas in *Antedon eschrichti* it reaches $\frac{4}{5}$ of the size of the second, and a similar difference appears in the relative proportions of their component joints.

There is another consideration which, taken by itself, would have no special probative value; but it is not without importance when combined with the other evidence given above. *Antedon quadrata* has been dredged at eleven stations altogether, but at only five of these was it found in association with *Antedon eschrichti*. The "Triton," "Alert," "Valorous," "Tegetthoff" and "Varna" (*bis*) obtained examples of this type at localities where *Antedon eschrichti* did not occur; and in the last four cases they were only single individuals.

These facts would seem somewhat improbable if *Antedon quadrata* is merely an immature stage of *Antedon eschrichti* as supposed by Levinsen. It is a common experience of Arctic dredging to find individuals of *Antedon eschrichti* associated together in considerable abundance, and at various stages of development; and one would therefore not expect to find isolated examples of young individuals, unaccompanied by older ones, quite so frequently as is mentioned above.

Sladen is the only naturalist, besides myself, who has had the opportunity of directly comparing examples of the two species which were obtained at the same locality; and in spite of Levinsen's remarks, I am still inclined to think that he was right in separating the two forms. I find it difficult to believe that the fine example of *Antedon quadrata* which I have figured in the "Varna" report is merely a young stage of the *Antedon eschrichti* obtained at the same locality; though I am by no means prepared to state definitely that it is not the case.

My present impression is that we have to deal with two distinct species, the smaller of which, as I have remarked before, represents a permanently immature form of the larger one.

Antedon quadrata is another of the species in which the cirri are strikingly dimorphic in their character. The mature cirrus of an Atlantic specimen is shown in Pl. XXVII. fig. 1, while fig. 2 represents one that is still immature as shown by the relative length of the sixth and following joints. This cirrus has developed upon the ordinary plan, a much earlier stage of which is seen in fig. 4; but fig. 3 represents another young cirrus, altogether different in appearance and belonging to the "small mature" type, just as has been described in *Antedon antarctica* and *Antedon australis* (Pl. XXV. fig. 7; Pl. XXVII. fig. 18). In the young individual figured on Pl. XXVI. fig. 1, the spread of which cannot have been more than four or five centimetres, most of the cirri seem to have developed upon the small mature plan; but a few rudimentary cirri of the other type are to be found round the margin of the centro-dorsal, and there are more in a considerably older though still immature individual.

The youngest form obtained shows less of the first radials on the exterior of the calyx than might have been expected; but its early age is indicated by the great relative length of the arm-joints and the small size of the proximal pinnules (Pl. XXVI. fig. 1).

This species ranges slightly further north than *Antedon eschrichti*, having been obtained at Discovery Bay (lat. 81° 41′ N.) together with *Antedon prolixa*, and at Franklin-Pierce Bay (lat. 79° 25′ N.) together with *Antedon eschrichti*, which was not met with at the higher latitude. The bathymetrical range is greater, however, in the larger form, which extends down to 632 fathoms, while *Antedon quadrata* was not found below 466 fathoms in the same region of the Færoe Channel; the nearest approach to this depth being the "Valorous" station in Davis Strait (410 fathoms).

The three "Triton" specimens are all of them small, like those of the "Tegetthoff" and "Valorous"; while they have a stiffer and less feathery appearance than the larger ones obtained further north by the "Alert" and "Willem Barents."

In fact they more nearly resemble the small individual figured by Sladen[1] in their general characters. The dorsal processes on the lower joints of the basal pinnules are less prominent than usual; while the peculiar characters of the first two pinnule-joints in the outer parts of the arms are by no means so marked as in larger individuals.

The only Arctic species that approaches *Antedon quadrata* in the great disproportion between the second and third pinnules is *Antedon barentsi;* but it has much smaller cirri with fewer joints, triangular joints in the middle of the arms, and the genital pinnules protected by plates as in *Antedon incisa*, *Antedon acoela*, and other tropical forms, though on a less massive scale.

Like *Antedon eschrichti*, with which it is often associated, *Antedon quadrata* officiates as host to *Myzostoma gigas*.

4. The *Tenella*-group.

Long-jointed lower pinnules.

The first three species on the list of those which I have included in this group, *Antedon phalangium*, *Antedon hystrix*, and *Antedon prolixa*, have many affinities with *Antedon eschrichti* and its allies, both in their distribution and in the characters of their arms and cirri.

Antedon hystrix and *Antedon prolixa* are exclusively cold-water species, not having been obtained south of lat. 60° N.; though *Antedon phalangium* occurs in the Mediterranean and in the East Atlantic as far south as the Seine Bank (lat. 33° 47′ N., long. 14° 1′ W.). These species differ from the *Eschrichti*-group, however, in the characters of the lower pinnules, which, though often long, slender, and more or less flagellate, consist of joints which are much longer than wide, as is particularly evident

[1] *Op. cit.*, pl. vi. fig. 5.

in *Antedon longipinna*, *Antedon tenella*, and *Antedon exigua* (Pl. XXX. fig. 2; Pl. XXXI. fig. 4; Pl. XXXII. fig. 4). On the other hand, in *Antedon eschrichti* and its allies the first two or three pairs of pinnules consist of short and wide joints (Pl. XXIV. figs. 1, 2, 7–9; Pl. XXV. figs. 1, 2; Pl. XXVII. figs. 8, 9, 11, 12, 14). The species of the *Eschrichti*-group are exclusively confined to the Atlantic and Circumpolar Seas, but do not extend downwards below 650 fathoms. The *Basicurva*-group, however, is principally limited to the Pacific, ranging from 140 to 1350 fathoms. But there are three Atlantic species which occur at depths of 420 to 1600 fathoms. On the other hand the members of the *Tenella*-group are chiefly confined to the Arctic Ocean, the Atlantic, and the Southern Sea. *Antedon prolixa* is one of the two northernmost Comatulæ known; and two more (*Antedon hirsuta* and *Antedon exigua*) reach further south than any others except *Antedon australis* and *Antedon antarctica*. Of the remaining fourteen species only five occur in the Pacific; four of them range between 150 and 775 fathoms; while the fifth, obtained at 2900 fathoms in the North Pacific (Station 244), was also found at 2600 fathoms in the Southern Ocean (Station 160). These were the two deepest stations at which Comatulæ were met with. The next deepest (1600 fathoms) in the Southern Ocean (Station 147) yielded two more species of the *Tenella*-group, the remaining members of which are confined to the Atlantic. One or two of them are littoral species, like *Antedon rosacea* itself, and *Antedon dübeni*, but this is not the case with the Pacific members of the group, which are not known as yet to occur above 150 fathoms.

With a few exceptions, then, the *Tenella*-group may be regarded as especially characteristic of the Atlantic and Circumpolar Seas, just as the *Basicurva*-group is chiefly confined to the Western Pacific; and in each case the exceptional species belong to the continental or abyssal, but never to the littoral fauna.

Long-jointed lower pinnules.

A. Forty or more long cirrus-joints.
- I. Second pinnule as long as the first, ... 1. *phalangium*, Müll, sp.
- II. Second pinnule smaller than the first.
  - *a.* Axillaries longer than wide; second radials very deeply incised, ... 2. *hystrix*, n. sp.
  - *b.* Axillaries as wide or wider than long; second radials incised, but not very deeply so, ... *prolixa*, Duncan and Sladen.

B. Fifteen to thirty cirrus-joints.
- I. Second pinnule distinctly smaller than the first.
  - *a.* Cirrus-joints mostly longer than wide, the lower ones very much so.
    1. First pinnule nearly three times as long as the second; syzygial interval two joints, . . . 3. *tenella*, Retzius, sp.

2. First pinnule less than twice as long as the second.	
α. Syzygial interval two joints; later cirrus-joints not specially long, ...	4. *exigua*, n. sp.
β. Syzygial interval one joint; later cirrus-joints elongated, ...	5. *alternata*, n. sp.
b. Cirrus-joints not specially elongated.	
1. Lower joints of genital pinnules not expanded; cirrus-joints not spiny.	
α. Lower arm-joints triangular, . . .	6. { *rosacea*, Linck, sp. *petasus*, Düb. and Kor., sp.
β. Arm-joints quadrate from the fifteenth, if not before, ...	7. *dübeni*, Böhlsche.
2. Genital pinnules having expanded lower joints; cirrus-joints spiny, ...	8. *lineata*, n. sp.
II. First and second pinnules tolerably equal.	
a. Less than twenty cirrus-joints which are not specially elongated; syzygial interval two joints, . . .	9. *remota*, n. sp.
b. Over twenty cirrus-joints.	
1. Elongated cirrus-joints; lower pinnules very long.	
α. Second pinnule slender like the first; syzygial interval one joint, . . .	10. *longipinna*, n. sp.
β. Second pinnule stouter than the first; syzygial interval two joints or more, . . .	11. *tenuicirra*, n. sp.
2. Cirrus-joints not specially elongated.	
α. Arms smooth; axillaries long, . . .	12. *lævis*, n. sp.
β. Arms serrate and spiny; axillaries wide, .	13. *hirsuta*, n. sp.
III. Second pinnule longer than the first.	
a. Cirrus-joints short; syzygial interval one joint, . .	14. *angustipinna*, n. sp.
b. Cirrus-joints long; syzygial interval one to five joints, .	15. *abyssorum*, n. sp.
C. Less than twelve cirrus-joints, ...	16. *abyssicola*, n. sp.

1. *Antedon phalangium*, Müll., sp. (Pl. XXVII. figs. 23–29; Pl. XXVIII. figs. 1–3).

Specific formula, $A.\frac{bc}{c}$.

1841. *Alecto phalangium*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 182.
1849. *Comatula (Alecto) phalangium*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1849, p. 253.
1857. *Comatula Woodwardii*, Barrett, Ann. and Mag. Nat. Hist., 1857, ser. 2, vol. xix. p. 33, pl. vii. fig. 1.
1857. *Comatula celtica*, M'Andrew and Barrett, Ann. and Mag. Nat. Hist., 1857, ser. 2, vol. xx. p. 44.
1862. *Comatula phalangium*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 198.
1865. *Antedon celticus*, Norman, Ann. and Mag. Nat. Hist., 1865, ser. 3, vol. xv. p. 104.
1872. *Antedon mediterraneus*, Wyville Thomson, Proc. Roy. Soc. Edin., 1872, vol. vii. p. 765.
1872. *Antedon celticus*, Wyville Thomson, *Ibid.*, p. 765.
1879. *Antedon phalangium*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1879. *Antedon celtica*, P. H. Carpenter, *Ibid.*, p. 29, pl. iv. figs. 1–8.

1879. *Antedon phalangium*, Marion, Ann. d. Sci. Nat. (Zool.), 1879, sér. 6, t. viii. p. 40, pl. xviii.
1879. *Antedon phalangium*, Ludwig, Mittheil. a. d. Zool. Stat. Neapel, 1879, Bd. i. p. 537.
1880. *Antedon phalangium*, Ludwig, *Ibid.*, 1880, Bd. ii. p. 53, Taf. iv. fig. 1.
1881. *Antedon phalangium*, P. H. Carpenter, Zool. Anzeiger, 1881, Jahrg. iv. p. 521.
1882. *Antedon phalangium*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1883. *Antedon phalangium*, P. H. Carpenter, Proc. Zool. Soc. Lond., 1882 [1883], p. 746.
1884. *Antedon phalangium*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 361.
1886. *Antedon phalangium*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1886, vol. ii. p. 476.

Centro-dorsal hemispherical, conical, or somewhat columnar, bearing from twenty-five to thirty-five cirri. The longest of these have forty to fifty joints, of which the fourth and its immediate successors are somewhat longer than wide.

The following joints may either remain longer than wide and end in a sharp claw, usually without an opposing spine, or become gradually shorter, so as to be square or even shorter than wide at the end of the cirrus, with one or two opposing spines and a smaller terminal claw.

Three radials visible; the second but little united laterally, nearly oblong, strongly convex, and more or less incised for the axillaries, which are of variable shape, usually pentagonal and wider than long, but sometimes rhombic and sometimes hexagonal.

Ten arms of two hundred smooth joints. First brachials also of variable shape, but usually not very much incised by the second; the fourth and three following brachials nearly oblong, with alternating backward projections and pinnules on the shorter sides. Above the second syzygy the joints are at first triangular, and as long or longer than wide, but they gradually become quadrate and finally elongated. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of one to seven joints, usually two or three.

The first two pairs of pinnules (on the second to fifth brachials) are tolerably equal, long and flagellate. They consist of thirty to thirty-five joints, of which the six or eight at the base are quite short, and their successors much longer than wide. The following pinnules are shorter, with fewer joints, but the length of the lower ones gradually increases, except in the two at the base, which become somewhat flattened. Ovaries long and fusiform. Disk naked. Pinnule-ambulacra sometimes imperfectly protected by small and delicate plates; sacculi very abundant.

Colour,—green when alive; brownish-white in spirit. Disk 7 mm.; spread about 30 cm.

Localities.—H.M.S. "Lightning," 1868, Station 13; lat. 59° 5′ N., long. 7° 29′ W.; 189 fathoms.

H.M.S. "Porcupine," 1869; the Minch; 60 to 80 fathoms. Several specimens, with *Myzostoma alatum* and *Myzostoma pulvinar*. Also off Loch Scavaig, Skye. Cruise of 1870; Station 13, off Cape Mondego; lat. 40° 16′ N. long. 9° 37′ W.;

220 fathoms; bottom temperature, 52° F. Several specimens, with *Myzostoma alatum*.

Off Cape Sagres (near Cape St. Vincent); 45 fathoms. Several specimens.

Off Carthagena; 80 fathoms. Several specimens, with *Myzostoma alatum*.

Bay of Benzert; 50 to 100 fathoms. Abundant.

Skerki Bank; 30 to 120 fathoms. Abundant.

Other Localities.—(Mediterranean) Naples; Nice; Marseilles. The Atlantic—the Seine Bank, 88 fathoms (S.S. "Dacia"); off Cadiz ("Talisman").

Remarks.—This species was described by Müller so long ago as 1841, though for a long time but little was known about it. The original specimens which Müller examined had been obtained at Nice and at Naples, but for many years afterwards the type was never recorded as having been found at either of these localities or anywhere else. It was obtained off the coast of Tunis by the "Porcupine" Expedition of 1870, though the fact was not recognised at the time; and it was not till 1879 that much attention was directed to it. Professor Marion had dredged it four years previously in the harbour of Marseilles, and he gave a careful analysis of its peculiarities, which was accompanied by some excellent figures.[1]

Meanwhile, in the year 1857, a *Comatula* which had been dredged by Mr. M'Andrew, in the sound of Skye, was briefly described by Barrett[2] as new both to science and to the British fauna. He at first called it *Comatula woodwardii*, but on finding that this specific name had been previously employed by Edward Forbes for a fossil species from the Crag, he proposed to call it *Comatula celtica*, under which name it is recorded as having been dredged in the Minch by the "Lightning" and "Porcupine" in the cruises of 1868–69. The original specimens to which Barrett gave the name *Comatula celtica* disappeared for a considerable time, and it was not till they were discovered in the collection of the British Museum by Professor F. J. Bell that the true nature of his type was revealed. They are somewhat smaller than those which had been obtained in the Minch by Mr. Gwyn Jeffreys, and by the "Lightning" and "Porcupine," and had been generally referred to *Antedon celtica*. But during the next twenty years neither Barrett nor any British zoologist seems to have thought of comparing them with the second Mediterranean species of *Antedon*, the first of which (*Antedon rosacea*) is abundant on the British coasts; while the examples of *Antedon celtica*, which were dredged in abundance on the Tunis coast in 1870, were noticed by Sir Wyville Thomson[3] in the following passage:—"Many examples of the form known to continental naturalists under the name *A. mediterraneus*, Lam., sp., were

[1] Draguages au large de Marseille, *Ann. d. Sci. Nat.*, 1879, sér. 6, t. viii. pp. 40–45, pl. xviii.

[2] On two species of Echinodermata new to the Fauna of Great Britain, *Ann. and Mag. Nat. Hist.*, 1857, ser. 2, vol. xix. pp. 32, 33, pl. vii. fig. 1.

[3] *Proc. Roy. Soc. Edin.*, 1872, vol. vii. p. 765.

dredged in the Mediterranean off the coast of Africa. I do not feel satisfied that this is identical with *Antedon rosaceus* of the coast of Britain, though the two specific names are usually regarded as synonyms. There is a great difference between them in habit, a difference which it is difficult to define." Sir Wyville was unfortunately prevented by the state of his health from accompanying the "Porcupine" in this cruise, and only made a cursory examination of the Comatulæ subsequently. Had he been able to work them out at leisure, I cannot but think that the rediscovery of *Antedon phalangium* would have taken place five years earlier than it did. Professor Marion, to whom it was eventually due, has been kind enough to provide me with some of his specimens from Marseilles, and I have not the smallest hesitation in identifying them with the *Antedon celtica* of the Ross-shire coast, and also with the *Antedon* which was found by the "Porcupine" in such abundance in the Bay of Benzert, and on the Skerki Bank, off the coast of Tunis. During this same cruise of 1870 the type was also obtained by the "Porcupine" in 220 fathoms off Cape Mondego on the Portugese coast, and likewise in 45 fathoms off Cape Sagres. Several specimens were obtained too in about 80 fathoms a little to the south of Carthagena. The "Dacia" dredged it in abundance on the Seine Bank in 88 fathoms, and the "Talisman" took it off Cadiz. It inhabits somewhat deeper water than *Antedon rosacea*, both in the Mediterranean and in the Atlantic, and this accounts to some extent for its having so long escaped notice.

Besides making a careful comparison of the external characters in numerous Scotch and Mediterranean specimens, I have also compared the dissected calyces of examples from both localities. Were they fossils, and the only material at my disposal, I should unhesitatingly refer them to the same species. In each case there is the same great variation in the shape of the centro-dorsal, which may be either a thick disk, columnar, hemispherical, or conical. But whatever its shape, the functional cirrus-sockets are limited to two or three irregular rows around the equator, all the inferior portions of the piece having the sockets more or less completely obliterated (Pl. XXVIII. figs. 1, 2). The appearances presented by the first radials are nearly or quite identical in examples from the two localities. The figures which I have given of the Scotch *Antedon celtica* would do equally well as illustrations of the same parts in *Antedon phalangium*; though in some of the Scotch forms the transverse ridges separating the muscle-fossæ from those below them are less oblique than in the calyces which I have figured,[1] and I have not found this to be the case in any examples of the Mediterranean variety that I have examined.

The chief difference to be noticed between the Scotch and the Mediterranean varieties of this species is in the characters of the cirri. The maximum number of joints in both forms is from forty-five to fifty; but while in the Mediterranean

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii., pl. iv. figs. 1-8.

examples all the joints except those just at the base are much wider than long (Pl. XXVIII. figs. 1, 2), the later cirrus-joints of the Scotch variety are relatively shorter and thicker, so that in the extreme forms they are actually wider than long (Pl. XXVII. figs. 23, 24).

The longest cirrus which I have found in specimens from the Tunis coast measures 52 mm., and contains forty-seven joints, while in one from the Minch there are fifty-one joints, though the length is only 47 mm., and in the most extreme forms from this locality there are forty-eight joints in a length of but 35 mm. I have pointed out elsewhere [1] that these two types of cirri, apparently so different, are linked together by a complete series of intermediate gradations, in all of which there is a great amount of variation in the characters of the terminal claw and of its opposing spine. Evidently, therefore, the only character of the cirri of *Antedon phalangium* on which we can at all rely as having a sufficient degree of stability for specific distinction is the great number of their component joints. This is common to *Antedon prolixa* and to *Antedon hystrix*, and it serves as a convenient means of separating these three species from the large group which embraces *Antedon rosacea*, *Antedon tenella*, and similar forms with shorter and fewer jointed cirri.

Marion [2] has described the second radial of *Antedon phalangium* as "profondément enchancrée pour reçevoir l'axillaire, qui est très-grande." The four figures which he gives of the calyx certainly bear out his statements. But I have seen individuals from Marseilles that I owe to his kindness, and others from the Tunis coast, which have much less quadrate axillaries, and therefore also less deeply incised second radials. Other examples from the Tunis coast correspond to Marion's figures; but in most of these and in all the Scotch specimens the second radials are oblong in their general outline, and but little incised, while the axillaries are subtriangular, subquadrate, or more usually pentagonal, with their bases curving slightly outwards. Not unfrequently there are forward projecting lateral processes on the second radials which are much more marked in some individuals than in others. The axillaries may have slight processes of the same kind, and they are continued on to the first brachials as a sort of flattening of their outer sides, thus affording an approach to the condition of the *Basicurva*-group.

The two first brachials, just like the two outer radials, vary considerably in their shape and mutual relations. Thus, for example, in the four individuals figured by Marion the two joints borne by the axillary are well separated from one another above its distal angle, and the second brachials have an irregularly quadrate shape. But in the specimens dredged by the "Dacia" on the Seine Bank the second brachials are almost triangular in outline, and the two joints below them are closely united above

[1] On the Variations of the Form of the Cirri in certain Comatulæ, *Trans. Linn. Soc. Lond.* (Zool.), 1886, ser. 2, vol. ii. pp. 475–480, pl. lvii.

[2] *Ann. d. Sci. Nat.* (Zool.), 1879, sér. 6, t. viii. p. 43, pl. xviii. fig. 11.

the axillary. This is also the case in some of the Tunis specimens; but in others the first brachials are quite free laterally, as in those figured by Marion, and in the "Porcupine" examples from off Cape Mondego and from the Minch. A considerable amount of local variation in the shape of the outer arm-joints is also to be noticed. The triangular joints beyond the second syzygy are distinctly longer in the Mediterranean forms than in those from the Seine Bank and from the Minch; and this is still more marked in the outer part of the arm where the joints become quadrate (Pl. XXVII. figs. 28, 29).

The length of the lower pinnules is usually somewhat greater in the Mediterranean variety than in the Scotch one. Marion gives an average length of 12 to 17 mm. for the four lowest pinnules (on the second to fifth brachials). They reach 15 mm. in the largest examples from the Seine Bank. I have never, however, seen any Scotch specimens in which either of the four lower pinnules was more than 13 mm. long. The next two pairs are usually distinctly smaller, though I have occasionally found the pinnule on the sixth brachial to be almost as large as that on the preceding joint. Beyond the first four pinnules their component joints diminish considerably in number, but the basal ones increase in length, so that the inequality in the length of the pinnules is less marked than it would otherwise be. On the whole the disparity between the first four pinnules and their successors is somewhat greater in the Scotch specimens.

The peculiar modification of the two basal joints of the outer pinnules, which reaches its maximum in *Antedon eschrichti*, is also, as might be expected, more distinct in the northern than in the southern variety of *Antedon phalangium*. The shape of the first joint is much the same in both forms; but as a rule the second is relatively narrower in the Mediterranean variety (Pl. XXVII. fig. 27), so that the distinction between it and its successors is less marked than in the northern form (Pl. XXVII. fig. 26). There is, however, a considerable amount of variation in this respect, even in individual arms.

The "Porcupine" dredging in 220 fathoms off Cape Mondego in 1870 yielded a single larva of this species, in which the radial plates have not yet made their appearance (Pl. XIV. fig. 1). It does not differ in any important respect from the corresponding stage in the larva of *Antedon rosacea*. But the stem is a trifle less robust, as compared with the size of the head, and the five sacculi which are so constant in the *rosacea*-larva, one between the bases of every two oral plates, do not appear to be present at all.

Fig. 3 on Pl. XXVIII. represents the youngest condition of the free stage of *Antedon phalangium* that I have met with. It was obtained on the Seine Bank, by the "Dacia," together with others somewhat older. The first radials are more exposed than in the adult, and the pinnule of the third brachial is much smaller than that on the preceding joint, the next two pinnules being smaller still, while some of the following brachials are altogether without pinnules. A considerable number of cirri are developed, however, and they already show very distinct indications of the peculiarities which are characteristic of the type.

Ludwig[1] has made some observations as to the comparative distribution of calcareous plates and granules in the Neapolitan examples of *Antedon phalangium* and *Antedon rosacea.* He finds that while calcareous deposits are more or less developed on the disk of *Antedon rosacea*, that of *Antedon phalangium* is almost or entirely naked, which I find to be the case also both in Tunis and in Marseilles specimens, and in the Atlantic ones as well. But in the British variety of *Antedon rosacea* the perisome of the disk may be either naked or bear scattered tubercles containing groups of radiating calcareous spicules, and the perisomatic skeleton of the larval arms and pinnules disappears in later life. I have found no trace of it in any specimens of *Antedon rosacea*, even in those from the north of Scotland; though examples of *Antedon phalangium* from this neighbourhood have delicate plates on the pinnule-ambulacra. Like Ludwig, however, I have found small rods in the marginal leaflets on the pinnules of *Antedon rosacea* from Naples, and also in a Marseilles specimen; while in the Tunis variety of *Antedon phalangium* I find delicate perforated plates, the rudiments of the covering plates which are so largely developed in many tropical Comatulæ. They are less distinct in the specimens dredged by the "Dacia," and in those from Marseilles they are reduced to small Y-shaped rods, but little better developed than those of *Antedon rosacea.* In some individuals of the Scotch variety the pinnule-ambulacra are in this condition, while in others they have delicate, but still very definite plates, as in the examples from the Tunis coast. In those from 220 fathoms off Cape Mondego, however, these plates reach a considerable relative size and have a closer network of limestone rods. There are about three to each pinnule-joint, and they alternate pretty regularly with the sacculi, just as the side plates do in *Antedon acoela* and in other forms from the Eastern seas. They are much better defined than the side plates of many tropical species, but they do not support any covering plates above them. On the other hand, they are altogether different from the large and oval covering plates of *Rhizocrinus*, *Bathycrinus*, and *Hyocrinus*, which are unsupported by side plates, and rest directly on the pinnule-joints. Their occurrence in *Antedon phalangium* in the East Atlantic is the more interesting, as the locality is within a few miles of that which yielded *Pentacrinus wyville-thomsoni* and *Antedon lusitanica*, both with plated ambulacra; while the latter is the only European *Antedon* with both side plates and covering plates on the pinnules.

On the whole I am disposed to confirm Ludwig's observations respecting the greater length of the anal tube in *Antedon phalangium* than in *Antedon rosacea;* but the difference is not great, and is of no value as a specific character. The only two species which have any great amount of resemblance to *Antedon phalangium* are *Antedon hystrix* and *Antedon prolixa.* But it differs from both of them in the greater

[1] Über enige seltenere Echinodermen des Mittelmeeres, *Mitth. d. zool. Stat. Neapel*, 1880, Bd. ii. p. 54.

length of the second pair of pinnules, which are nearly equal to the first; while the backward projection of the axillaries into the second radials is more marked in both these types than in *Antedon phalangium*, more especially in *Antedon hystrix*.

Antedon phalangium serves as host to two species of *Myzostoma*, viz., *Myzostoma pulvinar* and *Myzostoma alatum*. The former is only known from the Minch; but the latter occurs both there and in the Atlantic, off Cape Mondego, and also in the Mediterranean where it was dredged off Carthagena. It is curious, however, that no *Myzostoma* was obtained with the great number of individuals which were met with by the "Porcupine" on the Tunis coast.

2. *Antedon hystrix*, n. sp. (Pl. XXVII. figs. 21, 22; Pl. XXVIII. figs. 4, 5).

Specific formula.—A. $\frac{c}{bc}$.

1884. *Antedon hystrix*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 365.

Centro-dorsal hemispherical or subconical, bearing fifty or sixty dimorphic cirri. The longest, which are round the margin, reach nearly 50 mm., and consist of about forty-five smooth joints, most of which are longer than wide. The smaller cirri nearer the dorsal pole have only about twenty-five joints, which are relatively shorter and overlap slightly.

First radials partially visible at the angles of the calyx; the second comparatively short and often not visible at all in the middle line of the ray, owing to their being very deeply incised to receive the strong backward projections of the axillaries. These are quadrate in form, with their sides curved, especially the anterior pair, and they are distinctly longer than wide, sometimes seeming to overlap the centro-dorsal; but much less than half the length is in front of the line joining their lateral angles. The first brachials have long outer sides and very short inner ones, but like the second radials are almost invisible in the middle line of the arm, owing to the very strong backward projections of the irregularly triangular second brachials, which nearly reach the axillaries. Both on these joints and on the rudely oblong third brachials, which are much wider than long, the pinnule-socket is placed nearer the dorsal surface than usual. The next following joints are short and quadrate, with curved proximal and distal edges; and the pinnule is on the shorter side, the longer being marked by a backward projection. Syzygies in the third and eighth brachials, and afterwards at intervals of three or four joints. Ten arms; the lower brachials triangular and slightly wider than long, slowly becoming quadrate, and somewhat elongated towards the arm-ends.

The first pair of pinnules (on 2nd and 3rd br.) are much longer and stouter than the next pair. They reach nearly 15 mm. and consist of some thirty smooth joints, the first six of which are short and nearly square. The second pair have but eighteen or twenty slender joints, and are only about 6 mm. long. The following pinnules increase gradually, both in length and in stoutness, reaching 15 mm. in the outer parts of the arms. The two basal joints are flattened and trapezoidal, with incurved edges. Ovaries long and fusiform, extending over the greater part of the length of the lower pinnules.

Disk naked or nearly so; sacculi abundant.

Colour in spirit,—light reddish-brown.

Diameter of centro-dorsal 5 mm.; spread about 17 cm.

Localities.—H.M.S. "Porcupine," 1869. Cold area? Two specimens, with *Myzostoma cirriferum.*

H.M.S. "Triton," 1882. Station 4; lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ W., and 8° 14′ W. 327 to 430 fathoms; stones, mud; bottom temperature, 31°·5 to 30°·0 F. One specimen.

Remarks.—The two individuals of this remarkable type which were obtained by the "Porcupine" in 1869, seem to have been regarded as belonging to *Antedon eschrichti*, and so remained unnoticed, while their locality was not recorded. They did not come into my hands till 1883, when I also received the Comatulæ dredged by the "Triton" and "Knight Errant." The former collection included another example of the same type from the "cold area," and as its nearest ally is the Arctic species *Antedon prolixa*, the "Porcupine" specimens may be safely referred to one of the "cold area" stations. All three individuals agree very closely in their general features and especially in the curious dimorphism of the cirri, which is almost as marked as in *Antedon phalangium*. A good example of the mature smooth and long-jointed cirrus is shown in Pl. XXVIII. fig. 4, and some of its younger stages are seen in fig. 5 round the upper edge of the centro-dorsal. But the cirri attached nearer the dorsal pole are somewhat different in appearance (Pl. XXVII. fig. 21). Many of them are comparatively short, with only about twenty-five joints, which are as wide as or wider than long and have slightly expanded ends so as to overlap their successors. This is especially marked on the dorsal side, which is produced into a sharp forward projecting spine. These characters seem to disappear, however, as the cirri increase in age and develop additional joints (Pl. XXVII. fig. 22), so that eventually they are not very markedly different from the smooth and long-jointed cirri of the other type.

Antedon hystrix has a considerable amount of resemblance to *Antedon prolixa*, which was obtained in Robeson Channel by Nares's Arctic Expedition in 1875, and was subsequently well described by Sladen.[1] Before giving a new name to the "Porcupine" and "Triton" specimens, I compared them carefully with Sladen's type, and came to the conclusion that they should be regarded as distinct. Subsequent research has justified this view. I have elsewhere described two specimens of *Antedon prolixa* which were

[1] *Op. cit.*, p. 77, pl. vi. figs. 7–10.

dredged by the "Varna" in the Kara Sea; and by the kindness of Mr. F. Nansen, Conservator of the Bergen Museum, I have been able to examine half-a-dozen individuals of the same type which was met with in abundance by the Norwegian North Atlantic Expedition near Spitzbergen. These last come nearest to *Antedon hystrix* in their general robustness, the more northern forms of the type being generally smaller, except as regards the cirri. These seem to be a little less smooth and to reach a greater length in *Antedon prolixa* than in actually larger individuals of *Antedon hystrix*. Thus, for example, an imperfect cirrus of *Antedon prolixa*, with the extremity missing, which was measured by Sladen, reaches 58 mm.; while I have not found any cirrus exceeding 50 mm. in *Antedon hystrix*. This, however, is a point of minor importance. The great difference between the two types lies in the characters of the two outer radials and of the two lowest brachials. The second radials of *Antedon prolixa* are but little more incised for the axillaries than those of *Antedon phalangium*, with which species Sladen has well compared it, though the two differ altogether in the proportions of the second pair of pinnules; while the axillaries of *Antedon prolixa* are very regularly quadrate and as wide as or wider than long, the line joining their lateral angles dividing them into two nearly equal parts. In *Antedon hystrix*, however, they are longer than wide, and project so deeply backwards into the second radials that they sometimes seem to overlap the centro-dorsal (Pl. XXVIII. figs. 4, 5). The second radials are therefore almost invisible in the middle line of the ray, though when seen from the side they appear to have a considerable relative length and to form a projecting tubercle together with the axillaries, as is well shown in Pl. XXVIII. fig. 4. The shape of the axillaries therefore is not "very regularly quadriform" as described by Sladen in *Antedon prolixa*, but more pear-shaped, with much less than half the length of the plate in front of the line joining the lateral angles, a condition exactly the reverse of that which occurs in many forms of *Antedon eschrichti*. In like manner the second brachials of *Antedon hystrix* are relatively larger, and project further backwards into the first than in *Antedon prolixa*, so that there is a more distinct tubercle on the line of junction.

The "Triton" specimen of *Antedon hystrix* was dredged in about lat. 60° 30′ N., and *Antedon prolixa* was obtained by the Norwegian North Atlantic Expedition in lat. 76° N., near Spitzbergen. It is of course possible that future explorations in the intervening area of the Atlantic may discover a series of forms intermediate between those which now appear distinct; and I should not be very greatly surprised if this should turn out to be the case. Were they really identical, *Antedon prolixa* would present just the opposite condition to *Antedon eschrichti*, its northern variety being less robust than that found in lower latitudes. The small examples of *Antedon prolixa* from the Kara Sea (lat. 71° N.) are, however, very different from *Antedon hystrix*. The "Triton" specimen of the latter type presents a very curious malformation, which is shown in Pl. XXVIII. fig. 5. The two second brachials of one ray jointly support a single arm, so that there are only nine arms, not ten. The two third brachials are replaced by a single syzygial joint, which has the shape of an axillary reversed, *i.e.*, with the angle downwards, and it bears a pinnule on the left side. The following arm-joints are of the usual character. A somewhat similar monstrosity was noticed in Part I. (p. 347) as occurring in *Metacrinus angulatus*, and Levinsen[1] has figured one of much the same in kind in *Antedon eschrichti.*

Two larvæ which were dredged by the "Porcupine" in the "cold area" come to be referred to *Antedon hystrix* by a sort of process of exclusion, as I cannot identify them with the Pentacrinoids either of *Antedon tenella* or of *Antedon eschrichti*, with which latter species *Antedon quadrata* is very closely allied.

No. 1 (Pl. XIV. fig. 2). In this larva there is no trace of cirri, the anal plate separates two of the radials, and the arms are just beginning to sprout from the radial axillaries. There are five discoidal joints at the top of the broken stem, which is much more robust than that of the corresponding stage of *Antedon rosacea*, while the head, which exceeds 1 mm. in length, is nearly twice as big as that of the *rosacea*-larva. The orals, which rest directly on the radials, recall those of *Hyocrinus*, having a deep median groove, only more marked than in that type, with the lateral edges folded over somewhat strongly. This character is less marked in the *rosacea*-larva, and the orals of *Antedon tenella* in the first and second stages of the Pentacrinoid were described by Sars[2] as convex. In its general appearance the Pentacrinoid now under consideration comes between the second and third stages of the larvæ described by Sars, but is of larger size than both. Sars gives the measurements of the head as 0·5 and 0·75 mm. respectively, the larger individual having six brachials above the axillaries; but in the "Porcupine" larva there are only two short brachials, and the head reaches 1·1 mm. It resembles the larva of *Antedon tenella* in the great height of the basals, but differs from it altogether in the unusual shortness and width of the radials, especially the first. These plates are relatively wider than the corresponding plates in an older stage of *Antedon tenella*, whereas they would be relatively longer did the larva belong to this species. A similar difference between the radials of two other larvæ in almost the same stage of development will appear on comparison of figs. 8 and 9 on Pl. XIV. I think it not improbable that this "Porcupine" larva may be a younger stage of that represented in Pl. XIV. fig. 3, which was also dredged in the cold area during the cruise of 1869.

No. 2 (Pl. XIV. fig. 3). The stem, which is broken some 20 mm. from the calyx, forms an attachment to a hydroid-tube at about its thirtieth joint, and is continued downwards half-a-dozen joints further. There are six discoidal joints below the rudimentary centro-dorsal, which bears the sockets of five short cirri. Only one of them remains, however, reaching up to the top of the basals, which make up about half the

[1] *Op. cit.*, p. 35, Tab. xxxv. fig. 7.
[2] Mémoires pour servir à la connaissance des Crinoïdes vivants, Christiania, 1868, p. 48.

height of the cup. The second radials and axillaries are well developed, as are also the arms, which are unfortunately broken at about the tenth joint or earlier. But even under these circumstances the head has a length of 4 mm. A slightly bifid plate, having a somewhat worn appearance, stands up in one of the interradii of the disk. It may be one of the orals, or, as I am more inclined to think, the anal plate. For I cannot make out anything corresponding to it in the other interradii, which are, however, but imperfectly visible. A striking feature of this very robust larva, and one in which it resembles *Antedon tenella* rather than *Antedon rosacea*, is the large development of the arms before the appearance of the cirri. The radials and brachials are larger than those of a recently detached individual of *Antedon rosacea*. This is also the case in the Pentacrinoid of *Antedon eschrichti* and in that of *Antedon multispina*, from near Ascension (Pl. XIV. fig. 7), which has a very robust appearance, like the larva now under consideration. The latter can hardly be a younger stage of the Pentacrinoid of *Antedon eschrichti* than that figured by Levinsen.[1] Their difference in relative age is not great, while they are very unlike in many respects. The "Porcupine" larva has high basals and relatively wide first radials, with short, wide, and well-formed axillaries (Pl. XIV. fig. 3); while in the Pentacrinoid of *Antedon eschrichti* the basals are low, the radials relatively high, and the axillaries rhombic, about as wide as long. It would appear for the same reason that this larva cannot belong to *Antedon quadrata*, which is most closely allied to, if not identical with, *Antedon eschrichti*, while it is clearly not that of *Antedon tenella*, and the only other *Comatula* known to occur in the cold area is *Antedon hystrix*.

The brachial ambulacra of this larva are protected by relatively large plates, not unlike those which occur in some varieties of *Antedon phalangium*, but the armature of the ambulacra in the mature *Antedon hystrix* consists of quite simple rods of limestone. This difference may perhaps be explained by the fact that an absorption of the perisomatic skeleton of the Pentacrinoid seems to take place in some forms of *Antedon rosacea*, as noticed by Dr. Carpenter.[2]

3. *Antedon tenella*, Retzius, sp. (Pl. XIV. fig. 4; Pl. XXXI. figs. 1–4).

Specific formula—A.$\frac{c}{b}$.

1783. *Asterias tenella*, Retzius, K. Svensk. Vetensk. Akad. Handl., 1783, t. iv. p. 241.
1788. *Asterias tenella*, Linn., Systema Naturæ, ed. xiii., cura, J. F. Gmelin, Lipsiæ, 1788, t. i. pars vi. p. 3166.
1805. *Asterias tenella*, Retzius, Dissertatio, sistens Species Cognitas Asteriarum, Lundæ, 1805, p. 33.
1825. *Alecto dentata*, Say, Journ. Acad. Nat. Sci. Philad., 1825, vol. v. p. 153.
1835. *Comatula mediterranea* (?), Sars, Beskriv. og Jagtagels, Bergen, 1835, p. 40, pl. 8, fig. 19 *a–g*.

[1] *Loc. cit.*, tab. xxxv. fig. 8.

[2] *Phil. Trans.*, 1866, p. 741.

1844. *Alecto Sarsii*, Düben and Koren, K. Svensk. Vetensk. Akad. Handl., 1844 [1846], p. 231, t. vi. fig. 2.
1849. *Comatula (Alecto) Sarsii*, Müll., Abhandl. d. k. Akad. d. Wiss. Berlin [1847], 1849, p. 254.
1857. *Alecto Sarsii*, Lütken, Vid. Meddel. nat. Foren Kjobenhavn, 1857, p. 107.
1860. *Comatula Sarsii*, Alder, Ann. and Mag. Nat. Hist., 1860, ser. 3, vol. v. p. 74.
1861. *Alecto Sarsii*, Sars, Oversigt af Norges Echinodermer, Christiania, 1861, p. 1.
1862. *Comatula Sarsii*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 199.
1865. *Antedon Sarsii*, Norman, Ann. and Mag. Nat. Hist., 1865, ser. 3, vol. xv. p. 103.
1866. *Antedon (Alecto) dentata*, Verrill, Proc. Boston Soc. Nat. Hist., 1866, vol. x. p. 339.
1868. *Antédon Sarsii*, Sars, Mémoires pour servir à la Connaissance des Crinoïdes vivants, Christiania, 1868, p. 47, tab. v., vi.
1872. *Antedon sarsii*, Wyville Thomson, Proc. Roy. Soc. Edin., 1872, vol. vii. p. 765.
1874. *Antedon Sarsii*, Verrill, Amer. Journ. Sci. and Arts, 1874, vol. vii. p. 500.
1879. *Antedon Sarsii*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), 1879, ser. 2, vol. ii. p. 29.
1880. *Comatula Sarsii (?)*, A. Agassiz, Bull. Mus. Comp. Zoöl., 1880, vol. vi., No. 8, p. 150.
1880. *Antedon Sarsii*, Verrill, Amer. Journ. Sci. and Arts, 1880, vol. xx. p. 401.
1880. *Antedon Sarsii*, d'Urban, Ann. and Mag. Nat. Hist., 1880, ser. 5, vol. vi. p. 381.
1881. *Antedon Sarsii*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1881, vol. ix., No. 4, p. 5.
1882. *Antedon Sarsii*, Verrill, Amer. Journ. Sci. and Arts, 1882, vol. xxiii. p. 135.
1882. *Antedon dentatum*, Verrill, *Ibid.*, p. 222.
1882. *Antedon sarsi*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1883. *Antedon dentata*, P. H. Carpenter, Proc. Zool. Soc. Lond., 1882 [1883], p. 746.
1884. *Antedon dentata*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 362.
1884. *Antedon dentata*, Verrill, Ann. Rep. Commissioner Fish and Fisheries for 1882, Washington, 1884, p. 661.
1886. *Antedon dentata*, P. H. Carpenter, Bijdragen tot de Dierkunde, 13 Afdeling, vi. p. 9.

N.B.—Not *Antedon Sarsii*, von Marenzeller (1877), nor *Antedon dentata*, Fischer (1886).

Centro-dorsal hemispherical or conical, bearing a great number of cirri, seventy or eighty in large specimens. They have fifteen to nearly thirty joints, most of which are longer than wide, the lower ones greatly so, and somewhat dice-box-shaped; the later joints with sharp spines which project forwards over the bases of their successors.

First radials just visible; the second short, deeply incised by the rhombic axillaries, which are as wide, or usually wider than long, and extend laterally beyond them. Ten arms; the first brachials barely meeting above the sharp distal angles of the axillaries, and deeply incised by the quadrate second brachials. From the first to the second syzygy the joints have backward projections on alternate sides, and the next following joints are triangular, as wide or wider than long, gradually becoming obliquely quadrate. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of two joints.

The first pair of pinnules (on second and third brachials) slender and flagellate, reaching 15 mm. or more in length, and consisting of nearly forty joints, most of which are longer than wide. The next pair usually only one-third their length, with about ten joints, the lowest of which are stouter than in the first pair. The following pinnules similar in character and of gradually increasing length, with fusiform genital glands. The basal joints of the distal pinnules are quite short, with their apposed edges incurved, and the following joints are greatly elongated. Disk naked; the brachial ambulacra sometimes provided with delicate calcareous rods, which alternate with the numerous sacculi.

Colour in spirit,—white.

Disk reaching 7 mm.; spread may be 8 cm.

Localities.—H.M.S. "Porcupine," 1869, Station 51; lat. 60° 6′ N., long. 8° 14′ W.; 440 fathoms; bottom temperature, 42° F. One specimen.

Station 54; lat. 59° 56′ N., long. 6° 27′ W.; 363 fathoms; bottom temperature, 31°·4 F. One specimen.

Station 55; lat. 60° 4′ N., long. 6° 19′ W.; 605 fathoms; bottom temperature, 29°·8 F. Two specimens.

Station 74; lat. 60° 39′ N., long. 3° 9′ W.; 203 fathoms; bottom temperature, 47°·6 F. Three specimens.

Cruise of 1870, Station 17A; lat 39° 39′ N., long. 9° 39′ W.; 740 fathoms; bottom temperature, 49°·3 F. One specimen.

H.M.S. "Triton," 1882; Station 2; lat. 59° 37′ 30″ N., long. 6° 19′ W.; 530 fathoms; mud; bottom temperature, 46°·2 F. Five mutilated specimens.

Station 5; lat. 60° 11′ 45″ N. and 60° 20′ 15″ N., long. 8° 15′ W. and 8° 8′ W.; 433 to 285 fathoms; hard ground, stones; bottom temperature, 43°·5 to 40°·8 F. Two specimens, with *Myzostoma carpenteri*.

Other Localities.—The Shetlands; Scandinavia; Kara Sea; Barents Sea; West Atlantic, off the American coast from Nova Scotia to New Jersey.

History.—This species was separated by Retzius[1] in 1783 from the *Asterias pectinata* of Linnaeus, the type of which was an *Actinometra* from the Indian Ocean, but Linnaeus also referred to it the Δεκάκνημος *rosacea* and Δεκάκνημος *barbata* of Linck. These seem to be the British and Mediterranean varieties respectively of the somewhat protean type which is now known as *Antedon rosacea.* In fact Linnaeus's description of *Asterias pectinata* would apply equally well to almost every ten-armed *Comatula*; and it was remarked by Retzius that "the definition of the species is such that it includes two species, namely, *pectinata* and *tenella*." He described the latter form as being more delicate than *Asterias pectinata*, and as having the "bases brachiorum duplicatorum multo longiores."[2] This is a distinction of almost generic value between *Antedon* and *Actinometra*, in which latter genus the relative length of the radials is quite small; and Retzius pointed out further differences in the shape of the arm-joints between

[1] Anmärkningar vid Asteriæ Genus, *K. Svensk. Vetensk. Akad. Handl.*, 1783, t. iv. p. 241.
[2] Dissertatio, sistens Species Cognitas Asteriarum, Lundæ, 1805, p. 33.

the Linnean type of *Asterias pectinata* and the new form which he proposed to call *Asterias tenella*. He described the habitat of the latter as "St Croix"; and this is given as the island of "Santa Cruz" in Gmelin's edition of the Systema Naturæ, where *Asterias tenella* is added to *Asterias pectinata* and *Asterias multiradiata* of the earlier editions.

Lamarck took but little notice of these three species when he established the genus *Comatula*. *Asterias pectinata* was not noticed by him at all, though he proposed a new name, *Comatula mediterranea*, for Linck's *Decacnemos rosacea*, which had been included by Linnaeus in *Asterias pectinata;* while he referred *Asterias tenella* with a ? to his new species *Comatula brachiolata*,[1] which we now know to be an *Actinometra* closely allied to the type of *Asterias pectinata*. Lamarck, however, was the only post-Linnean zoologist who recognised that *Asterias tenella* was a Comatulid and not a Star-fish, a fact which would seem sufficiently obvious when we remember that Retzius had pointed out how it had been hitherto confused with *Asterias pectinata*. Goldfuss, indeed, gave the name *Comatula tenella* to a fossil from Solenhofen, which was one of the four species subsequently placed by Agassiz in his new genus *Saccocoma*.

Asterias tenella seems to have entirely escaped the notice of Johannes Müller when he examined the Retzian collection at Lund in 1841, and it has consequently altogether dropped out of the literature. The original of the type, however, is still extant, together with the examples of *Asterias pectinata* and *Asterias multiradiata* from the Indian Seas which are the types of these two species respectively. I have been privileged to examine all three, and find *Asterias tenella* to be very different from *Asterias pectinata*, for it is identical with the well-known Scandinavian species which was described in 1844 by Düben and Koren as *Alecto sarsii*.[2] This specific name has been in use for nearly forty years, and the range of the type was extended to lat. 70° N. by the "Willem Barents"; while the "Porcupine" had previously dredged it at various localities in the Færoe Channel and also at 740 fathoms as far south in the Atlantic as lat. 39° N.

In the year 1880, however, the same species was obtained several times off the coast of New England by the explorations of the United States Coast Survey and Fish Commission. Two years later Mr. Verrill[3] recognised that *Alectro dentata*, which was described by Say in 1825 from a specimen found at Great Egg Harbour, New Jersey, is identical with *Antedon sarsii*, which occurs in abundance at various depths off the American coast from New Jersey to Nova Scotia. A restoration of Say's specific name thus became inevitable, and the association of the type with the familiar name of a deservedly honoured Norwegian naturalist was no longer possible. Now, however, it appears that forty-two years before the publication of Say's name Retzius had described the same species from the American coast, and I have much pleasure therefore in restoring his name.

[1] *Op. cit.*, p. 535.

[2] Öfversigt af Skandinaviens Echinodermer, *K. Svensk. Vetensk. Akad. Handl.*, 1844 (1846), p. 231, t. vi. fig. 2.

[3] Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England. No. 4, *Amer. Journ. Sci. and Arts*, 1882, vol. xxiii. p. 222.

The non-employment of it by Düben and Koren in 1844 is not difficult to understand, for the occurrence of the same specific type on both sides of the Atlantic was not such a familiar idea then as it is now; and Müller had taken no notice of *Asterias tenella*, Retzius, in his "Neue Beiträge." These were published in 1843 after his visit to Lund, and contained amended descriptions of *Asterias pectinata* and *Asterias multiradiata*, the other two Comatulæ mentioned in Retzius's dissertation, which he had personally examined. Müller's omission to notice *Asterias tenella* seems to have caused its relegation to the class of *species incertæ sedis*, from which I am glad to be able to rescue it. I am in some doubt, however, as to whether the "St Croix" of Retzius can be the island Santa Cruz, as mentioned by Gmelin. Retzius did not repeat it in his later dissertation, but simply said "Habitat in oceano Americano." Santa Cruz being a Danish island, one can readily understand that specimens collected there might come into the hands of Swedish naturalists; but on the other hand it is in latitude 18° N., considerably (about 20°) further south than any locality at which *Antedon tenella* has been dredged by American naturalists. I have tried, however, but in vain, to identify the Retzian type with any Caribbean *Antedon*, though it has all the characters of the Scandinavian *Antedon sarsii* and of *Alectro dentata*, Say.

While, therefore, I have no doubt as to its identity with these two types, I should hesitate for the present to quote it as a Caribbean species.

Remarks.—The Scandinavian variety of *Antedon tenella*, which was described as *Alecto sarsii* by Düben and Koren, is considerably smaller and less robust than individuals dredged from deep water in various parts of the Atlantic. The cirri do not seem to have more than about twenty joints, while there may be six or eight more in individuals from the New England coast, Færoe Channel, and Kara Sea. The projecting spines at the distal ends of the cirrus-joints are also less developed in the Scandinavian examples. In the larger forms from the West Atlantic the distal ends of the joints in the long oral pinnules are fringed with strong spines, so that they appear to overlap the bases of their successors, and this character is much less developed in the European variety. On the other hand, the delicate calcareous rods at the sides of the ambulacra, which Sars described in the larva,[1] are larger in the Norwegian form than in examples from deeper water; and they are sometimes entirely absent in the American variety. The latter is also remarkable for the want of constancy in the proportions of its second pair of pinnules. In some examples these have only a dozen joints and are not more than 5 mm. long, but one-third the length of the first pair. But in others they reach 7 or 8 mm. and have as many as twenty joints, a condition which I have not noticed in any individuals from the East Atlantic.

Antedon tenella is closely allied to two other cold-water species, *Antedon hystrix* and *Antedon prolixa*, with both of which it has been found associated. It is distinguished,

[1] Crinoïdes vivants, p. 51, tab. vi. fig. 20.

however, by its smaller size, lesser number of cirrus-joints, and by the different proportions in the lengths of the first two pairs of pinnules. Like *Antedon prolixa*, too, it ranges from shallow water down to 700 fathoms; but it has a much more extensive geographical range.

Fischer[1] has recently come to the conclusion, which I believe to be an erroneous one, that the specimens which were described by Duncan and Sladen[2] under the name *Antedon prolixa* are in reality but "ausgewachsene Exemplare" of *Antedon sarsii*, *auct.*, *i.e.* of *Antedon tenella*. Two of the four Comatulæ which he obtained at Jan Mayen clearly belong, as he himself states, to *Antedon prolixa*, as defined by Sladen. The length of an incomplete arm in the larger one is 120 mm. The cirri, composed of twenty-eight to forty-three joints, vary in length from 20 to 60 mm.; the first pinnule with twenty-eight joints is 14 mm. long, and the second with twelve joints reaches only 4·3 mm.[3] It appears from these numbers that Fischer's larger specimen is somewhat better developed than Sladen's type, with which it is evidently identical. Fischer has further compared it with the two individuals which were obtained in the Barents Sea by the "Tegetthoff," and were referred by Dr. E. von Marenzeller to *Antedon sarsii*.[4] Fischer's conclusion is expressed in the following passage,—"Wenn man nun erwägt, dass mit Ausnahme der durch die Grössenverhältnisse bedingten Unterschiede (das grössere der von Marenzeller beschriebenen Exemplare hatte Arme von nur 80 mm. Lange) nämlich die geringere Anzahl von Ranken-Gliedern,—sonst keine Abweichungen zu verzeichnen sind, so muss man nothwendigerweise zu der Überzeugung gelangen, was ich übrigens an der Hand der später zu beschreibenden Jugendzustände des Weiteren ausführen werde, dass unter *Antedon prolixa*, Sladen nur ausgewachsene Exemplare von *A. Sarsii*, welche bislang noch nicht erschöpfend beschrieben waren, zu verstehen sind."

The largest cirri of the "Tegetthoff" specimens have thirty-three joints and reach 37 mm. long. These dimensions are altogether exceptional for *Antedon tenella*, in the Scandinavian examples of which there are usually not more than eighteen or twenty cirrus-joints, while there may be about twenty-five in those from the Kara Sea and the Færoe Channel, and twenty-eight or thirty in the American variety, with a maximum length of 24 mm.[5] I cannot help suspecting therefore that the "Tegetthoff" specimens may really be the young of *Antedon prolixa*. Dr. von Marenzeller was kind enough to send them to me for examination in 1881, and I have hitherto regarded them as he seems to have done, viz., as abnormal forms of *Antedon sarsii* (*tenella*). At the time I examined them I was unacquainted with *Antedon prolixa*, and the possibility of their being the young forms of this type never occurred to me. But in the six years which have passed since then I have seen many examples both of *Antedon*

[1] Echinodermen von Jan Mayen, *Die Österreiche Polarstation Jan Mayen*, Bd. iii., Wien, 1886, p. 30.
[2] *Op. cit.*, p. 77, pl. vi. figs. 7–10.
[3] This is accidentally printed as 43 mm. in Fischer's paper.
[4] *Denkschr. d. k. Akad. d. Wiss. Wien*, 1877 (1878), Bd. xxxv. p. 381.
[5] Figs. 3, 4 on Pl. XXXI. represent the average cirri of the Færoe Channel and American varieties respectively.

prolixa and of *Antedon tenella* in various stages of growth, and the largest cirri that I have met with in the most robust examples of *Antedon tenella* from the American coast are little more than half as long as those of the "Tegetthoff" specimens of the same size; while the measurements of these last correspond very well with those of the young *Antedon prolixa* from the Kara Sea and Spitzbergen.[1] Apart from this possibility, however, it appears to me that Fischer attributes to *Antedon tenella* a much greater variability in the size of the cirri than is justified by our knowledge of other Comatulæ. He asserts that the small Scandinavian form with cirri 10 mm. long, and consisting of eighteen or twenty joints, which he thinks he got at Jan Mayen,[2] is identical with Sladen's *Antedon prolixa* which reaches more than twice its size, and has cirri of forty to forty-five joints which reach 60 mm. long. The Scandinavian form is sexually mature and presents all the characters of an adult *Comatula;* and if it is only a dwarf variety there must be some reason for its existence. But Fischer believes it to occur at Jan Mayen, side by side with the large form which belongs to the type of *Antedon prolixa.* This fact, if true, would seem of itself to indicate that the two forms are different; for if the dwarfing conditions were in operation at Jan Mayen, the large *prolixa*-type would not exist there.

Even if we suppose that the "Tegetthoff" specimens really are a local variety of *Antedon tenella* with unusually developed cirri, 37 mm. long, of thirty-three joints,[3] there is a great difference between these cirri and those of the mature *Antedon prolixa*, which may have forty to forty-five joints, and reach 60 mm. in length; and the difference is still greater if we remember the average size of the cirri in the Scandinavian type. If it

[1] Since the above remarks were printed, Dr. von Marenzeller has been good enough to send me the two "Tegetthoff" specimens for re-examination; and I have no doubt whatever that they are immature forms of *Antedon prolixa*, for they agree with this type in all the characters of the cirri, calyx, arms, and pinnules, much better than with either the American or the European variety of *Antedon tenella.* They were dredged by the "Tegetthoff" in 1873, two years before Sladen's types were obtained by the "Alert," and are therefore the earliest discovered examples of the species.

[2] I have left this discussion almost exactly as it was written originally; but Dr. von Marenzeller's kindness has recently enabled me to examine the two small specimens from Jan Mayen which Fischer identified with the Scandinavian *Antedon sarsii* (*tenella*); and I can state without hesitation that they do not belong to this species. It is no doubt the case, as remarked by Fischer, that "Diese zwei exemplaren tragen sammtliche von Duben & Koren und den späteren Autoren für *Antedon Sarsii* angegebenen charakteristischen Merkmale." But Duben and Koren's description of the type is over forty years old; and subsequent writers have added little of importance to it. Fischer does not seem to have made a direct comparison of his two small specimens from Jan Mayen with actual examples of the Scandinavian *Antedon sarsii*, though this would have been by far the most satisfactory way of determining their real nature. Their cirri are considerably larger than those of a Scandinavian form of equal size which has well-developed genital glands and all the other characters of maturity. Its first radials are almost entirely concealed, while in Fischer's specimens a considerable portion of them is visible, very much as in the young *Antedon phalangium* shown on Pl. XXVIII. fig. 3. Similar differences appear in the characters of the lower arm-joints of the two forms. In those from Jan Mayen the joints are longer than wide, with incompletely developed pinnules; while in a Scandinavian *Antedon sarsii* (*tenella*) of equal size, these joints are as wide or wider than long, and present the shape characteristic of the adult individual (Pl. XXXI. fig. 1). The difference is so marked that Fischer can hardly have overlooked it if he really did compare the two types. But the shape of the arm-joints is not a character to which previous authors have paid much attention; and if Fischer simply attempted to identify *Antedon sarsii* from the published descriptions of it, his reference of the two small forms from Jan Mayen to this type may be readily understood.

[3] See note 1.

be admitted that the perfect cirri of sexually mature individuals of the same species may vary in size from eighteen to forty-five joints, and in length from 10 to 60 mm., the characters of the cirri become altogether valueless for systematic purposes, and Bell's formulæ for expressing them briefly are of no use whatever, while the various schemes of classification of the different specific groups which are given in this Report must be to a large extent rearranged.

Such an extensive range of variation in the characters of the cirri as is demanded by Fischer's theory is one of which I have no experience whatever. *Antedon eschrichti* ranges over nearly forty degrees of latitude; but in the small Atlantic variety, as in the large Arctic one, there are over forty joints in the cirri, which reach in the former to little short of the length that they do in the latter type. The cirri of *Antedon phalangium* have the same number of joints (about forty-five) in the Mediterranean as in the Minch, though the joints are much shorter in the latter locality, so that the total length of the cirri is reduced. Both these species thus resemble *Antedon prolixa* in having over forty cirrus-joints in their southern, as well as in their northern variety; and they thus afford no support whatever to Fischer's theory of the great range of variation in *Antedon tenella*.

If *Antedon tenella* of Scandinavia, the Arctic Ocean, and the Atlantic is merely a dwarf or undeveloped variety of *Antedon prolixa*, young examples of the latter species should present all the characters of *Antedon tenella;* but this is very far from being the case. Two immature individuals of *Antedon prolixa* in different stages of growth were obtained by the "Varna" in the Kara Sea, and others at about the same stage as the larger of these were kindly sent to me by Mr. F. Nansen from the dredgings of the Norwegian North Atlantic Expedition near Spitzbergen. I do not think that any one could possibly refer them to *Antedon tenella*. I have compared the smaller form with an absolutely larger example of *Antedon tenella* which was dredged by the "Willem Barents" in the Barents Sea at no great distance from the locality of the "Tegetthoff's" dredgings. The calyx of the latter is altogether more robust than that of the former, and the first radials are concealed, while both the axillaries and the second brachials have assumed the shape characteristic of the adult condition. The former (*Antedon prolixa*), however, shows its immaturity by the appearance of a considerable portion of the first radials externally, by the shape of the axillaries and of the second brachials, which is not that of these respective joints in the adult, and by the greatly elongated arm-joints. The cirri, on the other hand, are much better developed than those of the more mature and absolutely larger *Antedon tenella*, as seen from the comparison of measurements A in the following table :—

	Antedon prolixa.		*Antedon tenella.*	
	A.	B.	A.	B.
Length of cirri, ...	14·5 mm.	33·5 mm.	11 mm.	18 mm.
Number of joints, .	25 ,,	34 ,,	20 ,,	26 ,,

Measurements B represent the results of a similar comparison of the yet more robust *Antedon tenella* from the West Atlantic with other immature examples of *Antedon prolixa*, larger than that already considered, but absolutely smaller than the individual of *Antedon tenella* with which they are compared. In each case alike the cirri of *Antedon prolixa* with an incompletely developed calyx and arms, are longer and have more numerous joints than individually larger examples of *Antedon tenella*. The difference in *absolute size* may be judged from the fact that in *Antedon prolixa* (B) there is a length of but 4·5 mm. between the pinnule on the seventh and that on the thirteenth brachial; while in *Antedon tenella* this distance measures 7 mm., and yet the cirri of this latter type are not much more than half the length of those of the young *Antedon prolixa*.

The reverse is the case with the pinnules, however; the first pinnule of *Antedon tenella* has nearly forty joints, and reaches 15 mm., while that of the young *Antedon prolixa*, 10 mm. long, has but twenty-seven joints, though its cirri are so much better developed than those of the other species.

It will, I think, be evident from the above-mentioned facts that *Antedon tenella* and *Antedon prolixa* are different species, and not merely different stages of growth of one and the same type, as supposed by Fischer. The most robust examples of *Antedon tenella* with fully-developed arms and pinnules have very distinctly smaller cirri than immature and absolutely smaller examples of *Antedon prolixa*. This demonstrates the fallacy of Fischer's conclusion, which he further endeavours to support by the following passage:—"Sollten noch irgend welche Zweifel entstehen, so werden dieselben wiederlegt durch die Thatsache, dass ich gleichzeitig mit den bereits beschriebenen Exemplaren zwei *Pentacrinus*-Stadien auf einer *Rhynconella* aufsitzend fand, die volkommen mit den Beschreibungen übereinstimmen, die Sars in seinen 'Mémoires des crinoïdes vivants' gibt, und auf Taf. v und vi abbildet."

I must confess that I cannot see the force of this reasoning. Fischer found two examples of *Antedon prolixa* at Jan Mayen, and two smaller forms, together with two Pentacrinoids, all four of which he referred to *Antedon sarsii* (*tenella*). But I do not understand at all why the occurrence of these two Pentacrinoids[1] should render it so certain that *Antedon tenella* is only an immature *Antedon prolixa*. Precisely the same reasoning would entitle me to assert that *Antedon tenella* is only an immature form of *Antedon eschrichti*. For the latter species was dredged by the "Porcupine" in the cold area together with *Antedon tenella* and its Pentacrinoid; and in like manner *Antedon rosacea* was obtained on the Skerki Bank together with *Antedon phalangium* and its Pentacrinoid. *Antedon multispina* with three Pentacrinoids was dredged by the Challenger at the same Station (No. 344) as *Antedon porrecta*; while *Antedon*

[1] I cannot help suspecting that there may be differences between these Pentacrinoids and the larva of *Antedon tenella* which have escaped Fischer's notice.

tuberosa and its Pentacrinoid were found associated at Station 210 with *Antedon distincta*. But these facts afford us no grounds for asserting that *Antedon rosacea* and *Antedon phalangium*, *Antedon porrecta* and *Antedon multispina*, *Antedon tuberosa* and *Antedon distincta* are respectively identical types.

Thus then it appears to me that neither of Fischer's reasons for believing in the specific identity of *Antedon tenella* and *Antedon prolixa* has any probative value; and I see no necessity, therefore, for reducing *Antedon prolixa*, Sladen, to the rank of a synonym as Fischer has done. (See the footnotes on p. 175.)

One example of the Pentacrinoid larva of *Antedon tenella* was dredged by the "Porcupine" in the Færoe Channel. It is a trifle more advanced than that represented by Sars in figs. 9 and 11 on Tab. V. of his classical "Mémoires." The arms are longer, with no pinnule below the eighth joint. There is, however, but one cirrus, which seems to be the only one as yet developed, though it is of considerable size, reaching up to the level of the radial axillaries on the opposite side of the larva to that shown in the figure (Pl. XIV. fig. 4). The stem is attached by a slight calcareous expansion at about its thirty-fifth joint to one of the rays of a *Rhabdammina abyssorum;* and it then passes on to form two other spreading attachments, with radicular branches sprouting from them over a portion of a tubular Hydroid.

Two of the "Triton" specimens of *Antedon tenella* from the Færoe Channel were infested by *Myzostoma carpenteri*, the only species of *Myzostoma* yet found in association with this Comatulid.

4. *Antedon exigua*, n. sp. (Pl. XXXII. figs. 1–4).

Specific formula—$A.\frac{c}{ab}$.

Centro-dorsal hemispherical, almost covered by some fifty cirri of about twenty joints. The lowest of these are much longer than wide, but the distal joints are short and compressed.

First radials nearly or quite invisible; the second short, almost concealed in the middle line by the blunt hinder angles of the axillaries. These are broadly rhombic, with a sharp clavicular process, and extend laterally beyond the second radials. The surfaces of both joints fall away laterally from their medio-dorsal line. Ten arms; the first brachials with very long outer sides but a short centre and inner sides, the proximal ends of which just meet their fellows above the clavicular. They are raised in the median line to meet the sharp hinder angles of the large quadrate second brachials. Arm-joints oblong till the second syzygy, with more or less distinct, alternating, backward processes; the following joints subtriangular, gradually becoming obliquely quadrate. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of two joints.

The second brachials bear greatly elongated pinnules of thirty or more cylindrical joints. A similar one on the third brachial, sometimes with rather stouter joints. The next pair are considerably shorter and stouter, and bear more or less developed genital glands. The following pinnules all have relatively stout joints, with the basal pair but little modified.

Disk and ambulacra naked; sacculi abundant.

Colour in spirit,—light reddish-brown, the skeleton somewhat whiter.

Disk 6 mm.; spread probably 17 cm.

Localities.—Off Marion Island; 50 to 75 fathoms. Two specimens.

Station 145, December 27, 1873; off Marion Island; lat. 46° 43′ 0″ S., long. 38° 4′ 30″ E.; 140 fathoms; volcanic sand. One specimen.

Remarks.—This species, which represents *Antedon tenella* in the Southern Sea, differs from it in the shortness of the later cirrus-joints (Pl. XXXII. fig. 3) and in the characters of the lower pinnules. The second pair are relatively large and stout, with more or less developed genital glands, which do not appear in *Antedon tenella* until the fourth or even the fifth pair. They are especially large and well developed in the two examples from the smaller depth, and the pinnule-joints are proportionately stout (Pl. XXXII. fig. 2). Another point of difference from *Antedon tenella* is the greater backward extension of the axillaries, so that the second radials are almost entirely concealed in the middle line of the ray, while there is but little modification of the basal joints in the distal pinnules.

5. *Antedon alternata*, n. sp. (Pl. XVIII. figs. 1–3; Pl. XXXII. figs. 5–9).

Specific formula—$A.\frac{bc}{a}$.

Centro-dorsal more or less hemispherical, bearing some twenty-five to thirty-five cirri of about fifteen smooth joints, most of which are longer than wide.

First radials just visible; the second short and somewhat incised by the rhombic axillaries, which are usually wider than long, with incurved distal edges. Ten arms; the first brachials barely meeting above the sharp angles of the axillaries and somewhat incised by the quadrate second brachials. The next joints square or oblong till the second syzygy, and the following ones elongately quadrate with very oblique ends. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of one or sometimes two joints, the latter being the more common at first.

The second brachial has a slender pinnule about 7 mm. long, and consisting of twenty elongated joints; the third has a similar but shorter one. The next pair are still shorter but have stouter joints, one or both of them having well-developed genital glands, and the following ones gradually increase in length, becoming slender and delicate, with the two basal joints more or less flattened.

Disk and ambulacra naked; sacculi fairly abundant, especially on the outer pinnules.

Colour in spirit,—the skeleton white, with the perisome brownish.

Disk 4 mm.; spread probably 5 cm.

Localities.—Station 169, July 10, 1874; lat. 37° 34′ S., long. 179° 22′ E.; 700 fathoms; blue mud; bottom temperature, 40° F. One specimen.

Station 170A, July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. Two specimens.

Station 218, March 1, 1875; lat. 2° 33′ S., long. 144° 4′ E.; 1070 fathoms; blue mud; bottom temperature, 36°·4 F. One specimen.

Station 236, June 5, 1875; lat. 34° 58′ N., long. 139° 29′ E.; 775 fathoms; green mud; bottom temperature, 37°·6 F. Four specimens (two of them young) with *Myzostoma cornutum*.

Remarks.—This is another of those very interesting species which are widely distributed in the abyssal region. I was at first inclined to separate the two varieties from the South and the North Pacific respectively (Pl. XVIII. fig. 1; Pl. XXXII. fig. 8), but the additional experience of variable specific characters gained between 1879 and 1887 has led me to abandon this idea. The axillaries and second brachials of the more northern forms have sharper proximal angles than in the southern variety; while the joints both of the cirri (Pl. XXXII. fig. 9) and of the pinnules (Pl. XXXII. figs. 5, 7) are relatively longer. Sometimes also the first two or three syzygial intervals after the twelfth brachial consist of two joints (Pl. XXXII. fig. 8), instead of one only as in the southern variety (Pl. XVIII. fig. 1); though in the outer parts of the arms syzygial and simple joints alternate with great regularity (Pl. XXXII. figs. 5, 7).

The two young individuals obtained at Station 236 chiefly differ from the more mature form in the relatively greater length of the joints composing the cirri, arms, and pinnules, and in showing more of the first radials externally; this is especially the case in the youngest specimen, which has not yet developed its genital glands, and is only about 30 mm. in diameter. The appearance of the first radials externally gives the calyx a considerable amount of resemblance to that of *Antedon abyssicola* from Station 244 (2900 fathoms), but this, though absolutely larger, shows more of the radials than appears in the young *Antedon alternata*, and has fewer joints in its cirri (Pl. XXXIII. fig. 1), while the syzygial interval in the outer parts of the arms usually consists of more than one joint.

The single individual of *Antedon alternata* which was dredged at Station 218 is peculiar in having four radials on one ray (Pl. XXXII. fig. 6). So far as it is possible to judge from the characters of the other rays, the third of these seems to be the intercalated joint.

Antedon alternata is readily distinguished from *Antedon tenella* and from *Antedon exigua* by the presence of only one joint between every two successive syzygies in the middle and outer portions of the arms (Pl. XXXI. figs. 1, 4; Pl. XXXII. figs. 1, 5, 7). It also differs from *Antedon exigua* in the greater length of the outer cirrus-joints (Pl. XXXII. figs. 3, 8, 9).

Attached to one of the specimens obtained at Station 236 was a single individual of *Myzostoma cornutum*, von Graff.

6. { *Antedon rosacea*, Linck, sp.
Antedon petasus, Düben and Koren, sp.

Specific formula—$A.\frac{bc}{a}$.

No Comatulæ which can be referred to either of these closely allied species were dredged by the Challenger, but a single individual which seems to belong to *Antedon rosacea* was obtained by the "Porcupine" somewhere in the Færoe Channel; while five young specimens were met with on the Tunis coast, together with large numbers of *Antedon phalangium*. Another example of the "Porcupine" variety was obtainedby the "Knight Errant" in 1880, to the north of the Hebrides; and the "Triton" dredged *Antedon petasus* on the Færoe Banks in 1882.

The mutual relations of these various forms, and of the numerous examples of what is commonly called *Antedon rosacea* from different localities in Britain and elsewhere, constitute a problem of no little difficulty, and one which I prefer to leave undecided for the present. I have been collecting the materials for its solution for some years past, and shall hope in course of time to be able to arrive at a definite opinion on the subject.

Antedon rosacea has been described by Greeff as occurring at the Canary Islands and even at the Equatorial Island of Rolas,[1] in the Gulf of Guinea. But the question whether the forms mentioned by him are identical with the North British variety which goes by the same name, is one which cannot be definitely decided without a careful comparison of the individuals in question and of others from intermediate localities.

7. *Antedon dübeni*, Böhlsche (Pl. XXXVII. figs. 1–3).

Specific formula—$A.\frac{b}{a}$.

1866. *Antedon Dübenii*, Böhlsche, Archiv f. Naturgesch., 1866, Bd. i. p. 9.
1868. *Antedon Dubenii (?)*, Verrill, Trans. Connect. Acad., 1868, vol. i. p. 365.
1879. *Antedon Dubenii*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1882. *Antedon dubeni*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1883. *Antedon dubeni*, P. H. Carpenter, Proc. Zool. Soc. Lond., 1882 [1883], p. 746.

Centro-dorsal a slightly convex pentagonal disk, bearing from thirty to forty cirri, which have from twelve to fifteen smooth joints, the outer ones stouter than those at the base, laterally compressed, and rather longer than wide.

[1] Echinodermen, beobachtet auf einer Reise nach der Guinea-Insel Sao Thomé, *Zool. Anzeiger*, 1882, Jahrg. 5, pp. 116, 159.

First radials almost entirely concealed; the second oblong, and not united laterally; axillaries acutely triangular. There is a variable amount of calcareous plating on the perisome between the rays. Ten arms; the first two brachials tolerably similar in shape, oblong or subtriangular, the second being rather the longer. A few joints after the second syzygy may be triangular, but they soon become quadrate, with the sutures but little inclined, so as to be somewhat squarish in outline, becoming elongated towards the ends. The lower and middle joints may overlap more or less, but the distal parts of the arms are almost smooth. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of one to six joints.

The second brachial bears a tapering pinnule of some twenty-five or thirty elongated and overlapping joints, and reaches over 10 mm. in length; that of the third brachial is about half its size, with twelve or fifteen joints. The next pair are of about the same length, and the following pinnules gradually increase, becoming very long and slender towards the arm-ends.

There are a few scattered granules on the ventral surface of the disk, especially in the anal interradius. Sacculi very abundant on the pinnule-ambulacra.

Colour in spirit,—yellowish-brown or brownish-white.

Disk about 7 mm.; spread 8 or 9 cm.

Locality.—Bahia, 20 fathoms. One specimen. Also Rio Janeiro (Böhlsche), and the Abrolhos (Verrill)?

Remarks.—By the kindness of Dr. Otto Hamann of Gottingen I have been enabled to examine and figure the original specimen of this type, which was described by Böhlsche from Rio Janeiro (Pl. XXXVII. fig. 2). There is a very considerable difference between it and that obtained by the Challenger at Bahia (Pl. XXXVII. fig. 1), but their general resemblance is so close that there can be no question of their belonging to the same specific type. The cirri are very uniform in appearance, but the radial axillary has a much greater length in Böhlsche's specimen than in the Challenger one; while the anambulacral plating on the perisome between the rays is reduced in the former to a very definite nodule which intervenes between every two second radials, very much as was figured by Miller[1] in his *Comatula fimbriata* (=*Antedon rosacea*). In fact it seems to rest directly upon the upper angles of the first radials (Pl. XXXVII. fig. 2), and it may possibly represent a true calyx-interradial rather than anambulacral plates, which was shown by Dr. Carpenter[2] to be the case with Miller's type. The lower and middle arm-joints of Böhlsche's example overlap but little, and the basal ones after the eighth are distinctly triangular in outline, but in the Challenger specimen they are quadrate from the first and overlap considerably, so that the dorsal line of the arm is markedly serrate (Pl. XXXVII. fig. 3). In this form too the syzygial interval is often five or six joints, while it is

[1] *Op. cit.*, Frontispiece, fig. 2.

[2] *Phil. Trans.*, 1866, p. 716, pl. xxxiii. fig. 7, *a*, *b*.

usually two and nowhere more than four in the type specimen. The lower pinnules are also different in the two cases. Those of the type have spiny projections at the distal ends of the overlapping joints which are almost entirely absent in the Challenger specimen, and the length of the first pinnule is both relatively and absolutely much greater in the former than in the latter.

In many respects this species comes very near to some forms of *Antedon rosacea;* and it may be that a larger acquaintance with the variations of the two types will lead to their union. I do not think this possible at present, however, as they seem to be pretty clearly distinguished by the characters of the arm-joints. In the type specimen of *Antedon dübeni* there are a few triangular joints immediately above the second syzygy (Pl. XXXVII. fig. 2), but in that dredged by the Challenger these joints are shortly quadrate, though the length gradually becomes equal to the width, as is the case in the type, and the sutures are so little inclined that the outline of the joints is tolerably square, becoming more elongated, however, in the outer part of the arms. This character distinguishes *Antedon dübeni* from the British form of *Antedon rosacea*, in which the joints are subtriangular, or, at any rate, have much-inclined sutures till some way out on the arms; though they are more nearly square in the Mediterranean form. But in all the numerous varieties of *Antedon rosacea* the syzygial interval consists very regularly of two joints; and this seems to be also the case in the type of *Antedon dübeni* (Pl. XXXVII. fig. 2), so far as can be judged from the first forty brachials, the remainder having been lost, though Böhlsche mentions one to four joints as the length of the syzygial interval; while in the Challenger specimen the number varies from two to six joints.

For the present, therefore, I would regard *Antedon dübeni* as distinct from *Antedon rosacea.* The latter species has not yet been identified on the coast of the United States, and one must hesitate therefore before giving the South American coast as a locality for a type which is found as far north as the Shetlands, though it does seem to extend to Madeira and the Canaries, and possibly to the Gulf of Guinea; but I am not yet clear as to the latter point; and it is not improbable that Greeff's example from this locality may turn out to be identical with *Antedon dübeni.*

8. *Antedon lineata*, n. sp. (Pl. XIII. figs. 4, 5).

Specific formula—$A.\frac{b}{b}$.

Description of an Individual.—Centro-dorsal almost completely covered by some twenty-five cirri with about thirty short joints. The lower joints are rather stout and the fifth slightly the longest, while all of them overlap slightly on the dorsal side, and gradually acquire a faint dorsal keel with a forward projecting spine.

First radials partially visible; the second and third both rather high in the middle and falling away at the sides. The former are oblong, slightly incised, and not united laterally; the axillaries pentagonal and somewhat wider than long. Ten arms; the first brachials rather incised by the second, which are relatively short and wide. The following joints smooth and obliquely quadrate, becoming rather elongated towards the end. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of one to four, usually two or three joints.

The second brachial bears a styliform pinnule of about a dozen longish joints; and the next two or three pinnules on each side are of the same character, but of diminishing size. The following pinnules increase in length and stoutness, the third and fourth joints being expanded and broadly V-shaped; the later pinnules are slender and filiform. Disk invisible; the pinnule-ambulacra have abundant sacculi at their sides and also numerous small pieces of calcareous network, which do not, however, form definite plates.

Colour in spirit,—the arms dirty white, and the pinnules grey with white bands at the joints.

Spread probably about 18 cm.

Locality.—Station 320, February 14, 1876; lat. 37° 17′ S., long. 53° 52′ W.; 600 fathoms; green sand; bottom temperature, 37°·2 F.

Remarks.—This species may be at once distinguished from those previously described in the same group by the spiny cirrus-joints and by the expansion of the third and following joints in the genital pinnules, as shown in Pl. XIII. figs. 5*a*, 5*b*. A similar character presents itself in *Antedon gracilis* and in *Antedon acœla*, both from Station 214, off the Meangis Islands (Pl. XV. fig. 4; Pl. XVI. fig. 2), and also in *Hyocrinus bethellianus* from the Southern Ocean (Part I. pl. v. fig. 18; pl. vi. fig. 1). But in all these species the ventral side of the genital glands is more or less protected by calcareous plating, which is not the case in *Antedon lineata*.

9. *Antedon remota*, n. sp. (Pl. XXIX. figs. 5–9).

Specific formula—A. $\frac{b}{a}$.

Centro-dorsal sharply hemispherical, bearing twenty to thirty cirri, with nearly twenty joints; the lower ones are longer than wide and dice-box-shaped, with expanded distal ends, overlapping their successors both dorsally and ventrally. From the tenth joint onwards they are short and laterally compressed with a faint dorsal keel.

First radials just visible; the second nearly oblong, rather convex and considerably incised by the rhombic axillaries, which are wider than long, with sharp distal angles, so that the first brachials are not united laterally. Both the axillaries and the two lower brachials have traces of lateral projections.

Ten arms, of smooth, obliquely quadrate joints. Syzygies in the third and eighth or ninth brachials, and then at intervals of two to four joints.

The first two pairs of pinnules long, slender and delicate, composed of several elongated joints and tolerably equal in length. The two lower joints of the distal pinnules are expanded and flattened.

Disk and ambulacra naked; sacculi abundant on the pinnules.

Colour in spirit,—dirty white.

Disk about 4 mm.; spread probably about 8 cm.

Locality.—Station 147, December 30, 1873; lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze; bottom temperature, 34°·2 F. Four mutilated specimens and fragments of a fifth.

Remarks.—This species is readily distinguished from *Antedon tenella* and *Antedon rosacea* and their allies by the characters of the lower pinnules, which are all long and slender, but of tolerably equal size. They are much broken in all the specimens, and it is difficult to determine either their length or the number of their component joints at all exactly (Pl. XXIX. figs. 5, 7, 8); but the remains of them are quite sufficient to show their difference from the lower pinnules of *Antedon angustipinna* and *Antedon abyssorum* (Pl. XXIX. figs. 2, 11). There is no such enlargement of the joints of the genital pinnules as occurs in the former species (Pl. XXIX. fig. 3), to which *Antedon remota* has some resemblance in the characters of the cirrus-joints, though their number is less; while they are much shorter than those of *Antedon abyssorum* (Pl. XXIX. fig. 10).

One individual is peculiar in having only two radials on one ray; but the axillary or second radial is altogether different from the other rhombic axillaries, for it is broadly pentagonal in form, with a perfectly even proximal margin, and no indication whatever of a backward projecting proximal angle (Pl. XXIX. fig. 6).

10. *Antedon longipinna*, n. sp. (Pl. XXX. figs. 1–3).

Specific formula—A.$\frac{b}{b}$.

Centro-dorsal rather sharply hemispherical, and bearing about thirty cirri, which have twenty to twenty-five slightly overlapping joints, mostly longer than wide, and especially so near the base.

First radials just visible; the second short, free laterally, and deeply incised by the rhombic axillaries, which are about as wide as long and have a sharp distal angle separating the first brachials.

Ten arms of smooth, obliquely quadrate joints. Syzygies on the third, eighth, and twelfth brachials, and then on every alternate joint.

The first pair of pinnules are about 7 mm. long and consist of some eighteen elongated and rather dice-box-shaped joints. The second pair but little smaller, and the following ones all long, decreasing but slowly in size, and retaining the elongated joints, which bear short and fusiform genital glands. The later pinnules are slender again, but not as long as the first pair.

Disk and ambulacra naked; sacculi moderately abundant.

Colour in spirit,—dirty white.

Disk 4 mm.; spread probably about 4 cm.

Locality.—Station 320, February 14, 1876; lat. 37° 17′ S., long. 53° 52′ W.; 600 fathoms; green sand; bottom temperature, 37°·2 F. Three mutilated individuals.

Remarks.—The length of the cirrus-joints and the very regular alternation of the syzygies beyond the twelfth brachial readily distinguish this species from *Antedon remota*. It is strikingly characterised by the great length of the joints composing the lower pinnules, as is well seen in the immature specimen shown in Pl. XXX. fig. 1. Its genital glands are but little developed; but a somewhat older individual has tolerably large testes, and in that represented on Pl. XXX. fig. 2, there are much swollen ovarian sacs, extending over about three pinnule-joints, with thin walls through which large white ova are visible.

11. *Antedon tenuicirra*, n. sp. (Pl. XXX. figs. 4–8; Pl. XXXIII. figs. 4, 5).

Specific formula—A.$\frac{b}{b}$.

Centro-dorsal hemispherical, bearing thirty or more long and slender cirri of fifteen to twenty-five joints or more, the first three of which are very short and the rest much elongated.

First radials just visible; the second short, rounded and oblong, free laterally and scarcely incised by the axillaries, which are widely rhombic, with open proximal angles. Ten arms, of smooth obliquely quadrate joints. Syzygies in the third and eighth brachials and then at intervals of two to five joints.

The first pair of pinnules are long, slender, and delicate, composed of numerous joints which are but little longer than wide. The second pair is of about the same length, but consists like its successors of stouter and more elongated joints, which become slender again in the distal pinnules.

Disk and ambulacra naked; sacculi moderately abundant.

Colour in spirit,—light brown.

Spread, 11 cm.

Locality.—Station 219, March 10, 1875; lat. 1° 54′ 0″ S., long. 146° 39′ 40″ E.; 150 fathoms; coral mud. One specimen, and one varietal form.

Remarks.—Besides this one mutilated individual (Pl. XXX. fig. 4) Station 219 also yielded another, which I at first regarded as belonging to a different specific type; and it was accordingly represented on Pl. XXXIII. figs. 4, 5, as *Antedon notata.* Probably, however, it would be better considered as a varietal form of *Antedon tenuicirra;* though it presents some not unimportant differences from the type specimen described above. Although of larger size, it shows more of the first radials, while the axillaries have sharper proximal angles, and the second radials are therefore more incised. There are slight indications of lateral flattening upon the four lower brachials, and the joints of the first pinnule are relatively longer than in the type. The cirri are both more numerous and have a larger number of joints than in the type (Pl. XXX. fig. 4; Pl. XXXIII. fig. 4); but the joints have the same smooth elongated character in both forms; and until better-preserved material is available, it will probably be safer to regard them as specifically identical. The smooth and delicate long-jointed cirri and the difference in shape of the joints composing the first and second pinnules respectively separate the type very clearly from the species previously described. All the pinnules are much broken, but the basal portions of the first two are very different, as seen in Pl. XXX. figs. 5, 6. The lowest joints of the first pinnule recall those of the corresponding pinnules in *Antedon quadrata* and its allies (Pl. XXVII. figs. 8, 14), but the later joints are distinctly longer than wide, though not greatly so. In the second pinnule, however (Pl. XXX. fig. 6), the component joints are stouter, and all except the first two are distinctly longer than wide, as is the case in its successors (Pl. XXX. fig. 7).

12. *Antedon lævis,* n. sp. (Pl. XXXI. fig. 6).

Specific formula—A.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal hemispherical, covered with a cluster of about thirty cirri with some twenty-five to thirty joints, but few of which are longer than wide. The distal joints have a faint dorsal keel which passes into a small opposing spine on the penultimate.

Three radials visible; the first short, and the second rather sharply convex; axillaries rhombic, about as wide as long. Ten arms; first brachials nearly oblong, and but little incised by the second, which are irregularly quadrate. The next joints are nearly oblong till the second syzygy, and the following ones smooth and obliquely quadrate, gradually becoming longer than wide. Syzygies in the third, eighth, and twelfth brachials, and then at intervals of two joints.

The lowest pinnules seem to be tolerably equal in length, consisting of cylindrical joints which are relatively longer in the second than in the first pair.

Disk invisible; pinnule-ambulacra naked, with abundant sacculi.

Colour in spirit,—the skeleton straw-coloured, with the perisome brownish.

Spread probably about 5 cm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F.

Remarks.—This little species differs from the two last described in having much shorter cirrus-joints (Pl. XXX. figs. 3, 4, 8; Pl. XXXI. fig. 6). The lower pinnules are much broken, but they appear to have been tolerably equal in length, and the joints of the first pinnule are relatively shorter and stouter than those of the second; while in *Antedon tenuicirra* the reverse is the case. There is a certain amount of resemblance between *Antedon lævis* and *Antedon remota;* but the former species has relatively longer axillaries than occur in *Antedon remota*, and also more numerous cirrus-joints, which do not overlap as is the case in that species (Pl. XXIX. figs. 5, 6).

13. *Antedon hirsuta*, n. sp. (Pl. XXXI. fig. 5).

Specific formula—$A.\frac{bc}{b}$.

Description of an Individual.—Centro-dorsal conical, bearing about thirty-five cirri in irregular vertical rows. The cirri have twenty-five to thirty joints, the lower ones somewhat elongated and the later joints smaller, with slight dorsal keels.

Three radials visible; the first short, the second oblong, rather convex and but little incised for the widely rhombic axillaries. Ten arms; the first brachials nearly oblong, and the second relatively short and wide, with a very open proximal angle. The next few joints oblong, and the following ones elongately triangular, gradually becoming more quadrate and finally cylindrical, with slight lateral projections for the pinnule facets. The distal edge of each joint bears a small fringe of spines which projects forwards over the base of its successor so as to give the arms a somewhat serrate appearance. Syzygies in the third, and then in the sixth or eighth brachials, after which they are rather irregular, but generally at intervals of two or three joints.

The arms are mostly regenerated at the first syzygy; but in the uninjured ones the first two pinnules, which are stiff and tapering, consist of about twelve longish joints, and appear to be tolerably equal, the first being perhaps a little the longer, and with stouter joints, the lowest of which may be slightly flattened. The second pinnule has a genital gland, and the following ones are at first shorter and more slender than those below them, but have relatively longer joints, after which the length gradually increases.

Disk invisible; pinnule-ambulacra naked, with abundant sacculi at their sides.

Colour in spirit,—white.

Spread about 7 cm.

Locality.—Station 145, December 27, 1873; near Marion Island; lat. 46° 43′ 0″ S., long. 38° 4′ 30″ E.; 140 fathoms; volcanic sand. One specimen.

Remarks.—This species differs from *Antedon lævis* in the serrate appearance of the outer parts of the arms along their dorsal line, in the relatively greater width of the two outer radials and of the second brachials, and in the flattened appearance of the basal joints of the first pinnule. The syzygies too seem to be less regularly arranged than in *Antedon lævis;* but this may be due to the fact that most of the arms have been regenerated at the third brachial in the single individual obtained, entangled in the cirri of which was a specimen of *Ophiolebes scorteus.*

14. *Antedon angustipinna*, n. sp. (Pl. XXIX. figs. 1–4).

Specific formula—$A.\frac{bc}{b}$.

Description of an Individual.—Centro-dorsal nearly hemispherical, and almost covered by about thirty cirri. These have some twenty-five joints with sharpened dorsal edges, the lower ones slightly the longer and the remainder tolerably equal, but short.

Three radials visible; the second oblong, almost free laterally, and strongly incised to receive the rhombic axillaries, which are wider than long. Ten smooth and rounded arms, the joints after the second syzygy being elongately triangular or quadrate. Syzygies in the third, eighth, and twelfth brachials, and then on every alternate joint.

The second brachial bears a short stiff pinnule of five to eight joints, and there is an even smaller one on the third brachial; but that on the fourth is longer, often much so.

The next five or six pinnules on each side have longer and much stouter joints, and support the genital glands, the remaining pinnules being slender and delicate.

Disk and ambulacra naked; sacculi fairly abundant.

Colour in spirit,—yellowish-white.

Spread probably 5 cm.

Locality.—Station 320, February 14, 1876; lat. 37° 17′ S., long. 53° 52′ W.; 600 fathoms; green sand; bottom temperature, 37°·2 F. One specimen.

Remarks.—This curious little species from the South Atlantic is readily distinguished by its short cirrus-joints and by the peculiarities of its lower pinnules. That on the second brachial is unusually small, sometimes having no more than five or six joints, all of them, however, longer than wide (Pl. XXIX. fig. 2). The fourth brachial bears a much longer pinnule, the lower joints of which are usually, though not always, enlarged for the support of the genital glands, as in its successors (Pl. XXIX. fig. 3). After about the twelfth brachial, however, the glands become reduced in size and the pinnule-joints smaller again (Pl. XXIX. fig. 4). As in *Antedon alternata* every alternate brachial above the twelfth is usually a syzygial joint (Pl. XXIX. fig. 1; Pl. XXXII. figs. 5, 7).

15. *Antedon abyssorum*, n. sp. (Pl. XXIX. figs. 10–13).

Specific formula—A.$\frac{lc}{a}$.

Centro-dorsal conical, bearing about thirty cirri of fifteen to eighteen joints, nearly all of which are longer than wide.

Three radials visible; the second partially free, rather convex and very deeply incised for the axillaries. These are shield-shaped or rhombic, as long or longer than wide, with much incurved distal edges. First brachials deeply incised by the irregularly quadrate second brachials. Ten arms of nearly smooth joints, which are almost oblong up to the second syzygy and then become obliquely quadrate. Syzygies in the third and eighth brachials, then about the fourteenth, and afterwards at intervals of one to five joints.

The first pair of pinnules are slender and delicate, composed of ten or twelve elongated joints, that on the second brachial being rather the longer. Those on the fourth and the ten or twelve following brachials are longer with stouter joints, and support the short and thick genital glands. The later pinnules are much elongated.

Disk and ambulacra naked; sacculi tolerably abundant on the outer pinnules.

Colour in spirit,—dirty white.

Spread perhaps 6 cm.

Locality.—Station 147, December 30, 1873; lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze; bottom temperature, 34°·2 F. Eleven specimens.

Remarks.—This abyssal form agrees with *Antedon angustipinna* in the relatively small size of the first pair of pinnules (Pl. XXIX. figs. 2, 11), but differs from that type in several points.

There is a smaller number of cirrus-joints, but they are long and slender instead of short and wide; while there may be from one to five joints between the brachial syzygies, and not one only as in *Antedon angustipinna* (Pl. XXIX. figs. 1, 10). In the latter species those lower joints of the genital pinnules which support the glands are considerably thickened; but this is not the case in *Antedon abyssorum* (Pl. XXIX. figs. 3, 12); while the later pinnules of this species are much longer than in *Antedon angustipinna* (Pl. XXIX. figs. 4, 13).

16. *Antedon abyssicola*, n. sp. (Pl. XXXIII. figs. 1, 2).

Specific formula—A.$\frac{ab}{a}$.

Centro-dorsal subconical, bearing about fifteen cirri. These have eight to ten joints, of which the second is longer than wide and the following joints much elongated, the fourth being about the longest; the remainder diminish to the penultimate, which is not much longer than wide and has a very faint opposing spine.

Three radials visible; the first and second about equal in length, the angles of the former extending inwards and upwards for some distance, so that the second radials are not united laterally. They are somewhat incised by the hinder angles of the rhombic axillaries, the distal edges of which are much curved. Ten arms; the first brachials quite separated and more or less incised by the proximal angles of the irregularly quadrate second brachials. The following joints are square till the second syzygy or even slightly longer than wide; the later joints obliquely quadrate and much longer than wide, gradually becoming almost dice-box-shaped. Syzygies in the third, eighth, and twelfth or thirteenth brachials, and then at intervals of two to four, usually three, joints.[1]

All the pinnules are much broken, but they seem to have been slender and delicate on the arm-bases.

Disk and ambulacra naked; sacculi small and rare.

Colour in spirit,—white.

Disk about 3 mm.; spread perhaps 5 cm.

Localities.—Station 160, March 13, 1874; lat. 42° 42′ S., long. 134° 10′ E.; 2600 fathoms; red clay; bottom temperature, 33°·9 F. One specimen.

Station 244, June 28, 1875; lat. 35° 22′ N., long. 169° 53′ E.; 2900 fathoms; red clay; bottom temperature, 35°·3 F. Two specimens.

Remarks.—This little species is one of very considerable interest, apart altogether from the peculiarities of its calyx, for it is the only *Comatula* yet found at a greater depth than 2000 fathoms. *Bathycrinus*, and perhaps also *Ilyocrinus*, extend down to 2400 fathoms; *Promachocrinus* and *Thaumatocrinus* occur at 1800 fathoms, but with the exception of *Antedon abyssicola* no other Comatulæ have been found below 1600 fathoms, at which depth (Station 147) *Antedon abyssorum*, *Antedon bispinosa* and *Antedon remota* were obtained. *Antedon abyssicola* has been dredged, however, at two stations, one (Station 160) shortly before the Challenger reached Melbourne, where the depth was 2600 fathoms, and the other in the deepest part of the North Pacific at 2900 fathoms (Station 244). *Antedon abyssicola* thus resembles *Antedon alternata* in occurring at widely separated localities in the abyssal region, and it has some points

[1] In fig. 1 the tenth and fourteenth, and in fig. 2 the sixth brachials are wrongly drawn as syzygial joints.

of resemblance with the younger individuals of this type, as has been pointed out already. The three specimens obtained were unfortunately all much mutilated, especially as regards the cirri and pinnules; but the peculiarities of the calyx are very characteristic and serve to distinguish the type, though its precise relations to the other abyssal species must remain somewhat uncertain in the absence of properly preserved individuals.

A considerable portion of the first radials appears externally, and they are somewhat wider than the second radials, while their angles are considerably produced both upwards and inwards, so that the second radials are altogether prevented from coming into lateral contact. This is especially well shown in the southern form (Pl. XXXIII. fig. 2), but it is not so apparent in the larger individuals from the North Pacific, except in an inter-radial view of the calyx. Both this character and also the great length of the arm-joints, the later ones of which are almost dice-box-shaped, indicate that the type is an embryonic one, as is well seen on a comparison of figs. 1 and 2 on Pl. XXXIII. with the larvæ represented in figs. 3 to 6 on Pl. XIV. The extension of the first radials upwards and inwards, so as to keep the second radials from coming into lateral contact, is a larval character which is better developed in the fossil *Eugeniacrinus*, and reaches its maximum in the allied genus *Phyllocrinus*.

A few poorly developed sacculi are present in the individual from 2600 fathoms (Station 160), but I have not been able to find any indications of them in the two specimens from the greater depth in the North Pacific (Station 244, 2900 fathoms).

5. The *Milberti*-group.

The first pair of pinnules comparatively small, and their component joints but little longer than wide; one or more of the second, third, and fourth pairs are longer and more massive, with stouter joints than their successors.

Remarks.—This is a somewhat heterogeneous group, and I have had considerable trouble in working out an arrangement of it which I can regard as even approximately satisfactory. The definition given above would almost include such forms as *Antedon angustipinna* (Pl. XXIX. figs. 2–4) and *Antedon tenuicirra* (Pl. XXX. figs. 5–7), which have been described in the *Tenella*-group; while *Antedon parvicirra*, which I have placed in the *Milberti*-group, though with some doubt, has many points of resemblance with *Antedon rosacea* and *Antedon dübeni*. Indeed *Antedon milberti* itself exhibits traces of the wall-sidedness of the radials and lower brachials which is so marked in the *Basicurva*-group. Then again, the ubiquitous *Antedon carinata* differs in many respects from *Antedon serripinna*, *Antedon milberti*, and the typical members of the group, so that another group may have to be established for it at some future time.

The special character which distinguishes the *Milberti*-group is the large size of one or more of the second, third, and fourth pairs of pinnules, which are borne respectively by the fourth to ninth brachials. This feature is well shown in *Antedon anceps*, *Antedon milberti*, and *Antedon variipinna* (Pl. XXXV. figs. 2, 4; Pl. XXXVI. figs. 1, 4–6), and also in some species described by Bell in the "Alert" Report; while it reappears in a more marked degree in some of the multibrachiate species of *Antedon* (Pl. XLVIII. figs, 2, 3). In some cases, as in *Antedon milberti*, the second, third and fourth pairs are all of greater size than the pinnules above and below them, sometimes the second and sometimes the third being slightly the largest. In *Antedon anceps* and in *Antedon variipinna* the pinnules of the fifth or sixth brachials (or both) are considerably longer and stouter than their fellows (Pl. XXXV. fig. 2; Pl. XXXVI. figs. 1, 4–6); and in Bell's species *Antedon carpenteri* and *Antedon pumila*, the large pinnule is on the fourth brachial. But in *Antedon carinata* and *Antedon parvicirra* the third and the following pairs of pinnules are much more equal in size. At the end of the group I have placed two abnormal species in which the pinnule on the third brachial is absent, though in other respects they conform pretty well to the general type.

All the members of the *Milberti*-group are limited to the Pacific and the Eastern Archipelago, with the exception of *Antedon carinata*, which also extends into the Indian Ocean, Red Sea, and the Western Atlantic. It was dredged off St. Lucia, in 278 fathoms, by Captain Cole of the telegraph steamer "Investigator"; but all the remaining members of the group are confined to the littoral zone. Most of them have been obtained at depths of 20 fathoms or less; but *Antedon variipinna* occurs at 36 fathoms in the Arafura Sea.

The general relations of the various members of the *Milberti*-group are shown in the following table:—

A. A pinnule on the third brachial.

- I. Second pair of pinnules the largest.
  - *a.* Cirrus-joints short.
    - 1. Twenty-five cirrus-joints; the first brachials much incised, . . . *pinniformis*, Carpenter.
    - 2. Barely twenty cirrus-joints; the first brachials not incised.
      - Second pinnule serrate, ... *serripinna*, Carpenter.
      - Second pinnule with large processes on the lower joints, . *carpenteri*, Bell.
  - *b.* Twelve long cirrus-joints, ... *pumila*, Bell.
- II. Second and third, and sometimes the fourth, pairs of pinnules about equal.
  - *a.* Twenty-five to forty cirrus-joints.
    - Radials and lower brachials tubercular; the lower pinnules rounded, ... 1. *milberti*, Müll., sp.
    - Radials and lower brachials smooth; the lower pinnules carinate, ... *lævissima*, Grube, sp.
  - *b.* Forty-five cirrus-joints; syzygial interval seven to ten joints, . *tessellata*,[1] Müll., sp.
  - *c.* Sixty cirrus-joints; syzygial interval three to seven joints, . *perspinosa*, Carpenter.

[1] I only know this type from the description of it which is given by Müller; but it is the only species recorded in the list given on pp. 53–55 which I have not personally examined.

III. Third outer pinnule distinctly larger than the second.
  a. Over thirty cirrus-joints.
    Third pinnule has smooth joints; syzygial interval four to seven joints, ... 2. *anceps*,[1] n. sp.
    Joints of third pinnule with lateral processes; syzygial interval nine to twelve joints, ... 3. *variipinna*,[1] Carpenter.
  b. Twenty to thirty cirrus-joints. The third and next following pinnules tolerably equal in length; arms more or less carinate, 4. *carinata*, Lamk., sp.
  c. Not more than twelve cirrus-joints. The third pinnule rather the longest, ... 5. *parvicirra*, n. sp.

B. Usually no pinnule on the third brachial.
  I. Joints of second and third pinnules not specially elongated. Fifteen cirrus-joints, ... 6. *informis*, n. sp.
  II. Second and third pinnules have much elongated joints with enlarged and denticulate ends, ... *lovéni*, Bell.

1. *Antedon milberti*, Müller, sp. (Pl. XXXV. figs. 4–6).

Specific formula—$A.\frac{b}{b}$.

1846. *Comatula* (*Alecto*) *Milberti*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1846, p. 178.
1846. *Comatula Jacquinoti*, Müller, *Ibid.*, p. 178.
1849. *Comatula* (*Alecto*) *Milberti*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1847 [1849], p. 255.
1849. *Comatula Jacquinoti*, Müller, *Ibid.*, p. 255.
1862. *Comatula Milberti*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 202.
1862. *Comatula Jacquinoti*, Dujardin and Hupé, *Ibid.*, p. 202.
1867. *Antedon Milbertii*, Verrill, Trans. Connect. Acad. Arts and Sci., 1867, vol. i. p. 341.
1875. *Comatula lævissima*, Grube (*pars*), 53[e] Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult., 1875, p. 74.
1879. *Antedon Jacquinoti*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1879. *Antedon Milberti*, P. H. Carpenter, *Ibid.*, p. 29.
1882. *Antedon lævissima*, Bell (*pars*), Proc. Zool. Soc. Lond., 1882, p. 533.
1882. *Antedon jacquinoti*, Bell, *Ibid.*, p. 534.
1882. *Antedon milberti*, Bell, *Ibid.*, p. 534.
1882. *Antedon jacquinoti*, P. H. Carpenter, *Ibid.*, p. 746.
1882. *Antedon lævissima*, P. H. Carpenter, (*pars*), *Ibid.*, p. 746.
1882. *Antedon milberti*, P. H. Carpenter, *Ibid.*, p. 746.
1884. *Antedon Milberti*, Bell, Rep. Zool. Coll. H.M.S. "Alert," London, 1884, p. 156.
1884. *Antedon milberti*, Bell, Proc. Linn. Soc. N.S.W., 1884, vol. ix. p. 497.

Centro-dorsal hemispherical, bearing some twenty to thirty cirri. These have twenty-five to thirty-five or even nearly forty joints, most of which, and especially the lower ones, are wider than long. The middle and outer joints have a more or less distinct dorsal spine.

[1] These are both tridistichate species; see pp. 254, 256.

First radials almost or entirely invisible; the second rather sharply convex, and rising to a median tubercle at their junction with the wide axillaries. A similar but smaller tubercle at the junction of the first two brachials. In large specimens these four joints are sometimes slightly wall-sided, with straight edges and the margins of the dorsal surface flattened.

Ten arms, reaching nearly three hundred joints; the third and next following brachials smooth, rounded and nearly oblong, with a tendency to alternating tubercular elevations at their junctions. After the second syzygy the joints are shortly triangular and slightly overlapping, gradually becoming nearly oblong, but always much wider than long. Syzygies in the third and eighth or ninth brachials, and often also in the twelfth or thirteenth; others at intervals of three to nineteen joints, usually eight or ten, the intervals being somewhat longer in the outer parts of the arms than in their first third.

The first pair of pinnules are about 8 mm. long and consist of some eighteen moderately stout joints, of which some of the middle ones are longer than wide. The pinnules of the next five or six brachials (fourth to ninth) are somewhat longer and stiffer, with much stouter joints, sometimes the second and sometimes the third pair being the largest. The fourth pair are occasionally much smaller than the third, and the fifth pair are always much so, after which the length of the joints increases and the later pinnules become long and slender.

Disk naked; sacculi abundant.

Colour in spirit,—dark reddish-brown, bleaching to white.

Disk 10 or 12 mm.; spread 25 to 30 cm.

Localities.—Station 203, October 31, 1874; lat. 11° 6′ N., long. 123° 9′ E.; 20 fathoms; mud. One specimen.

Station 212, January 30, 1875; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand. Two specimens.

Other Localities.—Ceram (Valenciennes); North Borneo (Grube); H.M.S. "Alert," 1881, Port Molle (12 to 20 fathoms), Port Denison (3 to 4 fathoms), Prince of Wales Channel (7 to 9 fathoms), Torres Strait (10 fathoms); Padan Bay in the Mergui Archipelago (Dr. J. Anderson).

History.—Under this name I have united the two species that were found by Müller in the Paris Museum with the MS. names "*Comatula Milberti*" and "*Comatula Jacquinoti*" respectively, which had been given to them by Valenciennes. They are each based upon single specimens which I was able to examine carefully in 1876, and again in 1880; and the subsequent study of a considerable amount of material obtained by H.M.SS. Challenger and "Alert," and also by Dr. J. Anderson, F.R.S., of the Calcutta Museum, has convinced me that the two types are really identical. Müller hardly ever made any comparison of his species with one another, but simply contented himself with descriptions, leaving his readers to determine the real points of difference between his various species. For this purpose I have analysed his descriptions of *Comatula milberti* and of *Comatula jacquinoti* respectively, with the following result :—

Comatula milberti.	*Comatula jacquinoti.*
Twenty-five to thirty cirri of thirty-five spiny joints.	Twenty-two cirri of thirty-five spiny joints.
The spine "quer absteht."	The spine is "vorwärts gerichtet."
First radials "ausserst niedrig."	First radials "sehr niedrig."
Arm-joints "niedrig."	Arm-joints "niedrig."
Syzygial interval eight or nine joints.	Syzygial interval three to six joints.
The second, third, and fourth pinnules are "die grössten."	The three to four first pinnules are "stärker."
Colour,—brownish-black.	Colour,—brownish-black.
Spread approaching 2 feet.	Spread approaching 2 feet.

The preceding table shows that the differences between *Comatula milberti* and *Comatula jacquinoti,* as described by Müller, are in reality exceedingly slight. The number of cirrus-joints, the characters of the radials and of the arm-joints, the colour, and even the size are respectively identical in the two types. *Comatula milberti* has twenty-five to thirty cirri with the spines transverse, while in *Comatula jacquinoti* there are twenty-two cirri with the spines directed forwards. In *Comatula milberti* the syzygial interval is eight or nine joints, and the second, third and fourth pinnules are the largest, while in *Comatula jacquinoti* the syzygial interval is three to six joints and the first three or four pinnules are "stärker." Neither of these characters, however, nor even the combination of them, can be regarded as of specific value, especially when we remember that each of Müller's species was based upon a single specimen. That of *Comatula jacquinoti* had been obtained at Ceram by the expedition of d'Urville in the "Zelée" (1841), while the form which Müller described under the specific name *milberti* had previously received it from Valenciennes in honour of M. Milbert of New York, who had given it to the Paris Museum ; and it was possibly for this reason that the type was labelled as coming from North America. Under these circumstances Valenciennes, and after him Müller, were perhaps a little predisposed to regard it as distinct from the *Comatula jacquinoti* of Ceram, which Müller described along with it and in such nearly identical terms. I feel quite confident, however, that Milbert's specimen was not obtained anywhere on the Atlantic coast of North America. I have seen nothing like it among the West Indian Comatulæ dredged by the "Blake"; while the only species of *Antedon* which have been found on the Atlantic coast of North America are *Antedon tenella* and perhaps *Antedon eschrichti* (Stimpson). All its characters are those of the species of *Antedon* which inhabit the Eastern Seas, where the type has been obtained at various localities from the Mergui Archipelago to Eastern Australia ; and I have little doubt that Milbert's specimen had been brought to America from somewhere within this region.

Verrill[1] has referred it to the Caribbean fauna, but with a ?; while Dujardin and Hupé,[2] who must have seen it for themselves in the Paris Museum, refer to it as having come "de l'Amérique septentrionale." We know nothing respecting any Comatulæ on the Pacific coast of Central and North America, and I strongly suspect that Milbert's specimen must have been wrongly labelled.

Under the name of *Comatula lævissima*, Grube[3] described in 1875 two ten-armed examples of *Antedon* which he had obtained from Borneo; and Professor Schneider, Grube's successor at Breslau, has been good enough to send them to me for examination. They agree pretty closely in the characters of their cirri and short arm-joints; but, as is indicated in Grube's diagnosis, their colour is altogether different, while one of them has a tubercular junction between the two outer radials and also between the first two brachials, a character which is altogether absent in the other individual. In the latter too the joints of the lower pinnules are sharply carinate. This is not the case in the form with tubercular radials, which I find to be a small individual of *Antedon milberti*; and Grube's specific name *lævissima* will therefore only apply to the other specimen, which I propose to describe more fully at a future time.

Remarks.—The tubercular radials and the stout but rounded joints of the large lower pinnules, together with the spiny cirri and the short arm-joints, thus combine to make *Antedon milberti* an easily recognisable type. Although the second and third pairs of pinnules are distinctly larger than the first, neither of them is especially characterised by its greater size, as is the case in *Antedon anceps* and *Antedon dubia* (Pl. XXXV. fig. 2; Pl. XXXVI. figs. 1, 4–6). Sometimes the one and sometimes the other is a little the larger, while the third pair is occasionally nearly equal to the second, and in other individuals considerably smaller, though always distinctly larger than its successor.

The grouping of the syzygies in the arms is somewhat irregular. The second one is very often on the eighth or ninth brachial, and is followed by another four joints afterwards; but in some arms the second syzygy does not come till the twelfth or thirteenth joint. The examination of a large number of arms shows the syzygial interval to vary from three to nineteen joints. It is usually from eight to ten in the middle and outer parts of the arms, though somewhat less in their lower portions.

In some individuals the axillaries and the lowest brachials have indications of straight lateral edges and of the peculiar wall-sided character which has been described above as distinctive of the *Basicurva*-group. This is most marked in the specimen obtained by the Challenger at Station 203, which differs from all the other examples of the type that I have seen in showing a considerable portion of the first radials externally. Their length is more than half that of the second radials, and the tubercles which the latter form with the pentagonal axillaries are less prominent than usual. Both joints

[1] Echinoderms. Comparison of the Tropical Faunæ of the East and West Coasts of America, *Trans. Connect. Acad. Arts and Sci.*, 1867, vol. i. p. 341.

[2] *Op. cit.*, p. 202.

[3] 53^e *Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult.*, 1875, p. 74.

and also the first two brachials have the margins of the dorsal surface flattened, with straight lateral edges, and in some arms this character also extends on to the hypozygal of the third brachial, but the wall-sidedness is always much less distinct than in the *Basicurva*-group, and in some examples is scarcely visible at all; while there are no indications of the flattening of the sides of the first pinnule which is so characteristic of *Antedon basicurva*, *Antedon valida*, and their allies (see woodcut fig. 3, on p. 122). Furthermore *Antedon milberti* has unplated ambulacra, and in all other respects it is closely allied to *Antedon anceps*, *Antedon serripinna*, and the other species which I have placed with it in the same group. At the same time the indications in this distinctly littoral type of a peculiarity which is especially characteristic of Comatulæ from the continental and abyssal regions is a point of considerable interest.

Some of the examples of this species which were dredged at Mergui were infested by a species of *Myzostoma* which Professor von Graff has been unable to determine satisfactorily, owing to its state of preservation.

2. *Antedon anceps*, n. sp. (Pl. XXXV. figs. 1–3).

Specific formula—A.(3).$\frac{b}{b}$.

Locality.—Station 212, January 30, 1875; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand.

Remarks.—Of the three individuals of this species which were dredged by the Challenger, one has ten arms, while the other two have three and four distichal series respectively. The type will therefore be described together with the remaining members of the tridistichate group. But a few words may be said here about its ten-armed variety. It has a considerable superficial resemblance to the less tubercular forms of *Antedon milberti*, with which it agrees in the characters of its arm-joints; but the third outer pinnule (on 6 br.) is larger than the second (on 4 br.), as seen in Pl. XXXV. fig. 2, which represents the pinnules on the inner side of the arm, *i.e.*, on the third and following brachials. The cirri, too, have smooth joints, and so are very different from the spiny cirri of *Antedon milberti* (Pl. XXXV. figs. 3, 4).

3. *Antedon variipinna*,[1] Carpenter (Pl. XXXVI. figs. 1–6).

Specific formula—A.[3.(2)].$\frac{b}{b}$.

Locality.—Arrou Islands.

Remarks.—Most individuals of this species are distinctly tridistichate, but the two from the Arrou Islands seem to owe this character to a regeneration after fracture at

[1] A revised diagnosis of this species, together with its synonymy, will be found on p. 256.

the syzygy in the third brachial of the primary arm, and they may therefore be considered as members of the ten-armed series.

The terminal cirrus-joints of *Antedon variipinna* are more sharply carinate than those of *Antedon anceps* (Pl. XXXV. fig. 3; Pl. XXXVI. fig. 1), and are sometimes spinous, while the interval between the later syzygies of the arms is considerably longer (Pl. XXXV. fig. 2; Pl. XXXVI. fig. 3). Furthermore the joints of the third pinnule have more or less prominent lateral processes, while those of *Antedon anceps* are smooth (Pl. XXXV. fig. 2; Pl. XXXVI. figs. 1, 4).

4. *Antedon carinata*, Lamk., sp. (Pl. III. figs. 1–3; Pl. XXXIV.).

Specific formula—A.$\frac{b}{b}$.

1811. *Antedon gorgonia* (?), de Fréminville, Bull. Soc. Philom. Paris, 1811, t. ii. p. 349.
1815. *Alecto carinata* (?), Leach, Zool. Miscellany, London, 1815, vol. ii. p. 63.
1816. *Comatula carinata*, Lamarck, Hist. Nat. Anim. sans Vert. Paris, 1816, t. ii. p. 534.
1834. *Comatula carinata*, Griffith, Animal Kingdom (Cuvier), vol. xii., Mollusca and Radiata, London, 1834, pl. viii. fig. 2.
1834. *Comatula carinata*, de Blainville, Manuel d'Actinologie, Paris, 1834, p. 249.
1843. *Alecto carinata*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 135.
1849. *Comatula (Alecto) carinata*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1847 [1849], p. 252.
1862. *Comatula carinata*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 200.
1865? *Antedon Braziliensis*, Lütken, MS.
1867. *Antedon Braziliensis*, Verrill, Trans. Connect. Acad. Arts and Sci., 1867, vol. i. p. 341.
1868. *Antedon Dubenii*, Verrill, *Ibid.*, p. 365 (with ?).
1878. *Antedon carinata*, Pourtalès, Bull. Mus. Comp. Zoöl., 1878, vol. v. p. 214.
1879. *Antedon Brasiliensis*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 386.
1879. *Antedon carinata*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1879. *Antedon bicolor*, P. H. Carpenter, *Ibid.*, p. 29.
1879. *Antedon carinatus* (?), Rathbun, Trans. Connect. Acad. Arts and Sci., 1879, vol. v. p. 156.
1880. *Antedon brasiliensis*, P. H. Carpenter, Quart. Journ. Geol. Soc., 1880, vol. xxxvi. p. 41.
1881. *Antedon carinata*, P. H. Carpenter, Notes from the Leyden Museum, 1881, vol. iii. p. 179.
1881. *Antedon carinata*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1881, vol. ix. No. 4, p. 7.
1882. *Antedon carinata*, Ludwig, Mém. Acad. Sci. Bruxelles, 1882, t. xliv. p. 5.
1882. *Antedon carinata*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 502.
1882. *Antedon carinata*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1882. *Antedon carinata*, P. H. Carpenter, *Ibid.*, p. 746.

Centro-dorsal a thick, roughly circular disk, with the dorsal surface bare, and bearing from twenty to thirty marginal cirri. These have from twenty to thirty stout joints, all wider than long, the basal ones especially so. The penultimate joint sometimes, but rarely, has a small opposing spine.

The first radials partially visible; the second short and oblong. Axillaries triangular, twice the length of the second radials, and forming with them a more or less distinct median tubercle. The first two brachials wedge-shaped (the first least so), with sharp outer edges and a similar median elevation in their line of union. Ten arms of about one hundred and sixty short joints, which are wide and nearly oblong till the second syzygy, after which they are narrower and more triangular, gradually becoming more oblong again and finally square at the ends of the arms. The middle of the distal edge of each joint in the lower part of the arm is slightly raised, and gradually develops into a keel or crest curving slightly forwards. This may follow immediately after the median tubercle between the first and second brachials, or not begin till after the twentieth joint, and varies very much in its development, gradually becoming less marked towards the ends of the arms. Syzygies in the third and about the eighth and twelfth brachials, and then at intervals of two to eight joints, usually about four or six.

The lower pinnules are all of tolerably equal length. That on the second brachial is about 12 mm. long, rather slender, and consists of some twenty trihedral joints, most of which are longer than wide. The following pinnules have rather wider and more flattened joints, with a sharp dorsal edge, and they gradually increase in stoutness till that on the sixth brachial, which is the largest pinnule on the arm. The next few pinnules decrease slowly in stoutness but increase in length, their outer joints becoming relatively longer, but the basal ones remain wide for some distance; the terminal pinnules long and filiform.

Disk and ambulacra naked; sacculi very abundant on the disk, arms, and pinnules.

Colour in spirit,—very variable; light brown, purple, or various combinations of the two, either mottled or in broad or narrow bands; other specimens are mottled purple and white.

Disk 11 mm.; spread about 25 cm.

Locality.—Bahia, 7 to 20 fathoms.

Other Localities.—Off St. Lucia (278 fathoms); Venezuela; Pernambuco; the Abrolhos Islands; Rio Janeiro; Chile; Java (?); Ceylon; the Seychelles; Muscat; Aden; Red Sea; Zanzibar; Mauritius; Madagascar; St. Helena.

History.—This species has a wide distribution in the littoral zone of the tropical and the southern subtropical seas; and it is not improbably therefore identical with the *Alecto carinata* of Leach,[1] who defined his type very briefly from a specimen *sine patria* in the British Museum. But the originals of Leach's species are not now to be found in the national collection, although Professor F. J. Bell has made a careful search

[1] *Zool. Miscellany*, 1815, vol. ii. p. 63.

for them; and the identity of his *Alecto carinata* with the *Comatula carinata* from Mauritius, which was described by Lamarck[1] in the following year must therefore remain uncertain. Lamarck referred to *Antedon gorgonia*, de Fréminville, as a possible synonym of his species, and from this one may perhaps conclude that he had been unable to get access to de Fréminville's type. We have seen that he had ignored de Fréminville's generic name *Antedon*, which had five years' precedence over *Comatula*, and that his definition of this latter type differed but little from that of *Antedon* which had been previously given by de Fréminville. But the latter author gave no figure nor formal description of *Antedon gorgonia* as distinguished from his definition of the genus; and if Lamarck was unable to see de Fréminville's original specimen we can understand his uncertainty respecting the possible identity of *Comatula carinata* and *Antedon gorgonia*.

Lamarck's species was redescribed by Müller, and his diagnosis of it was copied by Dujardin and Hupé in 1862. A few years afterwards Dr. Lütken gave the MS. name *Antedon braziliensis* to a type which had been obtained at Rio Janeiro and has since proved to be very abundant on the Brazilian coast at the Abrolhos Islands and also at Bahia. Examples of it with Lütken's name attached were distributed to various museums, and in 1867 the name *Antedon braziliensis* appeared in a comparative list of the Echinoderms from the east and west coasts of Tropical America which was drawn up by Verrill.[2] The same author[3] in the following year doubtfully referred to *Antedon dübenii*, Böhlsche, another example of this type from the Brazilian coast, which he regarded, however, as different both from *Antedon braziliensis*, Lütken, MS., and from the *Antedon carinata* of Mauritius and Zanzibar. The difference, however, seems to be chiefly one of coloration, and it is now practically certain that Verrill's and Lütken's types alike are identical with the species from the Indian Ocean. Pourtalès[4] wrote as follows in 1878:—"A species common on the coast of Brazil answers to the description of the *Comatula carinata* Lamk. (Leach sp.). It is quoted as from Mauritius, and the museum has specimens from Zanzibar differing only in some minor details from the Brazilian ones." Rathbun,[5] writing a few months later, referred to the Brazilian form as *Antedon carinatus* (?), and made some comparisons between it and some examples from Zanzibar, concluding with the remark that "the study of a large series of specimens would probably serve to unite the Brazilian with the East African species beyond all doubt."

I was fortunately able to carry out this study in the autumn of 1880, when a careful examination of the material which I found in several continental museums, from a con-

[1] *Op. cit.*, p. 534.
[2] *Trans. Connect. Acad. Arts and Sci.*, 1867, vol. i. p. 341.
[3] *Ibid.*, p. 365.
[4] Reports on the dredging operations of the U.S. Coast Survey Steamer "Blake." Corals and Crinoids, *Bull. Mus. Comp. Zoöl.*, 1879, vol. v. No. 9, p. 214.
[5] A list of Brazilian Echinoderms with Notes on their Distribution, &c., *Trans. Connect. Acad.*, 1879, vol. v. p. 156.

siderable variety of localities, led me to acquiesce in the conclusions of Pourtalès and Rathbun, which were also adopted by Ludwig[1] two years later.

Remarks.—*Antedon carinata* is thus very extensively distributed in tropical and subtropical seas. Originally described from Mauritius, it has since been found at Ceylon, the Seychelles, Madagascar, Zanzibar, Muscat, Aden, and in the Red Sea. The British Museum contains specimens from St. Helena; it is common all along the South American coast from Rio Janeiro to Pernambuco, reappears at Venezuela, and was dredged abundantly in 278 fathoms off St. Lucia. As yet it is only known from Chile on the Pacific coast of America; and this is further south than any locality on the Atlantic coast at which the type has yet been obtained. I have a strong suspicion too that an individual from Norfolk Island, which I saw at Vienna in 1880 with the museum name *Antedon marmorata*, is very closely allied to, if not identical with, *Antedon carinata*; but I should prefer to leave the point undecided for the present, until I can make a more detailed examination of the Vienna specimen. In the same year I found some very typical examples of *Antedon carinata* in the museum at Hamburg, which were labelled as having been obtained at Java. This of course is only separated by a part of the Indian Ocean from Mauritius and the Seychelles; but if the locality of these four specimens is rightly given, it is curious that no other examples of *Antedon carinata* from the eastern shores of the Indian Ocean should have occurred in any one of the numerous collections of Comatulæ which I have examined. Thus, for example, it is not represented in Dr. Anderson's collection from the Mergui Archipelago. It has been recently obtained at Ceylon, however, but Mr. G. C. Bourne was unable to find any Comatulæ at all on the Coral reefs of the Chagos Islands, which occupy an intermediate position between Java and the Seychelles, although he was good enough to make a special search for them on my behalf. Under these circumstances, therefore, I must confess to a certain amount of doubt respecting the presence of *Antedon carinata* at Java, as the Hamburg label records, and can only wait with interest for further information on the subject.

The characters of the centro-dorsal, arms, and lower pinnules distinguish *Antedon carinata* very clearly from the other members of the *Milberti*-group. In fact, as hinted above, it may become desirable at some future time to remove the type from this group altogether. The lower pinnules are all of tolerably equal length, and only differ in the proportions of their component joints. The stoutness of the joints increases up to the third outer pinnule (on sixth brachial), and the next two or three pinnules are most frequently almost equally stout, but in a few cases the size of the pinnule-joints decreases from this point onwards. In full-grown individuals the width of the arm remains uniform until the second syzygy (eighth brachial), after which the joints become more triangular, and the width begins to decrease, while the median keel or crest becomes more

[1] Verzeichniss der von Prof. Dr. Ed. van Beneden an der Küste von Brasilien gesammlten Echinodermen, Mém. Acad. Sci. Bruxelles, 1882, t. xliv. p. 5.

distinct. This varies greatly in the extent of its development, and is so slight in some individuals which I have seen from Mauritius, the locality of Lamarck's original specimen, that he would most assuredly never have given them the specific name *carinata*. There is always more or less of a tubercular elevation on the junction lines of the two outer radials and the two lower brachials respectively, and from the second of these onwards the median dorsal line of the arm is more or less sharply indicated, owing to the way in which the dorsal surface of each joint falls away from it, so that the arm has somewhat the appearance of having been compressed laterally. The bases of many arms show little more than this; but in others the middle of the distal edge of each joint is distinctly raised, and a sharp forward projecting crest or keel is gradually developed upon it (Pl. XXXIV. figs. 4–7), and continues for some way out on the arms, till it becomes less and less distinct in their terminal portions. In the few specimens which I have seen from Muscat and from the Red Sea, this character, and also the tubercular elevations on the radials and lowest brachials are considerably less distinct than in those from the Indian Ocean, Brazil, or the Caribbean Sea; while both in the African and in the Red Sea variety the terminal portions of the arms have stiffer pinnules and a less feathery appearance than in the Brazilian examples. The sacculi are extremely abundant in this species, and occur in considerable quantity at the sides of the ambulacra both in disk and arms, which is by no means always the case in other forms of *Antedon*. The ambulacra are often supported by delicate rods and spicules of limestone, but there is never anything like a definite skeleton. The colour is extremely varied. Some specimens are dark reddish-purple or light yellowish-brown all over; others have alternating bands of these two colours, each band covering two or three arm-joints; in others again the bands are quite narrow, while some individuals have a more or less mottled appearance, with the brown occasionally replaced by white.

The cirri of *Antedon carinata* are peculiar from the very general absence of an opposing spine on their penultimate joint (Pl. XXXIV. figs. 1–3). In two individuals, one from Mauritius and one from Bahia, I have found a cirrus which shows signs of having been broken and subsequently repaired, the distal portion of it being much smaller than the base. This is worth recording, because I have generally found that regeneration after fracture, though common enough in the arms, occurs but rarely in the cirri.

The centro-dorsal of this type is very characteristic (Pl. III. figs. 1*a*, 3*b*; Pl. XXXIV. figs. 1–3). It is a thick disk with a single or partially double row of marginal cirri, but its dorsal surface is smooth and free from cirri, just as in *Actinometra* (Pl. V. figs. 1*b*, 2*b*, 2*c*, 4*b*, 5*b*, 5*c*), though in young individuals it is more convex, with only a small cirrus-free space at the dorsal pole. The ventral surface (Pl. III. figs. 1*b*, 3*a*) is marked by an indistinct pentagonal impression which corresponds to a similar marking on the under surface of the radial pentagon (Pl. III. fig. 1*c*), and is of interest from its foreshadowing to a certain extent the deeper bilobed impressions in the corresponding positions on the centro-dorsal and radials of *Antedon quinduplicava* (Pl. IV. figs. 1*c*, 1*d*).

Antedon carinata has a well-developed basal star, as shown in Pl. III. figs. 1*c*, 2*a*, 2*b*, 3*a*, 3*b*; and the articular surfaces of the radials, though relatively wider than is generally the case in *Antedon* (compare Pl. III. figs. 4*b*, 5*a*, 6*d*), are considerably inclined to the vertical axis of the calyx (Pl. III. figs. 1*d*, 3*a*, 3*b*); while there is a wide central funnel, the opening of which is often not filled up by any calcareous network, so that the ventral surface of the rosette is more or less visible through it (Pl. III. figs. 1*d*, 3*a*).

A few comparatively young specimens were obtained by the Challenger at Bahia. They differ from the more mature individuals in the greater length of the arm- and cirrus-joints, and in the more convex shape of the centro-dorsal, but a small portion of which is free from cirri (Pl. XXXIV. fig. 3).

One or two examples of *Antedon carinata* which were taken at Bahia were infested by *Myzostoma gigas*, which is also a common parasite of *Antedon eschrichti* in the Circumpolar Seas.

5. *Antedon parvicirra*, n. sp. (Pl. XXXVI. figs. 7, 8).

Specific formula—$A.\frac{bc}{a}$.

Description of an Individual.—Centro-dorsal small and hemispherical, bearing about forty cirri of ten or twelve joints, all but the lowest of which are longer than wide, the terminal ones being somewhat compressed laterally; the penultimate with a small opposing spine.

First radials scarcely visible; the second very short and quite free laterally. Axillaries four times their length, and pentagonal, with a faint median elevation on the proximal edge. Ten arms of about eighty joints, which are triangular at first, and about as long as wide, gradually becoming obliquely quadrate. Syzygies in the third, eighth, and about the twelfth brachials, and then at intervals of two or three joints.

The second brachial bears a slender pinnule about 4 mm. long, which consists of some fifteen joints. The following pinnules increase gradually both in length and in stoutness to those of the third pair (on sixth and seventh brachials), which bear long and fusiform genital glands. The succeeding pinnules are of nearly the same length, and then gradually diminish in stoutness.

Disk and ambulacra naked; sacculi very abundant on the disk, arms, and pinnules.

Colour in spirit,—purplish-red, with frequent intervals of white on the arms.

Disk 6 mm.; spread about 10 cm.

Locality.—Station 208, January 17, 1875; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud. One specimen.

Remarks.—The short cirri of this little species, with their somewhat compressed terminal joints, together with the freedom of the rays and the relatively long joints of the lower pinnules, give it a certain amount of similarity to *Antedon rosacea* and *Antedon dübeni* (Pl. XXXVII. figs. 1, 2). But it resembles *Antedon carinata* in the large size and the tolerable equality of the pinnules on the sixth and following brachials (Pl. XXXVI. fig. 8), a point which distinguishes it altogether from *Antedon rosacea* and *Antedon dübeni*, in which the first pinnule is the longest (Pl. XXXVII. fig. 3). The small number of cirrus-joints separates it from *Antedon anceps* and *Antedon variipenna*, which somewhat resemble it in the characters of the pinnules (Pl. XXXV. figs. 1–3; Pl. XXXVI. figs. 1, 4–6).

6. *Antedon informis*, n. sp. (Pl. XXXIII. fig. 3).

Specific formula—$A.\frac{ab}{b}$.

Description of an Individual.—Centro-dorsal discoidal, with a smooth dorsal surface and about a dozen marginal cirri. These have fifteen to eighteen joints which are as wide or wider than long, most of them with a slight elevation in the middle of the dorsal edge; the penultimate with a faint spine.

First radials partially visible; the second oblong, with a rounded dorsal surface, and but slightly united laterally. Axillaries also rounded, short, and widely rhombic. Ten arms; the first few brachials nearly oblong; the following ones rather wider than long, somewhat overlapping, and almost triangular, gradually becoming obliquely quadrate. A syzygy in the third brachial, and the next usually about the eleventh or twelfth, with others at intervals of three to five joints.

The second brachial bears a comparatively small pinnule of about a dozen squarish joints. There may be a similar but smaller one on the third brachial, or more generally none at all. That on the fourth is considerably longer and stouter, but the following pinnules are smaller again.

Disk lost; sacculi very abundant on both arms and pinnules.

Colour in spirit,—white.

Spread perhaps 8 cm.

Locality.—Station 208, January 17, 1875; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud. One imperfect specimen.

Remarks.—Of the five mature arms which remain in this much mutilated individual, only one, the central one in the figure (Pl. XXXIII. fig. 3), has a pinnule on the third brachial, and that but a small one. In the other four arms it is entirely absent, and in one ray which has been completely regenerated there are no pinnules on the third, fifth, and seventh brachials, although those on the other (outer) side of the arm are all present as usual.

There is a similar absence of a pinnule on the third brachial in the unique specimen of *Antedon lovéni*,[1] which was described by Bell, though the fact seems to have escaped his notice, for he makes no mention of it.[2] The cirri and one arm are lost; but only one of the remaining nine arms has a pinnule on the third brachial. The great size and the elongated joints of the second and third pinnules in *Antedon lovéni* are sufficient, however, to prevent any confusion between it and *Antedon informis*.

Another species in which the third brachial bears no pinnule is *Antedon manca* (Pl. XLIV. figs. 2, 3), which will be described further on in the Bidistichate group.

Apart from the absence of the pinnule on the third brachial, *Antedon informis* is also distinguished by the long interval between the first and second syzygies,[3] and by the peculiar minute spinelets on the cirrus-joints. I know of no described species with which it is likely to be confounded.

All the ten-armed species of *Antedon* which were obtained by the Challenger and "Porcupine" have now been considered, with one exception. This is the singular form which I have called *Antedon balanoides* (Pl. XXXIII. figs. 6, 7); and there are four other species besides it which do not seem to fit into any of the groups established above. All but one inhabit the Eastern Archipelago, and for the present they may be classified as follows :—

A. The second and third brachials have pinnules.
- I. The first pinnule is the largest. Cirrus-joints have two dorsal spinelets, ... *bidens*, Bell.
- II. The lower pinnules tolerably equal.
  - Twenty cirrus-joints without spines; syzygial interval three or four joints, ... *adeonæ*, Lamk., sp.
  - Twenty-five to thirty-five spiny cirrus-joints; syzygial interval nine or ten joints, ... *lævipinna*, Carpenter.

B. The second and third brachials have no pinnules.
- Sixty cirri of thirty-five to forty joints on a conical centro-dorsal, . 1. *balanoides*, n. sp.
- Twenty cirri of about twenty joints, ... *defecta*, Carpenter, MS.

C. The third, fourth and fifth brachials have no pinnules. Eight or ten cirri of twelve joints, ... *impinnata*, Carpenter, MS.

The last of these is a little species which was obtained at Mauritius by Professor Möbius, who was kind enough to show it to me when I visited Kiel; and I found it to be serving as host to *Myzostoma excisum* and *Myzostoma carinatum*, von Graff.

[1] "Alert" Report, p. 158, pl. x. fig. C (*non* A).

[2] Bell's figure is also incorrect; for the pinnules of the second, fourth, and sixth brachials are represented as being placed on the inner instead of on the outer side of the arm. A similar error occurs in the figure of *Antedon pumila* on the same plate, in which the first, second, fourth, and sixth, &c., brachials are all represented as bearing pinnules on the inner side of the arm, an arrangement which never occurs in any Crinoid.

[3] The central arm represented in the figure has a syzygy in the fourth brachial as well as in the third.

1. *Antedon balanoides*, n. sp. (Pl. XXXIII. figs. 6, 7).

Specific formula—A.$\frac{c}{b}$.

Description of an Individual.—Centro-dorsal a much elongated cone (5·5 mm.), bearing five converging double rows of cirrus-sockets, six or seven in each row. Its lower portion has no functional sockets, but shows faint scars continuing the rows downwards; a deep interradial furrow between every two double rows.

Thirty-five to forty cirrus-joints, of which the basal ones are short. The next till the tenth or twelfth are much longer than wide, and develop a faint dorsal keel sloping backwards from the distal edge, where it projects beyond the base of the next joint; the following joints are shorter and become compressed laterally.

First radials concealed; the second just in contact at their proximal angles, and oblong, with a deeply incised distal edge, the centre being very short and raised to meet the elevated blunt angle of the rhombic axillary.

Ten arms; the first brachials have long outer sides and a short raised centre; the second irregularly quadrate and similarly raised in the centre. Arm-joints triangular, wider than long. Syzygies about the third, eighth, and twelfth brachials, and then at intervals of two to six, usually three, joints.

The second and third brachials have no pinnules; the fourth bears a slender one of fifteen joints and 7 mm. long. The next pair are generally stouter, and the following ones less so, but of increasing length.

Disk naked; sacculi tolerably abundant on the pinnule-ambulacra.

Colour in spirit,—the calyx a deep rose red; the cirri and the ends of the arms white.

Disk about 6 mm.; spread probably about 12 cm.

Locality.—Station 201, October 26, 1874; lat. 7° 3′ N., long. 121° 48′ E.; 82 fathoms; stones, gravel. A calyx and some arm-fragments.

Remarks.—Only a single and much mutilated example of this remarkable type was obtained by the Challenger. Its centro-dorsal is not unlike that of *Atelecrinus* in shape (Pl. VI. figs. 5, 7; Pl. XXXIII. fig. 6), but the cirri are more numerous and the double rows more regularly arranged than in that genus. These characters also distinguish the type from *Antedon defecta* of the above list, which was dredged by the "Blake" in the Caribbean Sea.

The list given on p. 54 also includes six other ten-armed species of the "Blake" collection, viz.:—

Antedon armata, Pourtalès.
Antedon brevipinna, Pourtalès.
Antedon columnaris, Carpenter.
Antedon cubensis, Pourtalès.
Antedon duplex, Carpenter, MS.
Antedon hageni, Pourtalès.

I have not inserted these in any of the above schemes, since my work on the "Blake" Comatulæ is not yet complete; but they will be fully described and illustrated in the Report on the Collection, which will be published as one of the Memoirs of the Museum of Comparative Zoölogy at Harvard College.

Antedon, Series III.

Two articulated distichals.

Remarks.—This series includes all those multibrachiate species in which there are but two distichal joints united by a bifascial articulation as the two outer radials are (Pl. XL. fig. 1; Pl. XLIII.). The palmar and post-palmar series, when present, are normally of the same character, though, like the distichals, they may be occasionally replaced by a three-jointed series with a syzygy in the axillary. This, however, is far less common than in *Actinometra.* The individuals of *Antedon similis* and *Antedon occulta* represented in Pl. XLVII. fig. 3, and Pl. XLVIII. fig. 1, have their distichal and palmar series very regularly constructed; while in those of *Actinometra elongata* and of *Actinometra valida* (Pl. LVII. fig. 2; Pl. LIX. fig. 3) two and four of the bidistichate series respectively are replaced by sets of three joints, the axillary with a syzygy.

The bidistichate forms of *Antedon* make up the largest series, next to that of the ten-armed type, of all those into which the species of this genus naturally arrange themselves. It may be divided for the purposes of formulation into three groups, according as there are one, two, or three axillaries respectively above the radials, as is shown on pp. 54, 55. Several species of course appear in two groups, owing to the occasional total absence of palmar or post-palmar axillaries in some individuals; while others may sometimes have only ten arms. Thus, for example, there are now and then no distichal series at all in certain individuals of *Antedon brevipinna*, *Antedon duplex*, *Antedon flexilis*, and *Antedon lusitanica* (Pl. XXXIX. figs. 1, 3). In like manner *Antedon pourtalèsi* and *Antedon quinquecostata* always have one and sometimes two post-radial axillaries; while there are always two and sometimes three in *Antedon palmata* and *Antedon spinifera.*

While, therefore, it is useful to have a system of formulation which gives some information as to the extent of the ray-divisions, too much stress must not be laid upon the presence of a palmar or post-palmar axillary as an aid to classification. In the list given on pp. 54, 55, I have arranged the bidistichate species of *Antedon* in three groups, according to the frequency of the ray-divisions. There are certain occasions in which such a mode of grouping them is of considerable use; but one must always bear in mind that a species with (say) three post-radial axillaries which appears new at first sight, may in reality be identical with one which is already known, but has never yet been found with any axillary beyond the palmars, *e.g.*, *Antedon tuberculata* (Pl. XLV. fig. 2). The converse is also equally true. All the three Challenger specimens of *Antedon occulta* have post-palmar axillaries (Pl. XLVIII. fig. 1; Pl. XLIX. fig. 3), but it is quite possible that other examples of the type may be eventually discovered in which these are absent. It would be premature, however, to describe them as new, simply because they did not agree with any of the species which had no axillary beyond the palmars. In all such cases as these, and we shall meet with them frequently, the general characters of the type must be carefully taken into consideration, apart from the frequency of its ray-divisions, which is often much greater in some individuals of a species than in others; thus, for instance, examples of *Actinometra parvicirra* have been described with thirteen and with thirty-nine arms respectively, palmar axillaries being altogether absent in the former and abundantly developed in the latter.

It is therefore desirable, so far as may be possible, to employ some other means of classifying any particular series of multibrachiate Comatulæ than one which is based solely on the number of post-radial axillaries; and in the present case there is no difficulty in effecting this object.

We have seen that the bidistichate species of *Antedon* fall into three sets according as there are one, two or three axillaries above the radials. Each of these sets contains species which belong to two very different types of structure, the one with and the other without an ambulacral skeleton. Most of the forms which have a distichal but no palmar axillary (A.2) resemble the members of the *Basicurva*-group in the ten-armed series in the presence of an ambulacral skeleton and in the straight-edged and wall-sided nature of the radial axillaries and of the next following joints. In fact, two members of this group (*Antedon flexilis* and *Antedon lusitanica*) have been already noticed in connection with the *Basicurva*-group, owing to the occasional absence of any distichal axillary (Pl. XXXIX. figs. 1–3; Pl. XLII.). In like manner *Antedon quinquecostata* and *Antedon pourtalèsi* always have a number of distichal series, but these are not always followed by palmars; while I have seen some examples of *Antedon spinifera* with one or more post-palmar series, and others in which there are no axillaries beyond the palmars.

All these species, together with others which will be described immediately, are the bidistichate representatives of the *Basicurva*-group, and they form a very natural assemblage which may be conveniently designated as the *Spinifera*-group. It thus includes a variety of specific types which may have one, two, or three axillaries beyond the radials, *Antedon spinifera* having sometimes two and sometimes three, and being the first species in which an ambulacral skeleton was described. The remainder of the bidistichate species of *Antedon*, which have neither an ambulacral skeleton on the pinnules nor distinctly wall-sided rays, represent the *Milberti*-group among the ten-armed species of the genus in the characters and relations of their lower pinnules, and they may be conveniently designated as the *Palmata*-group. Like the *Spinifera*-group it includes species with one, two, or three post-radial axillaries, but one or more of the pinnules on the fourth and following brachials is considerably stouter and often much longer than its predecessors, very much as in the *Milberti*-group of the ten-armed series.

This is very well shown in *Antedon occulta* and in Smith's figure of *Antedon indica*;[1] and the distinctions between the different species of the *Palmata*-group depend very largely upon the number and position of these large pinnules, as shown in the key on p. 225.

Taking the Bidistichate Series as a whole, we find that its distribution, as at present known, is of a somewhat limited character. Unless the bidistichate example of *Antedon lusitanica*, which was dredged by the "Porcupine" from 740 fathoms in the East Atlantic, is anything more than a mere individual variation, there is no certain evidence of the Series being represented below 269 fathoms. The Challenger may have obtained *Antedon similis* from 610 fathoms at Station 174, but I think it more probable that the depth for this species and for the two associated with it was either 210 or 255 fathoms; for the only other Challenger station which yielded bidistichate species from below 100 fathoms was No. 192 (140 fathoms); though they range down to 269 fathoms in the Caribbean Sea, where they occur in considerable quantity. They are excessively abundant between the meridians of 100° and 180° E. (Sumatra to Fiji), and one species occurs at Rodriguez. But with the exception of the doubtful *Antedon lusitanica*, none have been found in the open Atlantic, nor are they known anywhere outside the fortieth parallels of latitude.

The Caribbean Sea and the Eastern Archipelago, therefore, are their two principal localities; and it may be broadly stated that the species with plated ambulacra (*Spinifera*-group) predominate in the former, while those with unprotected ambulacra and large stiff pinnules on the fourth and following brachials (*Palmata*-group) are mostly confined to the Eastern Seas. These are the only bidistichate species which belong to the strictly littoral fauna, *i.e.*, which have been found at depths of 20 fathoms or less. Three of them (*Antedon occulta*, *Antedon similis*, and *Antedon tuberculata*) were dredged by the Challenger at Station 174B,C, or D (255, 610 and 210 fathoms). The depth was probably one of the two lesser ones; but either of them is considerably below the usual range of the *Palmata*-group.

With the exception of the aberrant *Antedon macronema* from South-eastern Australia, no members of the *Spinifera*-group have been met with above 80 fathoms either in the Caribbean Sea or in the Eastern Archipelago. The "Blake" dredged them at some twenty stations in the Caribbean Sea between 80 and 270 fathoms; but all the five typical species of the Challenger collection were obtained from 140 fathoms in the Arafura Sea (Station 192), though one of them also occurred at Station 201 among the Philippine Islands (82 fathoms). The remaining species are *Antedon lusitanica*, dredged by the "Porcupine" from 740 fathoms in the East Atlantic, and *Antedon macronema* from 30 fathoms or less in King George's Sound, Port Jackson, and Port Stephens. The latter, however, is an abnormal species in many respects. The lateral flattening of its rays is very variable in its extent, and never specially distinct; while the

[1] Zoology of Rodriguez; Echinodermata, *Phil. Trans.*, 1879, vol. clxviii. pl. li. fig. 3*b*.

ambulacral skeleton of the pinnules, though well-developed as compared with that of species which have no covering plates at all, is far less highly differentiated than in *Antedon flexilis* and in *Antedon spinifera* itself, which have more distinct side plates than many species of Pentacrinidæ. It is worth notice that with the single exception of *Antedon denticulata* from 49 fathoms, no member of the *Basicurva*-group was obtained by the Challenger from a less depth than 140 fathoms, while they range as far downwards as 1600 fathoms. The bidistichate species with the same characters of the rays and ambulacra range from 80 to 740 fathoms, so far as is yet known; and the tridistichate species, which also have flattened rays and plated ambulacra, are likewise almost exclusively limited to the continental and abyssal regions. These facts are of interest because the Pentacrinidæ, which also have an ambulacral skeleton on the pinnules, do not occur at depths of less than 70 fathoms and range down into the abyssal fauna; and we may therefore not unreasonably infer that fossil species like *Millericrinus pratti*, which have the ambulacral skeleton still preserved on the pinnules, lived at depths of at least 50 fathoms. The same conclusion may perhaps be drawn for those Comatulæ such as *Solanocrinus costatus*, Goldfuss, in which the axillary radials and the lower brachials are very distinctly flattened and wall-sided.

The following key to the *Spinifera*-group contains the names of four Caribbean species, two of which, *Antedon brevipinna* and *Antedon spinifera*, have been described by Pourtalès and myself respectively.[1] *Antedon duplex* is one of the hosts of the encysting *Myzostoma murrayi*, von Graff, which also occurs on *Antedon breviradia* and *Antedon angustiradia* of the Challenger collection, both species from the Eastern Archipelago. *Antedon pourtalèsi* is a fine species which I have dedicated to the memory of the late Count Pourtalès, and is the host of *Myzostoma brevipes*, von Graff.

6. The *Spinifera*-group.

Bidistichate species with the radial axillaries and some of the following joints more or less wall-sided, and a well-marked ambulacral skeleton on the pinnules:—

A. Over thirty cirrus-joints; the later ones spiny.
  I. The first pinnule much smaller than the second. Centro-dorsal a thick disk or low rounded column, bearing two or three tiers of cirrus-sockets usually without definite arrangement; eighty or ninety cirrus-joints. First radials completely visible, . . . 1. *macronema*, Müll., sp.
  II. The first pinnule as long as or longer than the second.
    a. Centro-dorsal shortly columnar, with five double rows of cirrus-sockets, separated by interradial ridges.
      1. Twenty arms of sharply carinate joints; eighty cirrus-joints or more, ... 2. *quinquecostata*, n. sp.
      2. Thirty arms, their joints bearing curved dorsal spines; forty to sixty cirrus-joints, ... *spinifera*, Carpenter.

[1] *Bull. Mus. Comp. Zoöl.*, 1867, vol. i. No. 6, p. 111; *Ibid.*, 1881, vol. ix. No. 4, p. 8.

b. Centro-dorsal more rounded; the cirri without definite arrrangement.
1. Thirty to forty cirrus-joints; the radial axillaries long; lower joints of the genital pinnules expanded, . . *duplex*, Carpenter, MS.[1]
2. About fifty cirrus-joints; the radial axillaries short and wide, ... 3. *lusitanica*, n. sp.[1]

B. Fifteen to twenty-five stout and usually smooth cirrus-joints.
I. Centro-dorsal shortly columnar or conical, with five double rows of cirrus-sockets.
a. First radials visible; the arm-bases smooth and rounded, . 4. *flexilis*, n. sp.[1]
b. First radials entirely concealed; the lower arm-joints have raised distal edges, ... 5. *patula*, n. sp.
II. Cirri without definite arrangement.
a. The distichals and lower brachials have distinctly flattened sides. The later cirrus-joints smooth.
1. Calyx and arm-bases almost smooth; lower joints of the genital pinnules not specially distinguished, . . 6. *robusta*, n. sp.
2. Calyx and arm-bases irregularly tubercular.
α. The pinnules from the tenth to twentieth brachials have the third to fifth joints flattened and expanded laterally, ... *pourtalèsi*, Carpenter, MS.
β. The genital pinnules comparatively slender, with very slightly expanded joints, . . . *brevipinna*, Pourtalès.[1]
b. The distichals and lower brachials are but slightly flattened laterally; blunt spines on the later cirrus-joints, . . 7. *compressa*, n. sp.

1. *Antedon macronema*, Müll., sp. (Pl. IV. figs. 3, *a–d*; Pl. XXXVIII. figs. 4, 5).

Specific formula—A.2.$\frac{b}{c}$.

1846. *Comatula macronema*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1846, p. 179.
1849. *Comatula macronema*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 258.
1862. *Comatula macronema*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 203.
1879. *Antedon macrocnema*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 29.
1880. *Antedon macrocnema*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1880, vol. xv. p. 213, pl. xii. figs. 25, *a–c*.
1882. *Antedon macronema*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1882. *Antedon macronema*, P. H. Carpenter, *Ibid.*, p. 746.
1885. *Antedon macronema* (misprinted *mauonema*), Bell, Proc. Linn. Soc. N.S.W., 1884 [1885], vol. ix. p. 497.

Centro-dorsal a thick disk or short column with a smooth dorsal pole and about twenty-five to thirty-five cirri on its sides. These are very slender and reach 45 mm. in length, the longest having nearly one hundred joints, most of which are wider than long.

[1] Some individuals of these species have only ten arms; see p. 54.

The middle and outer joints are laterally compressed so as to overlap dorsally, and gradually develop a small spine.

The ends of the basal rays are often visible above the angles of the centro-dorsal. The first radials are nearly oblong; the second rather longer and more convex in the centre. Their lower ends are united, but the outer ends are free with sharp lateral edges. Axillaries pentagonal, also much rounded in the centre, with sharp straight edges and small flattened sides. The rays may divide twice; two distichals, the axillary not a syzygy. The distichals and lower brachials are rounded like the radials, with similar straight edges and small, flattened, outer sides. The inner side of the third brachial may also show traces of flattening.

Eleven to fifteen short arms, consisting of about seventy shortly triangular joints, the lower ones rounded; the later joints gradually become compressed laterally and develop a forward projecting spine which overlaps the base of the next joint and is much more distinct in some individuals than in others. A syzygy in the third brachial, and another between the tenth and twentieth. Others at intervals of three to eight joints, usually four or five. The first pair of pinnules (on second and third brachials) are short and stiff, consisting of eight or nine elongated joints, and not more than 5 mm. long. The next pair are much stouter, with about a dozen rounded joints, and reach 10 mm. long. The following pinnules are of about the same length, with broader and more flattened basal joints, which are sometimes slightly carinate. There are six or eight pinnules of this character on either side of the arm, but the greater width of the lowest joints is distinct for some distance further, and the length of the pinnules does not increase.

Disk and brachial ambulacra but slightly plated; the genital glands protected by an imperfect plating which supports the ambulacral skeleton. This is not well differentiated; the covering plates rest on a continuous limestone band which is scarcely segmented into side plates. Sacculi abundant on the arms and pinnules, with a few on the disk.

Colour in spirit,—the calyx nearly white, and the arms a darkish purple.

Disk 7 mm.; spread about 13 cm.

Locality.—Port Jackson; 30 to 35 fathoms.

Other Localities.—King George's Sound; Port Stephens.

Remarks.—This is one of the most isolated, and therefore among the most easily identified species of the genus.

Although the lower joints of the rays have sharp and straight edges as in the *Basicurva*-group, their dorsal and ventral surfaces approach one another so rapidly that they have but very small lateral faces. Such as they are, however, these faces have the usual flattened character, and as there is an ambulacral skeleton on the pinnules, the type clearly belongs to the *Spinifera*-group, rather than to that of *Antedon palmata*, *Antedon* *flagellata*, &c., which it somewhat resembles in the very small size of the first pair of pinnules as compared with their successors (Pl. XXXVIII. fig. 4). The characters of these pinnules, the shortness of the arms, the large number of cirrus-joints, and the presence of the first radials externally, together with the very slightly wall-sided character of the lower joints of the rays, render it very easy to recognise the type, which has really no close allies among the other bidistichate species.

The disk is scarcely plated at all, and the brachial ambulacra but slightly so. The genital glands contained in the expanded portions of the large lower pinnules are covered by an imperfect pavement of ill-defined plates, above which the ambulacra are situated. The covering plates are tolerably distinct, but the limestone band supporting them is scarcely differentiated into side plates, except in some of the later pinnules.

The position of the side plates, however, is indicated by the sacculi, which are also abundant on the brachial ambulacra and extend down on to the outer part of the disk.

The centro-dorsal of *Antedon macronema* varies considerably in its shape. Most commonly it is a thick disk with a smooth dorsal surface and the cirrus-sockets arranged irregularly on its sides, as shown in Pl. IV. fig. 3*a*; but it is sometimes more nearly hemispherical, and sometimes almost columnar, with the sockets disposed in alternating vertical rows of three or four each.

A similar series of variations in the form of the centro-dorsal is characteristic of *Antedon scrobiculata* from the Oxfordian of the Jura; and the whole aspect of the calyx of *Antedon macronema* is more similar to that of the Jurassic *Antedon costata* and *Antedon gresslyi* than that of any other recent *Antedon* which I have seen. The great difference between the fossil and the recent types is that the basals of the latter undergo metamorphosis into a rosette; while in the former they persist as prismatic rods between the radials and the centro-dorsal. The positions of these are occupied in the recent form by the rays of the basal star (Pl. IV. fig. 3*c*), the ends of which sometimes appear on the exterior of the calyx (Pl. IV. fig. 3*a*). The general characters of the radials of *Antedon macronema* have been already described on pp. 23 to 26, and it is not necessary therefore to refer to them again.

The type was first discovered by Quoy and Gaimard in King George's Sound, and the Challenger dredged it in Port Jackson, while there are examples in the Sydney Museum from Port Stephens. I have never heard of its occurrence at Port Philip, however, though I have seen various other Comatulæ from that locality, where its presence might naturally be expected.

Apart altogether from its resemblance to certain Jurassic Comatulæ, *Antedon macronema* is remarkable as being a link between the species with the rays flattened laterally and an ambulacral skeleton on the pinnules, and those in which these characters do not present themselves, even as slightly as they do in *Antedon macronema*; while its extension into the purely littoral fauna is quite exceptional, for the members both of the *Basicurva*-group and of the *Spinifera*-group are almost entirely confined to the continental and the abyssal regions.

2. *Antedon quinquecostata*, n. sp. (Pl. III. figs. 6, *a–d*; Pl. XXXVIII. figs. 1–3).

Specific formula—$A.2.(2).\frac{b}{c}$.

Centro-dorsal a shortly pentagonal column with five interradial ridges very prominent at their ventral ends, and separated by more or less alternating double rows of cirrus-sockets, three or four in each row. About thirty-five cirri which may reach 45 mm. long, with eighty to ninety joints. Some of the lower joints are much longer than wide, but the following ones become shorter and laterally compressed, with a sharp dorsal keel, which passes into a prominent spine in the short middle and later joints.

The angles of the first radials are just visible, being turned slightly outwards above the interradial processes of the centro-dorsal; the second are short and sharply convex, rising to meet a strongly carinate backward process of the widely rhombic axillaries. The rays may divide three times. Distichal and palmar series of two joints each, the axillary not a syzygy. The two joints of each series, like the two outer radials, have sharp median crests, which are continued out on to the arms. All these joints, and especially those at the outer side of the ray, have straight lateral edges and flattened sides. On some arms this character ceases at the second brachial, but in others it is very visible on the third and even on the fourth.

There are usually twenty arms (but one example has twenty-one), with a sharp median keel, and composed of one hundred and twenty or more joints, which become much compressed laterally so that the later ones overlap rather sharply. A syzygy in the third, and then not till the twentieth or twenty-fifth brachial; others at intervals of four to eleven (usually five to seven) joints.

The second brachial bears a moderately stout pinnule about 10 mm. long, and consisting of some twelve or fifteen joints, most of which are longer than wide. The first four or five are flattened on the outer side, where they meet the corresponding pinnules of adjacent arms, and their inner edges are also slightly cut away. The following pinnules are rather shorter, with more rounded joints, the two joints at the base being wider than their fellows on the lower part of the arm. Further out, however, this is less marked, and the pinnules are somewhat carinate, but never specially long.

Disk moderately plated, and the arms rather more so; the pinnule ambulacra have covering plates and partly differentiated side plates. Sacculi rare or absent altogether.

Colour in spirit,—the skeleton yellowish-brown or whitish-brown, but the perisome darker.

Disk 7 mm.; spread about 20 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. Eight specimens and two fragments.

Remarks.—This remarkable species is very readily distinguished from every other bidistichate *Antedon*, with the exception of *Antedon spinifera* from the Caribbean Sea. Both types alike have long and spiny cirri; but those of *Antedon quinquecostata* are both more numerous and reach a greater length than in the Caribbean species. The latter also has a shortly columnar centro-dorsal, with double rows of cirrus-sockets, though there are frequently only two sockets in each row and not four, as is so often the case in *Antedon quinquecostata* (Pl. III. fig. 6*d*).

In *Antedon spinifera* too, the radials, distichals and lower brachials are by no means so sharply carinate as in *Antedon quinquecostata*, and there is an alternating double row of strong curved spines on the base of each arm. Generally also there are thirty arms, owing to the presence of two palmar axillaries on each ray, while the number in *Antedon quinquecostata* is typically twenty, though I have found a single palmar series to be present in two separate individuals (Pl. XXXVIII. fig. 1). Another point of difference between the two species is that *Antedon spinifera* has very large and abundant sacculi, while, if present at all, they are most scantily developed in *Antedon quinquecostata*, as is also the case in some other species from the same station.

The lateral flattening of the radial axillaries and of the next following joints is less marked in this species than in the *Basicurva*-group. The first distichal and the first brachial, especially the two on the outer arms of each ray, are the joints which show it most distinctly; but it is sometimes to be traced as far as the fourth brachials of the outer arms. The pinnules of adjacent second brachials, however, have their lower joints flattened against one another, very much as in *Antedon valida* (Pl. XV. figs. 5, 6), though not quite to the same extent. The two lower joints of the next few pinnules are somewhat wider and more expanded than their fellows, but this feature disappears in those further out on the arm (Pl. XXXVIII. figs. 2, 3).

The radial pentagon of this type differs somewhat in character from that of most other species of *Antedon* (Pl. III. figs. 6, *a–d*). Its angles are produced outwards to correspond with the interradial ridges of the centro-dorsal, each of which fits into a notch between the everted lateral angles of two adjacent radials; and under ordinary circumstances these angles are the only parts of the first radials which are visible externally. The dorsal surface of the radial pentagon is remarkable for showing no signs of any basal star, as there is a very well developed one in *Antedon spinifera*. The central opening is relatively large, and the rosette within it rather ill-defined, an unusual condition in a tropical species of *Antedon*.

3. *Antedon lusitanica*, n. sp. (Pl. XXXIX. figs. 1–3).

Specific formula—A.(2).$\frac{ab}{c}$.

Locality.—H.M.S. "Porcupine," 1870, Station 17A; lat. 39° 39′ N., long. 9° 39′ W.; 740 fathoms; bottom temperature, 49°·3 F.

Remarks.—The ten-armed form of this species has been already described on p. 109; but its bidistichate variety finds a place here (Pl. XXXIX. fig. 1). It resembles *Antedon quinquecostata* and *Antedon spinifera* in having spiny and many-jointed cirri, but they show no traces of any definite arrangement as is the case in those two species; while it differs from *Antedon duplex*, another Caribbean species, in the shape of the axillaries and in the unmodified character of the genital pinnules, so far as can be determined from the condition of their fragmentary remains.

4. *Antedon flexilis*, n. sp. (Pl. XLII.).

Specific formula—A.(2).$\frac{b}{ab}$.

Centro-dorsal columnar or slightly tapering, with its ventral angles produced into marked interradial processes, and ten vertical rows of cirrus-sockets, three or four in each row. Thirty to thirty-five cirri of twenty to twenty-five stout, but very smooth joints, most of which are longer than wide; the penultimate with an opposing spine.

Three radials visible; each of them, and especially the axillary, rather sharply convex, with a more or less distinct median tubercle. Axillaries subhexagonal and considerably wider than the second radials, which are short and band-like and in close contact laterally.

Ten to thirteen arms; two distichals, the axillary not a syzygy. The first two brachials or the two distichals, if present, have median tubercles like those of the radials, but less prominent. The radial axillaries and the next two joints have sharp, straight edges and wall-like sides. The inner sides of the second and of the third brachial (hypozygal) are also flattened, especially if the distichals are absent. The lower arm-joints are somewhat discoidal, with very rounded surfaces; and the following ones are shortly triangular, with the edges slightly raised, but they gradually become more smooth and relatively longer. A syzygy in the third, and another between the twelfth and eighteenth brachials; others at intervals of three to seven, usually four or five joints.

The first pinnules, which reach 13 mm. in length, have their outer sides somewhat flattened against one another below, and consist of some forty short and wide joints. The following pinnules are of about the same length, but the joints gradually increase in size and diminish in number, still remaining much wider than long. In the pinnules of the fifteenth and several of the following brachials the fourth and fifth joints are considerably wider than their fellows, but in the later pinnules the joints are longer than wide.

Disk not much plated, except along the ambulacra. There is a strong covering of plates over the genital glands, with numerous sacculi imbedded in it; and the later pinnules have a well-defined ambulacral skeleton, the sacculi alternating with the side plates.

Colour in spirit,—a light whitish-brown, with a brownish-grey ventral perisome.

Disk 10 mm.; spread about 55 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. Four specimens.

Remarks.—Two of the four representatives of this fine species have but ten arms each, and they thus find a place in the *Basicurva*-group, as has been already noticed on p. 128. A third, that figured on Pl. XLII., has three distichal axillaries on separate rays; while the fourth has one normal distichal series and two others on a ray which has been regenerated from the second radial.

The tendency of the centro-dorsal to assume a columnar shape, and the arrangement of the cirri upon it in five double rows beneath the rays, are points of resemblance between this species and *Antedon quinquecostata* from the same locality (Pl. XXXVIII. fig. 1); but they are very different in other respects. *Antedon quinquecostata* has slender and spiny cirri composed of many joints; while those of *Antedon flexilis* consist of but twenty-five smooth and relatively stout joints. The tubercular nature of its rays and arm-bases is also a good distinctive character; while it has extremely abundant sacculi, although these structures are most scantily developed or even altogether absent in *Antedon quinquecostata*. Not only do they alternate with the side plates of the pinnule-ambulacra, but they are very abundantly distributed over the plated coverings of the genital pinnules which are unprovided with ambulacra, as in *Antedon incisa* (Pl. XXI. fig. 2*a*) and *Antedon angusticalyx* (Part I. pl. liv. fig. 5).

Attached to the under side of the centro-dorsal of one specimen is a Brittle-Star which seems to belong to the genus *Ophiomusium*, so far as I have been able to make out its characters from a view of the dorsal surface only. But I cannot refer it to any species of this genus, or to any other Ophiuran which was obtained by the Challenger. It has a relatively large dorso-central, five small basals, and five large radials, the other ends of which are tubercular, and fit in between the two large radial shields which are also more or less tubercular on their line of junction. The arms of the Brittle-Star extend outwards between the cirri of the *Comatula* and coincide in direction with its rays, while their ends are more or less twisted round the bases of the cirri. The relations of the two forms are thus somewhat closer than those of *Ophiolebes scorteus* with *Antedon hirsuta*, which were noticed on p. 189; and the symmetrical arrangement of the large primary plates on the Ophiurid disk, together with the position of its arms, gives a very singular appearance to the centro-dorsal of the *Comatula*.

5. *Antedon patula*, n. sp. (Pl. XLIII.).

Specific formula—A.2.$\frac{b}{ab}$.

Centro-dorsal subconical and flattened at the apex, with short and broad interradial processes at its ventral angles. Five double rows of cirrus-sockets, three or four in each row. About thirty cirri, of some twenty stout and smooth joints, most of which are longer than wide, and somewhat compressed laterally, so as to have a sharp dorsal edge. The first radials invisible; the second short, closely united laterally and almost V-shaped in side view. Axillaries widely rhombic, with a large and rounded backward projection which is more or less tubercular in character. The rays divide twice, forming twenty arms of about one hundred and sixty joints. Two distichals, the axillary without a syzygy. The radial axillaries, the distichals, and the first three or four brachials have sharp lateral edges and flattened sides. The surfaces of the distichals, and of the lowest brachials rise to a more or less distinct tubercular projection. The fourth and following brachials are short and nearly oblong, their surfaces rising considerably from the proximal to the distal margins, which stand up rather prominently. Beyond the fifteenth brachial the joints are more triangular, with a median ridge, and overlap slightly. A syzygy in the third and then not till the eighteenth or twentieth brachial; others at intervals of four to eight, usually six or seven, joints.

The first pinnule is some 8 mm. long, and consists of about twenty-five short joints, the lowest of which are broad and rather sharply flattened. The next pinnule is a trifle longer and stouter, with a smaller number of larger joints, and in the next following pinnules the joints gradually increase in size and become more carinate, the third to the fifth being the widest, but they do not become longer than wide till some way out on the arm.

Disk thickly plated, and also the arms, both along the ambulacra and in the intermuscular spaces. The genital pinnules have a covering of small plates, with the sacculi scattered upon them, and the ambulacra of the later pinnules have well differentiated side plates with intervening sacculi.

Colour in spirit,—the skeleton whitish-brown, and the disk darker.

Disk 10 mm.; spread about 35 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. Two specimens.

Remarks.—This is another robust species with a considerable resemblance to *Antedon flexilis* (Pl. XLII.) in its triangular arm-joints, expanded genital pinnules, and the smooth, stout cirri arranged in ten vertical rows. But the centro-dorsal is somewhat more conical than in that type and conceals the first radials entirely. The radial portions of its margin are very deeply incised, so that its interradial angles are extremely prominent, and they separate the lower lateral angles of the second radials, not of the first, as in *Antedon flexilis.* In a side view of the calyx the second radials have an almost V-shaped appearance, and are sometimes entirely invisible, owing to the manner in which the axillaries project backwards into them. This gives a somewhat pear-shaped appearance to the axillaries when seen "full," almost the whole of their length being behind the line which joins their lateral angles.

Antedon patula also differs from *Antedon flexilis* in the characters of the lower arm-joints. In the latter type they are smooth and rounded and in no way specially prominent (Pl. XLII.). But in *Antedon patula* the distal edges of the fourth and each of the following brachials, till the twenty-fifth or thirtieth, are raised into a sort of collar, which stands up above the base of the next joint; and as soon as the joints assume a triangular shape they are marked by a distinct medio-dorsal ridge, which gives the arm a carinate appearance, a character which is altogether absent in *Antedon flexilis.* The joints of the genital pinnules are also somewhat carinate, and less enlarged than in *Antedon flexilis;* but there is the same plating over the genital glands as in that species, though the sacculi are not quite so abundant.

6. *Antedon robusta*, n. sp. (Pl. XLIV. fig. 1).

Specific formula—A.2.$\frac{c}{ab}$.

Description of an Individual.—Centro-dorsal a thick disk, 9 mm. wide, and bearing about fifty cirri round its margin. These have from eighteen to twenty-three smooth, stout joints, several of which are longer than wide. The penultimate forms a small opposing spine.

First radials just visible at the angles of the calyx above the low interradial processes of the centro-dorsal, which partly conceal the short second radials in their median line. Axillaries widely rhombic, with an open distal and sharper proximal angle, the latter rising to form a prominence with the second radial. Twelve arms, there being one bidistichate series on each of two rays. The first two brachials (or the distichals when present) form a slight prominence as the outer radials do, and have much flattened outer sides like the axillaries. The inner sides of the second, and both sides of the third brachials, are also sometimes flattened. Arms long, of more than two hundred smooth joints, the first few oblong, and the later joints more triangular. A syzygy in the third brachial; the next not till after the twentieth, and others at long intervals (nine to twenty-five joints).

The second brachial bears a stout pinnule about 12 mm. long and composed of some twenty joints, the lowest of which are much larger than their successors and of almost prismatic shape, being flattened against the corresponding joints of the adjacent pinnules. The third brachial has a similar but slightly smaller pinnule, and its successors are of about the same length, but have broader and flatter joints. The later pinnules gradually become elongated, but none of their lower joints are conspicuously wider than the rest. In the styliform middle and outer pinnules the first joint is flattened and expanded, with a curved distal edge.

Disk thickly plated, and also the arms, both along the ambulacra and in the inter-articular regions. The genital pinnules are protected by irregular plates, and the ambulacra of the later pinnules have well-defined side plates, with alternating sacculi, which are also fairly abundant on the genital pinnules.

Colour in spirit,—the perisome dark blackish-brown, but the skeleton whiter.

Disk 12 mm.; spread nearly 50 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

Remarks.—This type is a larger and more massive species than *Antedon flexilis* or *Antedon patula*, which resemble it in the characters of the stout cirri, the flattened lower pinnules, and the thickly-plated ventral perisome. But the centro-dorsal is altogether different and the calyx less tubercular than in these two species. The centro-dorsal is a thick disk, with the cirri closely set round its margin in two or three tiers. (Pl. XLIV. fig. 1), while the wide dorsal surface, which is slightly concave, is entirely free from them. The radial axillaries are relatively wider and much less prominent than in *Antedon patula* (Pl. XLIII.), and the first radials are not so entirely concealed as in that type (Pl. XLIV. fig. 1). In this respect, as also in the smoothness of the arms, *Antedon robusta* approaches *Antedon flexilis* (Pl. XLII.); but the lower joints of the genital pinnules are not so markedly expanded as in that species.

The single specimen of *Antedon robusta* which was obtained by the Challenger has two distichal axillaries, but it is quite possible that other examples may some time be discovered which have only ten arms, as is the case in *Antedon flexilis*, two specimens of which have three axillaries each, while the other two are only ten-armed. In that case *Antedon robusta* would find a place in the *Basicurva*-group by the side of *Antedon flexilis*.

7. *Antedon compressa*, n. sp. (Pl. XLI.).

Specific formula—A.2.$\frac{b}{ab}$.

Centro-dorsal a thick convex plate, with the dorsal pole free, and fifteen to twenty marginal cirri. These have about twenty joints, a few of which are longer than wide, and the later joints are somewhat compressed laterally, with blunt dorsal spines.

The first radials are concealed, and sometimes also parts of the second. These are short and sharply convex, with a slight median ridge, and they meet one another laterally beyond the angles of the centro-dorsal. Axillaries short and widely rhombic, also with a median ridge, and forming a small tubercle with the preceding joints. The rays divide twice; distichals two, with a faint median ridge, the axillaries without a syzygy, short and widely rhombic. The outer sides of the radial axillaries, distichals, and of the two lower brachials are slightly flattened; and the inner sides of the second and third brachials are also somewhat flattened.

Fifteen to twenty arms, of one hundred and fifty or more joints; the lowest are nearly oblong, with indications of a dorsal keel and raised distal edges. The following joints more triangular and distinctly carinate, gradually becoming quadrate and somewhat compressed laterally, with a tendency to overlap. A syzygy in the third, and then in the eleventh or twelfth brachial; others at intervals of two to seven, usually four or five joints.

The second brachial bears a tolerably stout pinnule some 10 mm. long, and consisting of about eighteen short joints, the first few of which are much wider than their successors and slightly prismatic. That of the third brachial is smaller, with the basal joints more rounded, and not so wide; and the following pinnules diminish in size till about the tenth brachial, having fewer but relatively longer joints. Beyond this point the length gradually increases again and the later pinnules are slender and delicate, with the two basal joints flattened and somewhat expanded.

The disk is well plated along the ambulacra; but the interpalmar areas only have a few scattered granules; the brachial ambulacra and interarticular spaces also well plated. The side plates of the pinnule-ambulacra are fairly distinct, with intervening sacculi.

Colour in spirit,—very light brown; the disk darker.

Disk 8 mm.; spread 28 cm.

Localities.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S.; long. 132° 14′ 15″ E.; 140 fathoms; blue mud. Two specimens.

Station 201, October 26, 1874; Philippine Islands; lat. 7° 3′ N., long. 121° 48′ E.; 82 fathoms; stones, gravel. One specimen.

Remarks.—This species is in some respects a transitional form between *Antedon patula* and *Antedon flexilis* on the one hand, and the *Palmata*-group on the other. The lateral flattening of the lower brachials is scarcely more distinct than in *Antedon flagellata* or *Antedon brevicuneata*; but the first pinnule has prismatic lower joints, and the ambulacra of the disk, arms, and pinnules are well plated, though the interpalmar areas of the disk are comparatively bare. The genital pinnules are not specially distinguished, however, except by their shortness, and their glands are not protected by any special pavement of plates as in *Antedon flexilis* and *Antedon patula*, though there is an ambulacral skeleton above them which is less completely differentiated than in the slender later pinnules.

The presence of blunt spines on the later cirrus-joints also distinguishes this species from the three just described, all of which have very smooth cirri (Pls. XLII., XLIII.; Pl. XLIV. fig. 1), and are altogether of a more robust nature.

The two individuals which the Challenger collected at Station 192 are essentially similar in all their characters; but a younger specimen from Station 201 has much smoother joints at the bases of the arms, their distal edges being but little raised; while in some fragments of a larger form obtained at the same locality there is a tendency to expansion in the third and fourth joints of some of the genital pinnules, which recalls their condition in *Antedon flexilis* (Pl. XLII.). The interpalmar areas of the disk are also more plated than in the examples from Station 192.

7. The *Palmata*-group.

Bidistichate species with an unplated disk and no definite ambulacral skeleton. The sides of the lower brachials are scarcely, if at all, flattened. The first pinnule smaller than its successors.

Remarks.—This group is not only extremely well-defined as regards its general characters, but it is also distinctly limited in its distribution, both bathymetrical and geographical.

The disk is either naked or bears but a few isolated plates, and there is no definite ambulacral skeleton. The ambulacra may be supported by isolated rods and networks of limestone, but they never form distinct covering plates like those of the *Basicurva*- and *Spinifera*-groups. In a few species like *Antedon flagellata* and *Antedon similis* (Pl. XLVII. fig. 1), which have the rays closely approximated, the lower brachials of their outer arms are somewhat flattened laterally. But this condition is not a constant one, and it does not affect the lower pinnules; so that it is altogether different from the flattening of the arm-bases in *Antedon basicurva*, *Antedon valida*, or *Antedon robusta* (fig. 3 on p. 122; Pl. XV. fig. 6; Pl. XLIV. fig. 1).

We have seen that the *Spinifera*-group among the bidistichate species corresponds to the *Basicurva*-group of the ten-armed type; and in like manner the ten-armed *Milberti*-group is represented in the bidistichate series by the *Palmata*-group, all the members of which have either the second or the third pinnule (or both) distinctly larger than the first one. In a few species like *Antedon elongata* and *Antedon flagellata* the third pinnule is the largest, as in the ten-armed *Antedon variipinna* (Pl. XXXVI. figs. 1, 4–6). In others, again, like *Antedon articulata* and *Antedon regalis*, the second and third pinnules are of about equal size, as in the ten-armed *Antedon parvicirra* (Pl. XXXVI. fig. 8). But in *Antedon palmata*, and in the majority of the species composing the group, the second pinnule is considerably larger than both the first and the third (Pl. XLVIII. fig. 2; Pl. XLIX. fig. 4), just as in *Antedon pinniformis* of the *Milberti*-group. The parallel between the two groups may be continued yet further; for the singular *Antedon informis*, which is without a pinnule on the third brachial (Pl. XXXIII. fig. 3) has two representatives in the *Palmata*-group, viz., *Antedon disciformis* (Pl. XXXIX. fig. 4), and *Antedon manca* (Pl. XLIV. figs. 2, 3). The first of these has no axillary beyond the distichals, but palmars are present in *Antedon manca* as in most species of the group; and there are usually six arms to each ray, of which only the two outermost usually have pinnules on the second brachials.

Besides *Antedon disciformis*, *Antedon clemens* and *Antedon marginata* (Pl. XXXIX. fig. 5; Pl. XL. fig. 1) are the only members of the group which have but one post-radial axillary. Some forms, like *Antedon articulata*, *Antedon palmata*, and *Antedon conjungens* (Pl. XLV. fig. 1), always have two and occasionally three; while we are not yet acquainted with examples of *Antedon flagellata*, *Antedon gyges*, and *Antedon occulta* (Pl. XLVIII. fig. 1; Pl. XLIX. fig. 3) in which a post-palmar axillary does not occur on one or more of the rays. I have no doubt, however, that simpler forms of these species will eventually be found, and I have, therefore, made no use of the presence or absence of a post-palmar axillary for the purpose of classification.

With the exception of the three species (*Antedon occulta*, *Antedon similis*, and *Antedon tuberculata*), which were dredged by the Challenger at one of the three Stations 174B, C, or D (255, 610 or 210 fathoms), all the members of the *Palmata*-group belong to the littoral fauna; and they are exclusively limited to the Western Pacific and the Indian Ocean. They are extremely abundant between the Friendly Islands on the east, and the Mergui Archipelago on the west, ranging northwards as far as Southern Japan, but not extending to the south beyond the tropic of Capricorn. Isolated species occur at the Sandwich Islands on the east and also at Ceylon and Rodriguez on the west; while *Antedon palmata*, the type of the group, is common at Aden and in the Red Sea. This is the furthest western limit of the group, which is altogether unrepresented in the Atlantic; for all the bidistichate species of *Antedon* from the Caribbean Sea have plated ambulacra, and therefore belong to the *Spinifera*-group.

The mutual relations of the various species composing the *Palmata*-group are shown in the following key:—

A. No pinnule on the third brachial.
- I. Two post-radial axillaries; the inner arms of each ray usually without a pinnule on the second brachial, ... 1. *manca*, n. sp.
- II. One post-radial axillary; the second brachial always has a pinnule, . 2. *disciformis*, n. sp.

B. The third brachial has a pinnule.
- I. One post-radial axillary; the rays quite free laterally.
  - α. Thirty cirrus-joints; brachials very short; sides of rays smooth, . 3. *clemens*, n. sp.
  - β. Twenty cirrus-joints; brachials not specially short; irregular projections at the sides of the rays, ... 4. *marginata*, n. sp.
- II. Two or more post-radial axillaries.
  - a. Second pinnule larger than third.
    - 1. The rays free laterally.
      - *a*. The second pinnule stiff and styliform, of twelve to eighteen much elongated joints.
        - (i) Rays have marginal projections; third pinnule not greatly shorter than the second.
          - α. Forty cirri; axillaries more than twice as long as second radials, ... 5. *tuberculata*, n. sp.
          - β. Twenty-five cirri; axillaries less than half as long again as second radials, . . *spicata*, Carpenter.
        - (ii) Margins of rays smooth; third pinnule considerably shorter than the second, . . . *indica*, Smith, sp.
      - *b*. The second pinnule has twenty-five or more joints, which are not specially elongated.
        - (i) The lower pinnules are larger on the outer arms of each distichium than on the inner ones.
          - α. Third pinnule quite short, . . . *protecta*, Lütken, MS.
          - β. Third pinnule not specially short, nearly as long as the second on inner arms, . . 6. *conjungens*, n. sp.
        - (ii) The lower pinnules fairly uniform in size on all the arms.
          - α. The fourth and fifth brachials bear large and tolerably equal pinnules, . . . *æquipinna*, Carpenter.
          - β. The pinnule on the fourth brachial larger than that on the fifth.
            - Third pinnule smaller than the first; second syzygy about the twentieth brachial, . *lævicirra*, Carpenter.
            - Third pinnule equal to the first; second syzygy about the thirteenth brachial, . . *imparipinna*, Carpenter.
    - 2. The rays in close contact laterally.
      - *a*. Spiny cirri.
        - (i) The second pinnule not greatly larger than the third; no post-palmars; the fifth brachial has the first syzygy in arms which spring from a distichal axillary, ... *reginæ*, Bell.
        - (ii) The second pinnule considerably longer than the third; post-palmars; the first syzygy always in the third brachial.
          - α. Over thirty cirrus-joints; the first pinnule not much larger than the second. The lower brachials have flattened sides, . . . *gyges*, Bell.

β. Not over twenty-five cirrus-joints; the first pinnule much smaller than the second, . *palmata*, Müll., sp.
b. Cirri carinate, but not spiny.
(i) No post-palmars; lower brachials flattened; two radials visible.
a. Fourth pinnule altogether smaller than the third, ... *brevicuneata*, Carpenter.
β Fourth pinnule nearly similar to the third, . 7. *similis*, n. sp.
(ii) Post-palmars; axillaries almost concealed, . . 8. *occulta*, n. sp.
b. Second and third pinnules about equal in size.
1. Thirty-five to forty cirrus-joints, the later ones distinctly spiny, *articulata*, Müll., sp.
2. Twenty-five to thirty cirrus-joints, the later ones with pointed keels; lower brachials flattened, ... 9. *regalis*, n. sp.
c. Third pinnule larger than the second.
1. Spiny cirri.
a. Rays well separated; no post-palmars; second syzygy about the fourteenth brachial, . . . *elongata*, Müll., sp.
b. Rays in close contact, and slightly flattened laterally; post-palmars; second syzygy about the twentieth brachial, ... *flagellata*, Müll., sp.
2. Cirri not spiny; second syzygy about the twentieth brachial, *bimaculata*, Carpenter.

1. *Antedon manca*, n. sp. (Pl. XLIV. figs. 2, 3).

Specific formula—A.2.2.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal a thick disk, with a flattened dorsal surface and about twenty marginal cirri. These have twenty-five to thirty joints, a few of which are longer than wide, and develop a dorsal spine from the eighth onwards.

First radials concealed; the second oblong, and quite free laterally; axillaries pentagonal. Two distichals and two palmars, the axillaries not syzygies; but the palmars are only developed on the outer pair of every four secondary arms, so that there are normally six arms to each ray, viz., 2,1,1,2. But one palmar axillary is undeveloped, giving twenty-nine arms only. They have about one hundred smooth and rounded joints, the first few discoidal, and the following ones triangular, about as long as wide, but becoming quadrate further out. A syzygy in the third brachial, and the next about the eighteenth or twentieth; others at intervals of three to nine, usually five or six joints.

The third brachial has no pinnule at all, while that of the second brachial is always absent on the innermost of every two arms springing from a palmar axillary, and sometimes also on the arms which are borne directly on the distichal axillaries. But it is sometimes present on these latter arms, and always on the two outer arms of each ray, though varying in size, consisting of twelve or fifteen joints, most of which are longer than wide.

The pinnules of the fourth and fifth brachials are sometimes twice its length, reaching 12 mm., and consisting of about eighteen elongated joints, with spines at their distal ends. The next pinnule is not half the size of this pair, and is smaller than that on the second brachial, while the next pair are the smallest on the arm, after which the length of the pinnules increases slowly.

Disk very much incised, and quite naked; sacculi very abundant on the arms and pinnules.

Colour in spirit,—the skeleton reddish-brown, and the perisome rather darker.

Disk 8 mm.; spread 12 cm.

Locality.—Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

Remarks.—This is a very singular species, the general relations of which are with *Antedon marginata* and *Antedon æquipinna;* but it is distinguished from them both, and from all the other bidistichate forms of *Antedon*, by the peculiar distribution of the pinnules. The arrangement of the arm-divisions seems to be like that of *Pentacrinus maclearanus*, palmar axillaries being only developed on the two outermost of the four secondary arms on each ray, so that the grouping of the arms is 2,1,1,2. In one ray, however, a palmar axillary is missing, so that the total number of arms is twenty-nine, and not thirty as it would otherwise be.

There is never any pinnule on the third brachial, as is also the case in *Antedon disciformis* (Pl. XXXIX. fig. 4) and in the ten-armed *Antedon informis* of the *Milberti*-group (Pl. XXXIII. fig. 3); and that of the second brachial is also absent in some arms. It is undeveloped on the inner arm of every pair which springs from a palmar axillary, and it is occasionally also absent on the two inner arms of the ray which are borne directly on the distichal axillaries; though it is sometimes present, as in the two central arms of the lowest ray represented in Pl. XLIV. fig. 2, while it is always to be found on the two outer arms of the ray. Of the two single arms which are borne on the inner faces of the two distichal axillaries, one may have a pinnule on the second brachial and the other not; and there appears to be no constancy as to its occurrence in this position. When present, it is somewhat smaller than its fellow on the outside of the ray. The large pinnules of the fourth and fifth brachials are tolerably equal on all the arms, that on the fourth being perhaps a little the longer; but the pinnule of the sixth brachial is much smaller again, and the next pair still more so, barely reaching 4 mm.

The disk has a large pentagonal perisome (Pl. XLIV. fig. 2), but is much incised, and the anal tube appears to be quite at its margin, so far as one can judge from the mutilated condition of the specimen. The sacculi do not appear to occur on the disk, but they are well developed on the arms, and especially so on the pinnule-ambulacra.

2. *Antedon disciformis*, n. sp. (Pl. IV. figs. 2, *a–d*; Pl. XXXIX. fig. 4).

Specific formula—A.2.$\frac{b}{b}$.

Centro-dorsal a thick pentagonal disk, with an irregular row of marginal cirri and the dorsal surface free. Fifteen to twenty cirri, of twenty-five to thirty joints, several of which are longer than wide. The fourth or fifth joints project beyond their successors on the dorsal side, and the following joints gradually develop a sharp forward-projecting spine at their distal edge; as the joints shorten this comes to be placed further and further back, and is both shorter and more upright.

First radials mostly concealed; the second oblong and quite free laterally; axillaries pentagonal, nearly twice their length. The rays are well separated and may divide twice. Two distichals; the first nearly oblong, and the axillary without a syzygy. Fifteen to twenty arms of about one hundred and twenty smooth and rounded joints, the first few discoidal and their successors triangular, about as wide as long, gradually becoming more quadrate. A syzygy in the third, and then between the eighth and fourteenth brachials; others at intervals of one to five joints.

The second brachial has a slender pinnule of about eighteen short joints, but little longer than wide; but the third brachial has no pinnule. The next pair are rather stouter and much longer than the first pinnule, reaching 12 mm., and consisting of twenty elongated joints, the apposed edges of which are somewhat produced towards the ventral side. The pinnule on the sixth brachial may be of nearly equal size or distinctly smaller, and its successors diminish in length to about the tenth brachial, and then increase, becoming exceedingly slender in the outer parts of the arms.

Disk naked and rather incised, with a few sacculi, which are very abundant along the ambulacra of the arms and pinnules.

Colour in spirit,—the skeleton almost white, and the perisome grey or brownish.

Disk about 8 mm.; spread probably 15 cm.

Locality.—Zebu Reefs. Six specimens and one fragment.

Remarks.—This species, while resembling *Antedon manca* in its spiny cirri and in the absence of a pinnule on the third brachial, differs from it altogether in having no palmar axillary, and in the constant presence of a pinnule on the second brachial. The rays being quite free laterally, it stands rather near to *Antedon marginata* (Pl. XL.), resembling it also in the elongated joints, in the great size of the pinnules on the fourth and fifth brachials, and in the absence of a palmar axillary, though sharply distinguished from it by the want of a pinnule on the third brachial and by the very spiny cirri.

The extreme flatness of the centro-dorsal and the limitation of the cirri to its margin, so as to leave the dorsal surface free (Pl. IV. fig. 2*a*), recall the characters of *Actinometra*;

but the high articular faces of the radials, which are much wider below than above (Pl. IV. figs. 2*a*, 2*b*), are those of a typical *Antedon*. The lower parts of the fossæ lodging the great ventral muscles are cut off from their upper portions as seen in fig. 2*a*; and the same peculiarity appears both on the proximal faces of the second radials and on the distal faces of the axillaries. The ventral surface of the centro-dorsal (Pl. IV. fig. 2*d*) is marked by five minute radial pits, corresponding to the ventral ends of the radial axial canals, which are seen on the under surface of the radial pentagon (Pl. IV. fig. 2*c*), just as I have described in some forms of *Antedon phalangium* and of *Antedon rosacea*.[1]

3. *Antedon clemens*, n. sp. (Pl. XXXIX. fig. 5).

Specific formula—A.2.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal hemispherical, and bearing some twenty-five cirri, which have about thirty tolerably uniform, smooth joints, the penultimate with a small spine.

First radials not visible; the second slightly united laterally and the axillaries pentagonal. One ray does not divide at all; three divide once, and one twice. The latter has two distichals, the second axillary without a syzygy. Eleven arms of smooth triangular joints, which are much wider than long and gradually become quadrate. Syzygies in the third and then in the eighth to twelfth brachials, with others at intervals of one to nine, usually four or six joints.

The first pinnule is 5 mm. long, with about twenty joints which diminish greatly in size after the first five or six. The next pair are much longer, with a smaller number of stouter joints, several of which are considerably longer than wide, and the third pair are smaller again; the more distal pinnule of each pair is smaller than the proximal one. Those of the eighth and following brachials have slight dorsal keels on their lower joints.

Disk naked and rather incised; sacculi abundant on the pinnules.

Colour in spirit,—the perisome purplish-grey, and the skeleton brownish-white.

Disk 7 mm.; spread about 15 cm.

Locality.—Station 212, January 30, 1875; Celebes Sea; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand. One specimen.

Remarks.—This is a unique specimen in every way. I have never before met with any individual which combined in such a singular manner the characters of two other genera besides that to which it naturally belongs. One of the rays does not divide at all, as in *Eudiocrinus*.

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. p. 78, pl. iv. figs. 7, 16.

It has a pinnule on the second brachial, just as in *Eudiocrinus varians* (Pl. VII. figs. 3, 4); but the next joint has none, thus affording a parallel to the condition of *Antedon informis* and *Antedon disciformis.* On the other hand, one ray does not divide at all till the fourth joint beyond the primary radial, as is often the case in *Metacrinus moseleyi* and in *Metacrinus rotundus,* though the axillary is the syzygial joint, and not the second of the series as in those types; but the second and third bear pinnules just as in *Metacrinus.*

The only other bidistichate *Antedon*, besides *Antedon clemens*, which has a pinnule on the third brachial and no palmars developed is *Antedon marginata* (Pl. XL.). It is altogether a larger species than *Antedon clemens*, however, with relatively longer and more quadrate brachials, and more numerous cirrus-joints; while the second pair of pinnules of *Antedon clemens* are relatively longer than the first and third pairs than is the case in *Antedon marginata*, and the sides of the rays are smooth, without the lateral processes which are characteristic of that type.

4. *Antedon marginata*, n. sp. (Pl. XL.).

Specific formula—A.2.$\frac{b}{b}$.

Description of an Individual.—Centro-dorsal saucer-shaped, and bearing some twenty-five cirri on its sides, each of about twenty joints, a few of which are somewhat longer than wide. The terminal joints are rather compressed laterally and have a faint keel, passing into the dorsal spine of the penultimate.

First radials just visible; the second oblong, and quite free laterally; axillaries pentagonal, about one and a half times their length. The rays are well separated and may divide twice. Two distichals, the axillary without a syzygy. Both radials and distichals are rather convex, rising sharply to the middle of their apposed edges. The outer edges of all the pieces at the sides of the rays, from the second radial to the second brachial inclusive, are marked by irregular projections towards the ventral side. Fourteen arms, of about one hundred and fifty joints, the lower ones thick disks, and their successors more triangular, but wider than long, gradually becoming quadrate and more discoidal again in the middle of the arm. A syzygy in the third, and then between the eighth and thirteenth brachials; others at intervals of three to six joints.

The second brachial bears a comparatively slender pinnule of about twenty joints, most of which are longer than wide, and the third has a similar but smaller pinnule. The next pair of pinnules are not much longer than the first one, reaching 10 mm., but they have only ten or twelve very stout and rather elongated joints, which terminate somewhat abruptly. That of the fourth brachial is the larger of the two, and the next pair are of the same character, but less stout, though not much shorter. The following pinnules become more slender and gradually increase in length.

Disk naked and moderately incised; the ambulacra have lines of sacculi at their sides, which become very prominent towards the margin of the disk, and give off branches to the first pair of pinnules. The sacculi are large and abundant along the ambulacra of both arms and pinnules.

Colour in spirit,—the skeleton reddish-white, with dark red lines at the articulations; perisome grey or purplish-grey.

Disk 15 mm.; spread 20 cm.

Locality.—Station 208, January 17, 1875; off Manila; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud. One specimen.

Remarks.—This type is readily distinguished from the only two other bidistichate species of *Antedon* in which the rays divide but twice. It differs from *Antedon disciformis* (Pl. XXXIX. fig. 4) in the presence of a pinnule on the third brachial, the shorter arm-joints, and the smaller number of cirrus-joints (Pl. XL. fig. 1); while the second pair of pinnules are relatively much stouter than in *Antedon clemens*, and the number of cirrus-joints is smaller than in that type (Pl. XXXIX. fig. 5). In the freedom of its rays and in the irregular processes at their sides it resembles *Antedon tuberculata* (Pl. XLV. fig. 2), but differs from it in having a smaller number of cirri and no palmars developed, so that there are only fourteen arms instead of thirty, while the lengths of the first pinnules are much more nearly equal than is the case in that type (Pl. XLV. fig. 3).

The second pair of pinnules of this unique specimen of *Antedon marginata* terminate so abruptly that they seem to have been broken by some accident and not completely repaired. The diameter of the joints suddenly decreases and there are from one to four quite small joints at the end of a large and stout one which is considerably longer than wide.

The disk of this specimen is remarkable for the abundance of sacculi upon it. There is a line of them along each side of the ten secondary ambulacra; and branches proceed direct from these lines to the primary pinnules as seen in Pl. XL. fig. 2, thus marking the course of their water-vessels, which, however, have no tentacular extensions. This character recalls the arrangement of the pinnule-ambulacra on the disk of *Metacrinus* as figured on pl. xxxix. fig. 2 and pl. xliii. fig. 3 of Part I. But in *Antedon marginata* the lines of sacculi and the water-vessels are unaccompanied by the other ambulacral structures, and the lower pinnules are non-tentaculiferous, as in *Antedon rosacea* and other types.

5. *Antedon tuberculata*, n. sp. (Pl. XLV. figs. 2, 3).

Specific formula—A.2.2.$\frac{c}{b}$.

Description of an Individual.—Centro-dorsal saucer-shaped, bearing about forty rather stout cirri, of twenty to twenty-five tolerably uniform joints, few of which are longer than wide; a small spine on the penultimate.

Only two radials visible; the second short and rather convex, not united laterally; axillaries more than twice their length and widely pentagonal, the junction of the two joints rather tubercular. The rays are well separated and may divide three times; the distichal and palmar series each of two joints, with a tubercular junction, and the axillary not a syzygy. The palmar axillary is usually only developed on the outer pair of every four secondary arms, giving six arms to the ray, viz., 2,1,1,2. The outer edges of all the pieces at the sides of the rays from the radial to the palmar axillaries are marked by small tubercles, which project somewhat towards the ventral side. Thirty-one arms of one hundred and twenty or more joints, the first eight or ten of which are thick disks, and the following ones shortly triangular, gradually becoming more discoidal again. A syzygy in the third brachial, and the next between the seventh and twenty-first, generally about the twelfth or fourteenth; others at intervals of five to ten, usually seven joints.

The first pair of pinnules are about 9 mm. long, and consist of some twenty-five longish joints; the next pair much stouter and very stiff and tapering, reaching 15 mm., and composed of about a dozen joints, all of which, except those at the two ends, are much longer than wide. The succeeding pair are of the same character, but rather shorter than the second pair; and the fourth pair are much smaller and less stiff.

Disk lost; sacculi abundant on the ambulacra of both arms and pinnules.

Colour in spirit,—the skeleton purplish-white, with occasional dark purple bands; the perisome greenish-grey.

Disk probably about 12 mm.; spread about 180 mm.

Locality.—Station 174[1] (B, C, or D), August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms; Coral mud; bottom temperature (at 610 fathoms), 39° F. One specimen.

Remarks.—This species, as well as *Antedon spicata* and *Antedon indica*, are distinguished by the characters of the second pair of pinnules, which are well shown in Smith's figure[2] of the last mentioned type. They are considerably longer than the first pair, though composed of a smaller number of joints. But these joints are of very large size, some of them reaching 1·5 mm. in length. They decrease gradually in diameter

[1] The exact locality, and consequently the exact depth, is not recorded.
[2] Zoology of Rodriguez, Echinodermata, *Phil. Trans.*, 1879, vol. clxviii. pl. li. fig. 3*b*.

from the base to the tip of the pinnule, so as to give it a remarkably stiff and tapering appearance (Pl. XLV. fig. 3). There is some indication of this in *Antedon marginata*, but its large pinnules are less stiff, with relatively shorter joints, which are more uniform in diameter, so that the pinnule lacks the tapering and styliform appearance which is so marked in *Antedon spicata* and *Antedon tuberculata*. Its cirri too are both smaller and have fewer joints than those of *Antedon tuberculata*, while the second radials and the axillaries are more equal in length, and portions of the first radials are visible (Pl. XL. fig. 1; Pl. XLV. fig. 2).

Antedon tuberculata has many points of resemblance with *Antedon spicata* from the Banda Sea, and it may be that a larger knowledge of both types will eventually lead to their union. The cirri of *Antedon tuberculata* are both considerably more numerous and reach a larger size than in *Antedon spicata*, though the actual number of joints composing them is the same in both forms. The second radials of *Antedon tuberculata* are short as compared with the axillaries, not reaching half their length; while in *Antedon spicata* the axillaries are short as compared with the second radials. The arms of the latter type are also longer than in *Antedon tuberculata*, and the muscle-plates more prominent at the sides of the ambulacra.

Antedon indica differs from both these types in the slighter development of marginal projections at the bases of the rays, and in the marked difference in the characters of the second and third pairs of pinnules. The latter are not so stiff as in *Antedon tuberculata*, but are considerably smaller than the second pair, consisting of a number of small joints, like the first pair.

6. *Antedon conjungens*, n. sp. (Pl. XLV. fig. 1).

Specific formula—A.2.2.2.$\frac{b}{b}$.

Centro-dorsal a thick slightly convex disk, bearing about twenty-eight cirri round its margin. They have twenty to thirty uniform joints, the later ones somewhat compressed laterally, with a sharp dorsal edge which passes into the spine of the penultimate.

First radials not visible; the second widely hexagonal, partly united laterally; axillaries pentagonal. The rays, which are free from the second radials, divide thrice and occasionally four times; each series of two joints, the axillary without a syzygy. Rather over forty arms of about one hundred and fifty joints, the first few discoidal, and their successors shortly triangular, gradually becoming quadrate, but always much wider than long. A syzygy in the third brachial, and the next between the fourteenth and twentieth, generally about the fourteenth or fifteenth; others at intervals of five to eleven, usually seven or eight, joints.

Of the four or more arms borne on each distichal axillary the two outer ones have much larger lower pinnules than the inner arms. That of the fourth brachial may reach 15 mm., with nearly thirty joints, the lowest of which are very stout, but not specially long. The corresponding pinnule of the inner arms is about two-thirds of its length, with fewer and smaller joints, and the pinnule of the next joint is of nearly equal size, while on the outer arms it is considerably smaller than its predecessor. The next pinnule is about equal to it, reaching 10 mm., with twenty joints, but on the inner arm it is markedly smaller than that on the fifth brachial. In like manner the first pinnule reaches 12 mm. on the outer arms, with nearly thirty joints, less stout than those of the second pinnule, but still of considerable size at the base, while on the inner arms it is small and slender. That of the third brachial is always quite small. The disk is very deeply incised, almost to the level of the radial axillaries. The outer sides of the distichal and palmar joints are much produced towards the ventral surface, so that each of the five divisions of the disk, as seen from the ventral side, has more or less distinct bony margins. Sacculi abundant along the pinnule-ambulacra.

Colour in spirit,—the disk is grey, and the skeleton white, more or less mottled with purplish- or reddish-grey in bands and patches.

Disk 17 mm.; spread 20 cm.

Locality.—Zebu Reefs. Two specimens.

Remarks.—This species may be readily distinguished by the characters of its lower pinnules, which have more numerous and much shorter joints than those of *Antedon tuberculata* and its allies, while they are not of equal size on all the arms. Excepting in one ray of each specimen there is no axillary beyond the palmars, and so there are normally eight arms, four on each distichal axillary. In the two outermost of these four arms, the first three pinnules are much larger than their fellows on the inner pair. This is especially the case with the second pinnule (on fourth brachial), so that while on the inner arms it is about equal to that on the next joint, it is one-half longer and considerably stouter on the outer arms.

A somewhat similar variation is presented by one of the types which have been distributed by the Godeffroy Museum under the MS. name *Antedon protecta*, Lütken. Thus in one individual, which I owe to the kindness of Professor Lovén, the first two pinnules on the outer pair of every four tertiary arms are greatly larger than the corresponding pinnules on the inner arms. The second one has twenty-five joints and reaches 12 mm., nearly three times the length of its fellow on the inner arm.

In this type, however, the third pinnule on both inner and outer arms alike has little more than a dozen joints, and is only some 4 mm. long. The small size of this third pinnule is remarkable, not only as distinguishing the type from *Antedon conjungens*, in which it is at least half the length of the second pinnule, if not more, but also in the whole group of species with large second pinnules.

Each of the two examples of *Antedon conjungens* which are described above has normally eight arms to the ray, but a palmar axillary is occasionally absent; while in the D ray of each individual post-palmars are developed, one axillary in the one, and two in the other specimen.

For the present therefore the formula of the type must be $A.2.2.2.\frac{b}{b}$, though it is quite likely that examples of it will be eventually discovered in which post-palmars are absent, so that the last figure must then be put within brackets.

7. *Antedon similis*, n. sp. (Pl. XLVII. figs. 1–3).

Specific formula—$A.2.2.\frac{bc}{b}$.

Description of an Individual.—Centro-dorsal a thick disk, bearing about forty marginal cirri. These have some twenty-five tolerably uniform joints, the later ones compressed, with a sharpened dorsal edge which passes into the penultimate spine.

The first radials are entirely concealed, and also part of the second, which are closely united laterally. Distichals are present all round the calyx, and palmars on four of the rays, the two outer secondary arms bearing palmar axillaries, so as to give six arms to the ray, viz., 2.1.1.2. Each series is of two joints, the axillary without a syzygy. The distichals and palmars of adjacent rays are closely appressed, with sharp lateral edges and flattened sides. Twenty-eight long and slender arms of about one hundred and fifty joints, the lower ones discoidal and the rest shortly triangular, gradually becoming quadrate, but always much wider than long. A syzygy in the third brachial, and the next between the sixteenth and twenty-first, with others at intervals of eight to sixteen joints.

The first pinnule is some 7 mm. long, with about twenty joints, which are but little longer than wide. The second is much stouter, consisting of nearly twenty-five rather longer joints, and reaching 14 mm. The fifth brachial has a similar but rather smaller pinnule, and that on the sixth is 6 mm. long with nearly twenty joints. The fourth pinnule is but little shorter, with a dozen joints.

Disk naked and rather incised; sacculi abundant on the pinnule-ambulacra.

Colour in spirit,—a mixture of brownish-white and greenish-grey.

Disk 12 mm.; spread 16 cm.

Locality.—Station 174[1] (B, C, or D), August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms; coral mud; bottom temperature (at 610 fathoms), 39° F. One specimen.

Remarks.—This species stands very close to *Antedon brevicuneata*, which was brought from Amboina to the Leyden Museum, and it is with some hesitation that I

[1] The exact locality, and consequently the exact depth, is not recorded.

have separated them. The large size of the centro-dorsal and the lateral flattening of the rays appear in both types. But in *Antedon similis* the greater part of the second radials is concealed (Pl. XLVII. fig. 1), which is not the case in *Antedon brevicuneata*; while the lower pinnules are smaller in the latter type, though it is individually of larger size and has palmar axillaries developed on all the secondary arms instead of on the outer arms of each ray only. The fourth pinnule of *Antedon similis* is similar to and of almost the same length as the third; whereas in *Antedon brevicuneata* it is a good deal shorter and has a smaller number of joints. It is in the proportions of these pinnules and the characters of the second radials that the chief difference between the two types presents itself.

One of the arms of this specimen bore a *Myzostoma*-cyst of a somewhat peculiar type. It was entirely independent of the arm- and pinnule-joints, but consisted of a number of relatively large granules of limestone, irregularly aggregated together on the ventral surface of the arm.

8. *Antedon occulta*, n. sp. (Pl. XLVIII. figs. 1, 2; Pl. XLIX. figs. 3, 4).

Specific formula—A.2.2.2.$\frac{bc}{b}$.

Centro-dorsal a thick disk, reaching 6 mm. in diameter, and bearing thirty-five to forty-five marginal cirri. These have twenty-five to thirty tolerably uniform joints, the later ones compressed laterally with a slight dorsal keel which passes into a faint spine on the penultimate.

The first radials are entirely concealed, together with the greater part of the second and also part of the axillaries. The rays may divide four times, and the lower joints of adjacent rays are in close lateral contact and somewhat flattened, but are not specially straight-edged. Each division is of two joints, the axillary without a syzygy and often somewhat unsymmetrical. Thirty-six to forty-eight arms, of about one hundred and seventy smooth joints, the first few quadrate and the following ones shortly triangular, gradually becoming quadrate again, but remaining much wider than long till near the end of the arm. A syzygy in the third brachial and another between the thirteenth and thirtieth; others at intervals of seven to seventeen joints.

The lower pinnules of the inner arms are generally rather smaller than those on the outer arms of each distichal group, and more especially than those on the outer arms of the rays. The first one may be 7 to 9 mm. long, with twenty to twenty-five joints, the lowest of which are rather wide. The second pinnule may have thirty joints, the first half of which are very stout, and reaches 10 or 15 mm. The third is sometimes nearly equal to it, but is more usually considerably smaller both in length and in stoutness, while its successor on the seventh brachial is always much smaller than the pinnule on the fifth.

Disk naked and more or less incised; sacculi abundant at the sides of the pinnule-ambulacra.

Colour in spirit,—the skeleton brownish-white, and the perisome the same or greenish-grey.

Disk 12 mm.; spread reaching 22 cm.

Locality.—Station 174[1] (B, C, or D), August, 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms; coral mud; bottom temperature (at 610 fathoms), 39° F. Three specimens.

Remarks.—These three individuals, which are somewhat variable in their characters, but apparently belong to the same specific type, were obtained at Station 174 together with the single example of *Antedon similis.* They all agree in the presence of one or more post-palmar series, in the great development of the centro-dorsal, so as to partly cover the axillaries, and in the absence of the sharp straight edges to the distichal and palmar joints on the outer sides of the rays, which are so marked in *Antedon similis* (Pl. XLVII. fig. 1). They are therefore pretty clearly distinguished both from this type and from its close ally *Antedon brevicuneata.* But they vary considerably in the characters of their lower pinnules. Those at the outer side of each distichal group, and more especially the outer pinnules of the rays, are generally rather longer and stouter than the corresponding pinnules on the inner arms; but I have been unable to make out any great constancy in this arrangement, and it is much more marked in one of the two specimens with the lower pinnules exposed than it is in the other. The third pinnule is generally much smaller than the second (Pl. XLVIII. fig. 2; Pl. XLIX. fig. 4), but is sometimes nearly or quite equal to it in size, a character which may occur on the inner as well as on the outer arms. In the individual which shows the greater inequality of the pinnules on the inner and outer arms (Pl. XLIX. figs. 3, 4), they are generally stiffer and more styliform than in the more regular example (Pl. XLVIII. figs. 1, 2). The latter thus presents an approach toward *Antedon conjungens,* while the former rather resembles *Antedon protecta.* These two species, however, have much less closely approximated rays and a smaller centro-dorsal, which leaves the second radials visible as well as the axillaries (Pl. XLV. fig. 1).

9. *Antedon regalis,* n. sp. (Pl. XLVI.).

Specific formula—A.2.2.$\frac{bc}{b}$.

Description of an Individual.—Centro-dorsal a thick disk, bearing about forty cirri of twenty-five to thirty joints. The middle and outer joints are somewhat compressed

[1] The exact locality, and therefore the exact depth, is not recorded.

laterally, developing a bluntly pointed keel, which passes into the dorsal spine of the penultimate.

The angles of the first radials just visible; the second short and partly united laterally; axillaries wide, more than twice their length, and almost triangular. The rays may divide three times, each division of two joints, the axillary without a syzygy. The first few joints above the radial axillary on the outer side of the ray have their outer edges curved and folded; while the lower brachials, both of the inner and of the outer arms, have their apposed sides flattened against one another. Twenty-seven long and tapering arms, of about one hundred and eighty joints, the lower ones discoidal and their successors shortly triangular, becoming more quadrate in the middle, and in the terminal third more nearly square, elongating slightly towards the end. A syzygy in the third brachial; the next between the fifteenth and eighteenth, with others at intervals of eight to eighteen joints.

The first pinnule on the outer side of the ray may reach 8 mm., with twenty-seven joints, but on the inner arms it is generally somewhat smaller. That of the third brachial is about equal to it. The second pinnule is also rather larger on the outer than on the inner arms, reaching 15 mm., with about thirty joints, of which the first third are moderately stout, and the remainder more slender and somewhat elongated. The pinnules of the next three brachials (fifth to seventh) are of nearly equal size, but the fourth pair are only about half their length, with fifteen joints, and the next pair are still smaller.

Disk naked and much incised; sacculi abundant at the sides of the pinnule-ambulacra.

Colour in spirit,—dark purple, with greenish-white spots on the disk.

Disk 20 mm.; spread about 30 cm.

Locality.—Tongatabu reefs. One specimen.

Remarks.—This fine specimen is not unlike *Antedon articulata*, Müller, but has a smaller number of cirrus-joints, with less well defined spines than occur in that species. In fact the spines are hardly anything more than a small pointed process in the middle of the sharp dorsal keel. The fourth pinnule is relatively smaller and the second syzygy nearer the disk than in the type of *Antedon articulata*; and there are less than thirty arms, instead of nearly forty, or even more, as palmar axillaries are not always developed, and there are no post-palmars at all.

Antedon, Series IV.

Three distichals, the first two articulated, and the third axillary with a syzygy.

Remarks.—The tridistichate species of *Antedon* are less numerous than those in which only two distichals are present, but the two series have many points of resemblance, both in their distribution and in their modifications of structure.

We have seen that, alike in the ten-armed and in the bidistichate series, two very distinct morphological types are to be found, the one with the rays flattened laterally and a complete ambulacral skeleton, and the other without these characters. The first of these, represented by the *Basicurva*- and *Spinifera*-groups, is restricted almost entirely to the continental and abyssal regions, and is especially characteristic of the Pacific Ocean and Eastern Archipelago. One abnormal form occurs in the littoral fauna of the Southern Australian Seas; a few typical but isolated species have been found at considerable depths in the Atlantic and Southern Sea; while three more range from 80 to 270 fathoms in the Caribbean Sea. Among the tridistichate species of *Antedon* there are seven which have wall-sided rays and an ambulacral skeleton. Two of them occur in the Philippine Archipelago; a third was obtained at two (or perhaps three) stations in the South Pacific; the Challenger dredged two more at a station near Ascension (Station 344), one of which was also found off Tristan da Cunha (Station 135G); and yet two more appear in several of the "Blake" dredgings in the Caribbean Sea at depths of 80 to 270 fathoms. These seven forms may be spoken of collectively as the *Granulifera*-group, after the name of a Caribbean species which was described by Pourtalès in 1878; and they have essentially the same distribution, both bathymetrical and geographical, as the *Basicurva*- and *Spinifera*-groups, which are also distinguished by wall-sided rays and an ambulacral skeleton.

On the other hand, the tridistichate species of *Antedon*, which have unprotected ambulacra and no flattening of the lower ray-joints (*Savignyi*-group), belong for the most part to the littoral fauna of Northern Australia and the great Eastern Archipelago, ranging northwards to Hong Kong and Japan. Individual species occur here and there on the western shores of the Indian Ocean; but I am not aware that there is any tridistichate *Antedon* in the Atlantic or in the Caribbean Sea which has simple rays and unprotected ambulacra.

8. The *Granulifera*-group.

Tridistichate species with plated ambulacra and the lower parts of the rays flattened laterally.

Remarks.—Four of the five members of the *Granulifera*-group which are considered in this Report are constructed upon the same type as *Antedon granulifera* itself.

Neither the lateral flattening of the rays, nor the plated disk and ambulacral skeleton of this species, seem to have attracted the attention of Count Pourtalès when he examined it, though they have since turned out to be characters of primary systematic value. He described the type[1] as having "three brachials between primary and

[1] *Bull. Mus. Comp. Zoöl.*, 1878, vol. v. No. 9, p. 215.

secondary axials, one between secondary and tertiary." This would now be stated as "three distichals, the axillary a syzygy, and two palmars united by syzygy"; but in neither case is the syzygy at all easy to recognise, and his omission to notice it is therefore not surprising. He found, however, that "sometimes there are syzygia in the first and second joints of the arms." This, interpreted by the light of later morphological work, would mean that the first two brachials are united by syzygy,[1] and that the third may also be a syzygial joint. *Antedon granulifera* thus presents a type of structure which we have not yet studied. There is no syzygy between the two outer radials or between the first two distichals, and yet the first two joints above the distichal axillary are united by syzygy, instead of by the usual bifascial articulation; while the normal syzygial union in the third brachial may or may not persist. If a palmar series is present it consists of two joints united by syzygy, just as the first two brachials are; and the formula of the type thus becomes $A.3.\frac{(p.)br}{2}$. This also holds good for *Antedon distincta* of the Challenger collection, as seen in Pl. LI. fig. 1. The unique specimen of this fine species has its full complement of ten distichal series, which are all normal in character, and it has already been noticed on p. 55 as illustrating an exceptional type of arm-structure. But in *Antedon granulifera* some of the distichal series are usually absent, so that the arms spring directly from the radial axillaries. This is frequently also the case in *Antedon angusticalyx* and *Antedon inæqualis*, which are constructed on the same type as *Antedon distincta* and *Antedon granulifera*, except that there is normally no axillary above the distichal (Pl. L. fig. 1; Pl. LI. fig. 2). But in all three species alike the first syzygy of an arm which starts directly from the radial axillary is in the third brachial, the two preceding joints being united bifascially. We thus meet with a reversion from the abnormal grouping of the syzygies, which is most fully developed in *Antedon distincta* (Pl. LI. fig. 1), to that of the simple ten-armed type with the first syzygy in the third brachial.

Antedon multispina affords another excellent instance of the same kind. Four individuals of this type were obtained by the Challenger, three of them having only ten arms. But in the fourth (Pl. LXIX. figs. 1, 2) there are two tridistichate series, and in each of the four arms which are thus produced the first two brachials are united by syzygy. This is not the case, however, in the tridistichate varieties of *Antedon rosacea*, *Antedon variipinna*, and *Antedon anceps* (Pl. XXXV. fig. 1), which retain the third brachial as a syzygial joint above the intercalated distichal axillary, and thus remain normal in character.

The syzygial union of the two lowest brachials above the distichal axillaries of *Antedon multispina* thus gives an important clue to its affinities, which is of the greater

[1] My reasons for considering this union as a syzygy *between* the first two brachials, and not as a syzygy *in* the first brachial, will be found in Part I. pp. 51, 52.

value, as there is no tridistichate *Antedon* of the normal type with a syzygy in the third brachial which has flattened rays and protected ambulacra.

A still more striking instance of reversion to the more generalised condition is sometimes met with both in *Antedon angusticalyx* and in *Antedon inæqualis.* The tridistichate series may be replaced by a bidistichate one; but this apparently unimportant variation is always accompanied by a change in the grouping of the syzygies above the distichal axillary. Except in one or two abnormal species like *Actinometra pulchella*, the first two brachials are never united by syzygy when they follow two articulated distichals; and so when a bidistichate series occurs as a variation in *Antedon angusticalyx* or *Antedon inæqualis* the first two brachials are articulated, and there is a syzygy in the third. This is well seen in the two lateral rays of the figured specimen of *Antedon angusticalyx*[1] (Pl. L. fig. 1).

There is one species of the *Granulifera*-group which presents a different type of arm-structure from the rest. *Antedon porrecta* is also tridistichate, but the second joint above the distichal axillary is a syzygial one (Pl. LII. fig. 3). There are often no palmars; but when they do occur the series consists of two joints, the axillary a syzygy, so that the formula of the type becomes $A.3.2\{(p.)br\}$. This is the only species of *Antedon* with a syzygy in the second brachial, though the character is a common one in *Actinometra*, as seen in Pl. LX.; Pl. LXII. fig. 3; and Pl. LXVI. figs. 1, 4.

The species of the *Granulifera*-group may be classified as follows:—

A. A syzygy between the first two brachials.
- I. Calyx and arm-bases not spinous. The first two pinnules about equal, with compressed and carinate joints; the genital pinnules have unequally expanded joints.
  - *a.* Primary arms of adjacent rays in close lateral contact. Palmars usually absent; the second syzygy generally not beyond the fifteenth brachial.
    - 1. Cirri smooth and without an opposing spine. First radials invisible; the second very short and deeply incised. The lower joints of the distichal pinnule not specially wide, . . . 1. *angusticalyx*, n. sp.
    - 2. Cirri somewhat carinate, with an opposing spine. First radials partly visible. The lowest joint of the distichal pinnule much wider than the rest, ... 2. *inæqualis*, n. sp.
  - *b.* The distichal axillaries of adjacent rays partially separated by the pinnule of the preceding joint. Palmars usually present; the second syzygy from the twentieth to the twenty-fifth brachial.
    - 1. The lower pinnules rather stout, ... *granulifera*, Pourtalès.
    - 2. The lower pinnules comparatively slender, . . 3. *distincta*, n. sp.
- II. Calyx and arm-bases spinous. The first pinnule much longer than the second, with stout joints, the lowest of which have their inner edges cut away. The genital pinnules have uniformly expanded joints, . 4. *multispina*,[2] n. sp.

B. A syzygy in the second brachial, ... 5. *porrecta*, n. sp.

[1] The fourth brachial is the syzygial joint in one arm of the right-hand ray.
[2] Some forms of this species have only ten arms; see p. 117.

1. *Antedon angusticalyx*, n. sp. (Pl. II. figs. 4, *a–d*; Pl. L. figs. 1, 2 woodcut on p. 246, fig. 5, B: also Part I. pl. liv. fig. 5; pl. lv. fig. 6).

Specific formula—A.3.$\frac{br}{2}$.$\frac{b}{b}$.

Centro-dorsal a truncated hemisphere, marked by indistinct interradial ridges which are produced upwards into rather prominent processes between the radials. Twenty to twenty-five cirri, of eighteen to twenty-three smooth joints, most of which are slightly longer than wide; the penultimate without an opposing spine.

First radials entirely concealed; the second quite short, especially in the middle line, barely in contact above the angles of the centro-dorsal. They are deeply incised by the tubercular backward processes of the axillaries, which sometimes almost reach the centro-dorsal. Three distichals, the junction of the first two somewhat tubercular, and the axillary a syzygy, in close contact with its fellow on the next ray. The outer radials and the three distichal joints have sharp straight edges, and both sides flattened, and the first two or three brachials may show the same characters, but to a less extent.

Fourteen to twenty arms, of over one hundred joints, of which the lowest are nearly oblong, their successors triangular, and wider than long, gradually becoming longer and more quadrate.

The first syzygy is in the third brachial when the primary arms do not divide, and the next between the eleventh and fifteenth. When distichals are present the first two brachials are usually united by syzygy, and the next syzygial joint is from the seventh to the twenty-fifth brachial, usually about the twelfth or fourteenth. After this an interval of four to twelve, generally six or seven joints, between successive syzygia.

The distichal pinnule is about 9 mm. long, and consists of some thirty short, carinate joints, the lowest of which, though thick, are not specially wide. The next two or three pinnules are of about the same length, with relatively longer terminal joints, and the lower ones somewhat flatter. The following pinnules are a little shorter, with the first two joints smaller than in the proximal pinnules; but the third joint and from two to four of its successors are broad and flattened, with the outer edges much produced towards the ventral side. Traces of this expansion may be visible as far as the twenty-fifth brachial, after which the joints become elongated and the pinnules more slender.

The disk is much incised and completely plated, as are also the brachial ambulacra and the interarticular spaces. The genital glands are covered by closely set plates in which sacculi are embedded. These are small and inconspicuous on the pinnule-ambulacra, which have well-defined side plates.

Colour in spirit,—light whitish-brown.

Disk 7 mm.; spread 15 cm.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. Several specimens, some with cysts of *Myzostoma tenuispinum*.

Remarks.—This species is readily distinguished from all the other tridistichate forms of *Antedon*, with the exception of *Antedon inæqualis* (Pl. LI. fig. 2), with which it has many characters in common. It does not reach the size of that species, however, and differs in various respects from its younger stages, as will be explained further on.

The cirri have rather elongated joints, which are unusually smooth, hardly any trace of an opposing spine appearing on the penultimate. The centro-dorsal is much flattened at the dorsal pole and has more or less distinct indications of interradial ridges on its sides, which are produced upwards into rather prominent processes at the angles (Pl. II. fig. 4*a*). It is considerably wider than the radial pentagon (Pl. II. fig. 4*d*), so that the first radials are entirely concealed by it, with portions of the second as well. Both edges of these latter joints are thus strongly curved in the adult calyx, the proximal edges occupying the hollows between the interradial processes of the centro-dorsal, while the distal edges are incised to receive the strong backward processes of the axillaries (Pl. L. fig. 1). The first two distichals, or in their absence the first two brachials, have a similarly tubercular junction.

Antedon angusticalyx is a species of considerable interest from its presenting several of the characters which are distinctive of three species of *Antedon* that were found associated in the South Pacific, near the Kermadec and the Fiji Islands respectively (Stations 170A and 174). Two of these, with only ten arms (*Antedon basicurva* and *Antedon incisa*), are characterised by having less than thirty smooth cirrus-joints, and some of the lower joints of the genital pinnules expanded on the outer side so as to form a protection for the genital glands, which are also covered by a strong anambulacral plating (Pl. XXI. figs. 2*a*, 2*b*). *Antedon inæqualis* (Pl. LI. fig. 2), which also occurred at both Stations (Nos. 170A, 174), is a tridistichate species possessing these same peculiarities; while *Antedon angusticalyx*, which closely resembles it in the characters of the arm-divisions and genital pinnules (Pl. L. figs. 1, 2), represents the tridistichate type in the North Pacific. But the sides of its rays are less distinctly flattened than in the three species from the South Pacific; while those of the ten-armed species (*Antedon acœla*), which is associated with it, have no flattening at all (Pl. XVI. fig. 1), though the cirri and genital pinnules have much resemblance to the corresponding parts of *Antedon basicurva* and *Antedon incisa*.

Some of the characters of *Antedon angusticalyx* and *Antedon inæqualis* appear in *Antedon granulifera* of the Caribbean Sea. But this type usually has two post-radial axillaries, *i.e.*, distichals and palmars, and the rays are less closely in contact than is the case in the Pacific species.

2. *Antedon inæqualis*, n. sp. (Pl. II. figs. 5, *a–d*; Pl. LI. fig. 2; woodcut, p. 246, fig. 5, A; also Part I. pl. liv. fig. 8).

Specific formula—$A.3.\frac{(p.)br}{2}.\frac{b}{b}$.

Centro-dorsal hemispherical, rather flattened at the dorsal pole, and bearing twenty to twenty-five cirri. These have about twenty joints, a few of which are longer than wide; the later ones are somewhat compressed laterally and more or less distinctly carinate; the penultimate with an opposing spine.

First radials partially visible above the angles of the centro-dorsal; the second short, sharply convex, and closely united laterally. Axillaries short, broadly pentagonal, and very convex in the centre, forming a median tubercle with the second radials.

Three distichals with a syzygy in the axillary, which is in close contact with its fellow on the next ray, and another syzygy between the first two brachials. These five joints, and in a less degree also the two outer radials and the third brachials, are in close lateral contact and very distinctly wall-sided, with sharp edges and the margins of the dorsal surface a little depressed. The second, and occasionally also the third, brachial may likewise be slightly flattened on both outer and inner sides. One specimen has two palmars united by syzygy, and another two with the axillary a syzygy.

Eleven to twenty arms of some one hundred and twenty joints, the lowest nearly oblong, and the following ones triangular, as long as wide, and gradually becoming more quadrate. The pieces of the calyx and the lower parts of the arms often have somewhat prominent edges. On the arms, which start directly from the radial axillary, the third brachial is a syzygial joint, and the next syzygy is between the fourth and the thirteenth brachials; but when distichals are present the first two brachials are generally united by syzygy, and the next syzygial joint is from the seventh to the tenth brachial. After this there is an interval of two to fifteen, usually four to seven, joints between successive syzygia.

The second distichal bears a small pinnule, 7 mm. long, which consists of some twenty to twenty-five short joints, the lowest of which, and especially the first, are wide, trihedral, and flattened against the arm, while the remainder are slightly carinate. The next pinnule (on second brachial) is a trifle longer, with relatively long terminal joints, and the basal ones less wide and more carinate. The third and following brachials have still longer and stouter pinnules (12 mm.), with the outer edges of the third and the two to four following joints much produced towards the ventral side, so as to give them a broad and flattened appearance. The length of the pinnules decreases somewhat after the sixth brachial, but the expansion of their lower joints is traceable till the fifteenth or twentieth, after which they become more slender, with only the two lower joints wider than long. Disk much incised and completely plated, as are also the arms, both along the ambulacra and at their sides. A pavement of anambulacral plates covers the genital glands. The pinnule-ambulacra have well-defined side plates, alternating with and partly concealing the sacculi, which are mostly small.

Colour in spirit,—light whitish-brown.

Disk 10 mm.; spread 20 cm.

Localities.—Station 170A, July 14, 1874, near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W., 630 fathoms; volcanic mud; bottom temperature, 39°·5 F. Twelve specimens; two of them with cysts of *Myzostoma tenuispinum* and *Myzostoma willemoesii.*

Station 174 (B, C, or D), August 3, 1874, near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms;[1] coral mud; bottom temperature (at 610 fathoms), 39° F. Five specimens, one with *Myzostoma*-cysts, and some free individuals.

Doubtful.—Station 175, August 12, 1874, near Kandavu, Fiji; lat. 19° 2′ S., long. 177° 10′ E.; 1350 fathoms; Globigerina ooze; bottom temperature, 36° F. One broken specimen.

Remarks.—This species is rather closely allied to *Antedon angusticalyx*, but reaches a considerably larger size. The cirri are often slightly carinate, with a tolerably distinct opposing spine on the penultimate.[2] The radial pentagon is relatively larger than in *Antedon angusticalyx*, so that it completely covers the centro-dorsal (Pl. II. figs. 4*a*, 4*d*, 5*a*, 5*d*), and the whole of the second radials, together with more or less continuous portions of the first, are thus visible on the exterior of the calyx. The axillaries are relatively short, and have no such large tubercular projections into the second radials as are visible in *Antedon angusticalyx* (Pl. L. fig. 1; Pl. LI. fig. 2).

The difference between the calyces of the two types, which are so closely similar in other respects, comes out very clearly if a young individual of the larger *Antedon inæqualis* be compared with a mature *Antedon angusticalyx* of equal size. The first radials of the former are completely visible, forming a narrow but continuous band between the centro-dorsal and the second radials, which plates are not incised by the short axillaries; whereas in *Antedon angusticalyx* the first radials are entirely concealed, and the second are rather deeply incised by the tubercular backward projections of the axillaries.

The characters of the distichal pinnules afford another good distinction between the two types. Those of *Antedon angusticalyx* have somewhat carinate joints, the lowest of which are rather wider than the rest, though not markedly so (fig. 5, B), but in *Antedon inæqualis* the lower joints are generally more rounded and less carinate, while the first,

[1] The exact station, and consequently the exact depth, are not recorded.

[2] The two cirri which remain on the figured specimen are rather more smooth than is usually the case.

or sometimes the first and second, is considerably wider than its successor (fig. 5, A). It is produced towards the ventral side, so that it has a large flattened lateral surface corresponding to those of the first and second distichals, which are both relatively and absolutely larger than the same parts in *Antedon angusticalyx* (fig. 5, B), and are also divided by a groove into two portions at different levels, which is not the case in the latter species.

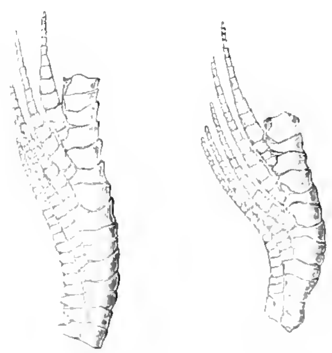

Fig. 5.—The lowest pinnules of *Antedon inæqualis* (A) and of *Antedon angusticalyx* (B). × 3.

The number of arms which may be present in *Antedon inæqualis* varies very considerably, just as in *Antedon angusticalyx*. Several individuals have twenty, but fourteen to sixteen is a not uncommon number, and two specimens have only eleven; so that it is quite possible that this may really be a dimorphic species, and that it should find a place with the ten-armed series near to *Antedon basicurva*, as well as in the tridistichate group. Palmar series occur in two specimens. In one there are two palmars united by syzygy, just as is naturally the case in *Antedon distincta* (Pl. LI. fig. 1), while the other presents the type of *Antedon porrecta*, viz., two palmars, the axillary a syzygy (Pl. LI. fig. 2; Pl. LII. fig. 3). This, however, is an abnormal variation owing to the intercalation of a joint above the distichal axillary; because the first two brachials are united by syzygy in the ordinary way, instead of being articulated with a syzygy in the second one as in *Actinometra sentosa* and *Actinometra multiradiata* (Pl. LXVI. figs. 1, 4).

One example of *Antedon inæqualis* and some fragments of *Pentacrinus naresianus* were sent me with the label of Station 175; but there is no record in the Station Book of their having been dredged at this Station (1350 fathoms), though there are two Comatulæ mentioned which reached me with the corresponding label. These are the ten-armed *Antedon breviradia* and *Antedon acutiradia* (Pl. XI. figs. 3, 5), which have the general facies of abyssal forms; and as no other *Antedon* with more than ten arms has been obtained from a greater depth than 750 fathoms, I much doubt whether *Antedon inæqualis* really was obtained from 1350 fathoms at Station 175.

Both Stations 170A and 174 yielded examples of *Antedon inæqualis* with the cysts of *Myzostoma tenuispinum*, which also occurred on the allied species *Antedon angusticalyx* at Station 214. One individual from Station 170A, with four cysts of this *Myzostoma*, had another of *Myzostoma willemoesii*; while at Station 174 an individual was found with cysts of *Myzostoma tenuispinum*, and also a combined cyst of this species and *Myzostoma willemoesii*, which type likewise occurred at Station 170A on *Antedon basicurva*.

3. *Antedon distincta*, n. sp. (Pl. LI. fig. 1).

Specific formula—$A.3.\frac{p.br}{2}.\frac{b}{a}$.

Description of an Individual.—Centro-dorsal a thick disk, with the angles somewhat produced and some twenty-five cirri on its sides. These have about twenty rather stout joints, of which the sixth and seventh are the longest. The following joints are shorter and gradually develop a dorsal keel.

The first radials not visible; the second are short and much curved, and the axillaries subtriangular, both joints being very convex, with a rather sharp dorsal edge. Three distichals, the first two very convex at the junction and the axillary a syzygy. The first two brachials, or the two palmars when present, united by syzygy. The outer radials and the first two distichals are in close lateral contact, with sharp edges and flattened sides; and in the middle line of the ray this character is continued on to the distichal axillaries and the next four or five joints. But the outer sides of the distichal axillaries are prevented from meeting those of adjacent rays by the pinnules of the second distichal joints, which are placed very near the dorsal surface.

Twenty-seven arms, the first twelve joints nearly oblong and the following ones more triangular, gradually becoming longer than wide. A syzygy between the first two brachials, and the next about the twenty-fifth; others at intervals of five to fourteen, usually seven to ten, joints.

The distichal pinnule is about 8 mm. long and rather slender, composed of some thirty small, compressed, and slightly carinate joints. The following pinnules are similar, slightly decreasing in size to about the sixth brachial, after which the next eight or ten pinnules on each side have the lower joints carinate and expanded on the outer side, with the upper ones more styliform. This character gradually dies out, and the pinnules become more elongated and slender.

Disk and brachial ambulacra well plated. The pinnule-ambulacra have well-defined side plates which alternate with the sacculi.

Colour in spirit,—light whitish-brown, with patches of brownish-grey.

Spread 20 cm.

Locality.—Station 210, January 25, 1875; off the Panglao and Siquijor Islands; lat. 9° 26′ N., long. 123° 45′ E.; 375 fathoms; blue mud; bottom temperature, 54°·1 F. One specimen.

Remarks.—Only a single example of this elegant species was obtained by the Challenger; and it seemed so different from all the other species of *Antedon* then known that I proposed to call it *Antedon distincta*. Several months afterwards I received Pourtalès' description[1] of some new Comatulæ dredged by the first "Blake" expedition,

[1] *Bull. Mus. Comp. Zoöl.*, 1878, vol. v. No. 9, p. 215.

amongst which was *Antedon granulifera* with "three brachials between primary and secondary axials, two between secondary and tertiary." The first part of this statement clearly indicates that the type has three distichals, of which the axillary is a syzygial or double joint. But it was impossible to tell from Pourtalès' description whether the two palmars are articulated or united by syzygy, though the latter condition seemed probable from his further note that "sometimes there are syzygia in the first and second joints of the arms." When the "Blake" collection came into my hands I found not only that *Antedon granulifera* has the same grouping of the arms as *Antedon distincta*, but also that it has an ambulacral skeleton and the rays flattened laterally, two characters of which no hint was given in Pourtalès' description. In fact, these two species, though so widely separated geographically, are in reality very closely allied, the chief point of difference between them being the greater size of the lower pinnules in *Antedon granulifera*.

Antedon distincta differs from *Antedon angusticalyx* and *Antedon inæqualis* in the long interval between the first and second syzygies of the arms, and also in the separation of the distichal axillaries of adjacent rays by the pinnules on the preceding joints, which are attached nearer to the dorsal surface than usual. This is less marked in *Antedon granulifera*, though it agrees with *Antedon distincta* in the long syzygial interval. On the other hand, the joints of the genital pinnules of *Antedon distincta* are more uniformly expanded than in *Antedon granulifera*, which rather resembles *Antedon angusticalyx* and *Antedon inæqualis* in this respect. But in all four species alike the outer side of each pinnule-joint is more expanded than the inner one, just as in *Antedon basicurva* and *Antedon incisa* (Pl. XXI. fig. 2), while in the tridistichate variety of *Antedon multispina* the large joints of the pinnules are broadly V-shaped and similarly expanded on both sides.

Antedon granulifera seems to be fairly abundant in the Caribbean Sea; but it exhibits a good deal of variation in its characters, which will be fully discussed in the report on the "Blake" Comatulæ.

4. *Antedon multispina*, n. sp. (Pl. XIII. figs. 1–3; Pl. XIV. figs. 5–7; Pl. L. figs. 3–6; Pl. LXIX. figs. 1–4).

Specific formula—$A.\left(\frac{3.br}{2}\right).\frac{b}{b}$.

Localities.—Station 135G, October 18, 1873; off Tristan da Cunha; lat. 37° 10′ 50″ S., long. 12° 18′ 30″ W.; 550 fathoms; hard ground. One mutilated specimen.

Station 344, April 3, 1876; near Ascension; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W.; 420 fathoms; volcanic sand. Four broken individuals and three Pentacrinoids.

Remarks.—Three individuals of this species, and also three larvæ, all with ten arms, were obtained at Station 344, near Ascension, and have been already described.[1] But another individual from the same station must be noticed here from its having two tridistichate series. It resembles *Antedon angusticalyx* and *Antedon inæqualis* in the syzygial union of the two lowest brachials, but it differs both from them and from the other tridistichate species in its spiny calyx and in the characters of the pinnules. The first pinnule (Pl. LXIX. figs. 2, 3) consists of rather massive joints with their inner edges cut away a little and the outer sides slightly flattened, presenting, in fact, the same characters, though in a less prominent form, as the first pinnules of *Antedon valida*, *Antedon incerta*, and their allies among the ten-armed species of the *Basicurva*-group (Pl. XV. figs. 5, 6; Pl. XVIII. fig. 5). The first pinnule of *Antedon multispina* is much larger than its successor, a character which distinguishes the type both from the species just mentioned and from the other members of the *Granulifera*-group, from which it also differs in the uniformly expanded shape of the large joints of the genital pinnules.

Station 135c, off Tristan da Cunha, yielded a single mutilated *Antedon* (Pl. L. figs. 3–6), which after some consideration I have decided to refer to this species, though I was at first inclined to place it elsewhere. The cirri are generally similar to those of the more northern form (Pl. XIII. fig. 1; Pl. L. fig. 6), but may have as many as thirty-five joints, while the number does not exceed thirty in the smaller and premature individuals from near Ascension. The latter do not show the first radials externally (Pl. LXIX. figs. 1, 2), but they are visible in the larger calyx of the southern variety (Pl. L. fig. 3), which is also less distinctly spinous than that of the northern individual, and the same is true of the arm- and pinnule-joints.

The first pinnules of the southern form have somewhat the same flattened appearance on their outer sides as is traceable in that from Ascension (Pl. LXIX. figs. 2, 3), and is more marked in the typical members of the *Basicurva*-group (Pl. XV. figs. 5, 6; Pl. XVIII. fig. 5). But it is so slight as to be hardly recognisable except by a trained eye, and the same may be said of the lateral flattening of the lower brachials. In fact this variety of *Antedon multispina* is a good connecting link between the *Basicurva*- and *Granulifera*-groups on the one hand, and the ordinary Comatulæ with normal rays and unplated ambulacra on the other, for the plating of the disk is very incomplete (Pl. L. fig. 4) and the ambulacral skeleton of the pinnules by no means well differentiated.

There are thirteen arms in this individual, owing to the presence of three distichal series. One of these is only two-jointed, and the first syzygy above it is in the third brachial (Pl. L. fig. 3), just as in the case of *Antedon angusticalyx* already referred to on p. 241 (Pl. L. fig. 1). But of the two arms which follow each tridistichate series one has the normal syzygy (for this type) between the first two brachials, while in the other

[1] See pp. 117–119.

these two joints are articulated and the first syzygy is in the third brachial; so that we here get an approach to the characters of the *Savignyi*-group, next to be described, while the bidistichate series indicates a similar variation towards the *Palmata*-group. In this single individual, therefore, we meet with the characters of one ten-armed and three multibrachiate types of Comatulæ, and its true affinities would have been a matter of some doubt, but for the presence of more normal individuals of the same type at another station.

Three Pentacrinoid larvæ were also obtained off Tristan da Cunha, but at a considerably greater depth (1000 fathoms) than the mature *Antedon* (Station 135E, October 18, 1873; lat. 37° 21′ 0″ S., long. 12° 22′ 30″ W.; 1000 fathoms; hard ground, shells, gravel). The best preserved of them is represented on Pl. XIV. fig. 8. It appears to belong to a ten-armed species, as is naturally to be expected at such a great depth; and it has many points of resemblance with the "cold area" larva which I have referred conjecturally to *Antedon hystrix* (Pl. XIV. fig. 2). The basals are high and the first radials very wide, while the two following joints are relatively long and narrow; though a considerable number of brachials are developed above them. These show no traces of an ambulacral skeleton, however, as is the case in the youngest larva of *Antedon multispina* (Pl. XIV. fig. 5), which has only about the same number of arm-joints, though the calyx is relatively much more developed than that of the abyssal larva.

5. *Antedon porrecta*, n. sp. (Pl. LII. figs. 3–5).

Specific formula—$A.3.2\{(p.)br\}.\frac{b}{c}$.

Centro-dorsal a thick disk with the interradial angles slightly produced, and from twenty to thirty long and stout cirri on its sides. They have from forty to fifty joints, nearly all of which are wider than long, and produced on the dorsal side into a strong pointed process. The first radials are invisible except at the angles of the calyx; the second and third both rather convex and slightly tubercular at the junction, the second short, united laterally, and the axillaries broadly pentagonal, about two and a half times their length. Three distichals and sometimes two palmars, each axillary with a syzygy. These joints are very convex and have their inner sides flattened against one another; but this is less marked at the outside of the rays where the hypozygals of the distichal axillaries and of the second palmars (or brachials) are kept apart by the large pinnules on the preceding joints.

Over twenty arms, of compressed triangular joints, which become elongated and quadrate towards the end. From the third brachial onwards the middle of the distal edge of each joint is raised into a strong plate, the front face of which is hollowed. Beyond about the tenth or fifteenth joint this gives place to an overlap of the usual character, which extends far out on the arm.

A syzygy in the second brachial, and the next between the sixth and fourteenth; others at intervals of three to twelve joints, the intervals often becoming shorter towards the end of the arm.

The second distichal and the first palmar (or brachial) bear tolerably equal pinnules of about fifteen stout joints, the five lowest of which are rather broad and trihedral, with flattened outer faces and the inner sides slightly bevelled away. The second and third brachials have smaller pinnules with fewer joints, the basal ones being more compressed; and the following pinnules are larger again, with broader lower joints, the outer edges of which are expanded towards the ventral side. This arrangement gradually dies away in the outer parts of the arms, and the joints become more elongated.

Disk slightly incised and well plated, like the brachial ambulacra; the pinnule-ambulacra have well-defined side plates and small sacculi.

Colour in spirit,—dark grey-brown.

Disk 15 mm.; spread probably 30 cm.

Locality.—Station 344, April 3, 1876; near Ascension; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W.; 420 fathoms; volcanic sand. Four broken specimens.

Remarks.—This species cannot well be mistaken for any other, as it is the only tridistichate *Antedon* with a syzygy in the second brachial (Pl. LII. fig. 3); though the type is common enough in the genus *Actinometra* (Pl. LX.; Pl. LXII. fig. 3). The four specimens obtained were all much mutilated, the arms having broken away at the syzygy in the second joint above the distichal axillary. In some cases this was the hypozygal of the palmar axillary, but as only a few arms are preserved it is impossible to determine their number, or whether palmar axillaries occurred in all the specimens. Under these circumstances therefore I have thought it best to enclose the palmar sign within brackets in the specific formula.

The length of the cirri and the strong dorsal processes on their numerous joints are also good distinctive characters of the type. One cirrus, as shown in the figure (Pl. LII. fig. 3), has been fractured and subsequently regenerated, a somewhat rare occurrence, as I have already remarked on p. 203. The characters of the pinnules of *Antedon porrecta* are the same as those of *Antedon basicurva* and its allies, though in a less marked degree. The lower joints of the genital pinnules are expanded towards the ventral side so as to protect the genital glands, which have but a slight covering of anambulacral plates, while the first two pinnules have massive lower joints with the outer sides flattened just as in *Antedon valida* and *Antedon incerta* (Pl. XV. figs. 5, 6; Pl. XVIII. fig. 5).

Apart from its general specific characters *Antedon porrecta* is remarkable as being one of the few Atlantic species of the genus which have an ambulacral skeleton. It was obtained in the neighbourhood of Ascension, together with the dimorphic *Antedon multispina*, which also occurs near Tristan da Cunha, and they thus serve as a connecting link between *Antedon lusitanica* and the Caribbean species (*Antedon granulifera*, *Antedon spinifera*, &c.) of the North Atlantic, and *Antedon bispinosa* of the Southern Ocean.

9. The *Savignyi*-group.

Bidistichate species with an unplated disk and no definite ambulacral skeleton; the bases of the rays are not flattened laterally.

Remarks.—I have associated this group with the name of Savigny, as its earliest described representative was brought by him from the Red Sea and named after him by Müller; while it is one of those which appear both with and without palmar series, and it therefore has a wide range of alliances. It also occurs at Muscat and at Kurrachee, but is not known to extend further eastwards.

Antedon reynaudi has been described from Ceylon, and I have seen some undescribed species from Zanzibar in the continental museums. But all the remaining types of the group belong to the littoral fauna of the eastern seas from Japan to Sydney, with the exception of *Antedon angustiradia*, which was found by the Challenger at 140 fathoms in the Arafura Sea (Station 192).

Some forms of this group have no palmars above the distichals; while in others there are palmar series, consisting sometimes of two and sometimes of three joints. I have not thought it necessary, however, to separate these latter species as a distinct group. They all belong to the same general tridistichate type, and may be classified as follows:—

A. Three distichals, not succeeded by palmars.
- I. The centro-dorsal bears ten vertical rows of cirri with sixty or seventy joints. The distichal pinnule longer than its successors, . . 1. *angustiradia*, n. sp.
- II. Not more than forty-five joints in the cirri, which are without definite arrangement. The distal pinnule generally smaller than its successors.
  - *a*. The joints of the lower pinnules without lateral processes.
    - 1. Forty to forty-five cirrus-joints, which are mostly spiny; usual syzygial interval seven to ten joints, . . *reynaudi*, Müll., sp.
    - 2. Twenty-five to thirty-five cirrus-joints; usual syzygial interval three to seven joints.
      - α. Twenty-five to thirty cirri with strong spines on the later joints; second syzygy about the eighteenth brachial. Distichals always present and sometimes palmars, . . . *savignyi*, Müll., sp.
      - β. Twenty cirri, the later joints not spinous; second syzygy not beyond the fourteenth brachial. Distichals sometimes absent, . . . 2. *anceps*,[1] n. sp.
  - *b*. The joints of the lower pinnules have lateral processes at their ends, ... 3. *variipinna*,[1] Carpenter.

[1] These species may have only ten arms: see p. 194.

B. Palmar series developed above the distichals.

I. Two palmars, the axillary not a syzygy.

a. The joints of the lower pinnules have lateral processes at their ends, ... 3. *variipinna*,[1] Carpenter.

b. The joints of the lower pinnules have no lateral processes.

1. Twenty-five to thirty-five cirrus-joints.

α. Twenty cirri, the later joints not spinous; second syzygy not beyond the fourteenth brachial. Tolerably equal pinnules on second distichal and second brachial, ... 4. *quinduplicava*, n. sp.

β. Twenty-five to thirty cirri with strong spines on the later joints; second syzygy about the eighteenth brachial. Distichal pinnule smaller than that of second brachial, ... *savignyi*, Müll., sp.

2. Forty-five to fifty-five cirrus-joints.

α. Cirrus-joints smooth and longer than wide; no spine on penultimate, ... *acuticirra*, Carpenter.

β. Cirrus-joints wider than long; the later ones with faint tubercles, and the penultimate with a spine, ... *ludovici*, Carpenter.

II. Three palmars, the axillary a syzygy.

a. Forty-five cirrus-joints; the later ones short and spiny, . *philiberti*, Müll., sp.

b. Nearly sixty cirrus-joints, the later ones longer than wide and quite smooth. The terminal joints of the lower pinnules much smaller than the basal ones, ... *bipartipinna*, Carpenter.

1. *Antedon angustiradia*, n. sp. (Pl. XLV. fig. 4).

Specific formula—A.3.$\frac{c}{c}$.

Description of an Individual.—Centro-dorsal columnar, its sides bearing ten vertical rows of cirri, usually four in each row, which alternate more or less with those of adjoining rows. They are long and slender, reaching 25 mm. in length, with sixty or seventy joints, a few of which are longer than wide. The distal edges of the outer half have a forward projecting spine which becomes more marked in the shorter terminal joints. Three radials visible; the first short, and depressed at their lateral edges, the second oblong, twice their length, quite free laterally, rather convex, and rising to the middle of their junction with the pentagonal axillaries. The rays are quite free and may divide a second time; three distichals, the axillary with a syzygy. The first distichals (or brachials) nearly oblong and quite free laterally; the second quadrate, with a slightly angular base.

Fourteen arms, of about one hundred joints, at first triangular and then quadrate, the later ones becoming narrow and elongated. A syzygy in the third, and then between the twelfth and fifteenth brachials, with others at intervals of one to six, usually four or five, joints.

[1] This species may have only ten arms; see p. 194.

The second joint above the radial axillary, whether brachial or distichal, has a pinnule about 10 mm. long, composed of some thirty elongated joints, the basal ones being rather stout. The next few pinnules are much shorter and less stout at the base, with fewer joints, and their successors increase again, becoming long and filiform in the outer parts of the arms.

Disk naked and much incised; the rays and the lowest pinnules somewhat webbed by perisome; sacculi abundant on the disk, arms, and pinnules.

Colour in spirit,—the skeleton a very light brown, and the perisome darker.

Disk 9 mm.; spread about 9 cm.

Locality.—Station 192, September 26, 1874, near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One specimen.

Remarks.—This type is unfortunately represented only by a single and much-mutilated individual, the disk of which bears the cysts of *Myzostoma inflator*, von Graff. It may be readily distinguished, however, from the other members of the group by the abundance of long and spiny cirri, and by the complete freedom of the rays, the second radials not coming into lateral contact at all.

One of the distichal series is only two-jointed, as shown on the right of the figure (Pl. XLV. fig. 4); while in that on the left side the two elements of the axillary have almost the appearance of being articulated and not united by syzygy. If this be really the case, it is a somewhat anomalous condition, especially as the lower joint, the normal "hypozygal," bears no pinnule.

2. *Antedon anceps*, n. sp. (Pl. XXXV. figs. 1–3).

Specific formula—A.(3).$\frac{b}{b}$.

Centro-dorsal a low convex disk with about twenty cirri on its sides. These have twenty-five to thirty-five tolerably uniform joints, few of which are longer than wide, the later ones being slightly carinate.

First radials partially visible; the second short and partly united, forming a more or less distinct tubercle at the middle of their junction with the widely pentagonal axillaries. Ten to fourteen arms, distichal series being sometimes absent altogether; when present, they consist of three joints, the axillary with a syzygy. The arms have about one hundred and fifty joints, the earlier ones triangular and much wider than long, their successors becoming more quadrate and finally almost oblong, with a slight tendency to overlap. A syzygy in the third, and then between the eighth and twelfth brachials, with others at intervals of two to nine, usually four to seven, joints. The first pinnule, whether distichal or brachial, is considerably smaller than its successor on the same side. In arms which spring direct from the radial axillary the largest pinnules are those of the fifth, sixth, and seventh brachials, which may reach 12 mm. long, and consist of twenty smooth joints, most of them longer than wide, and the later ones carinate. On the inner arm borne by a distichal axillary, the largest pinnules are those of the fourth and fifth brachials; while on the outer arms these are little, if at all, larger than that of the second brachial. But the third brachial always bears a small pinnule.

Disk naked and much incised; sacculi very abundant on the disk, arms, and pinnules.

Colour in spirit,—the skeleton white, with patches or bands of a faded purple, and the perisome darker.

Disk 8 mm.; spread 17 mm.

Locality.—Station 212, January 30, 1875; off Samboangan, Philippine Islands; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand. Three specimens.

Remarks.—This is another of those dimorphic species which may or may not have distichal series; and it has therefore been assigned a place among the ten-armed forms of *Antedon*, as noticed on pp. 194, 198. It is readily distinguished from the other members of the *Savignyi*-group, which have no palmar series nor lateral processes on the pinnules like *Antedon variipinna* (Pl. XLVIII. fig. 3).

Antedon reynaudi has more numerous and spiny cirrus-joints and a longer syzygial interval; while there is a larger number of cirri in *Antedon savignyi*, also with spiny joints, and the second syzygy is further from the calyx instead of being within the first fourteen brachials as in *Antedon anceps* (Pl. XXXV. figs. 1, 2). The arrangement of the lower pinnules of this type is rather peculiar. On the outer side of the ray the distichal pinnule, when present, is much smaller than that of the second brachial above it. That of the third brachial is again small; but the next pair are little if at all larger than that on the second. On the other hand, if there is no distichal pinnule, owing to the arms springing directly from the radial axillary, the pinnule on the second brachial is smaller than that on the fourth, and this again is smaller than those of the next three joints (Pl. XXXV. fig. 2). An arrangement intermediate between these two is found on the inner arm of each pair borne on a distichal axillary, in which the fourth and fifth brachials have the largest pinnules, that on the second, as the first pinnule on the arm, being distinctly smaller.

3. *Antedon variipinna*, Carpenter (Pl. XXXVI. figs. 1–6; Pl. XLVIII. figs. 3–5; Pl. XLIX. figs. 1, 2).

Specific formula—A.[3.(2)].$\frac{b}{b}$.

1882. *Antedon variipinna*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 506.
1882. *Antedon crenulata*, P. H. Carpenter, *Ibid.*, p. 507.
1882. *Antedon decipiens*, Bell, Proc. Zool. Soc. Lond., 1882, p. 534.
1882. *Antedon irregularis*, Bell, *Ibid.*, p. 534.
1882. *Antedon decipiens*, P. H. Carpenter, *Ibid.*, p. 746.
1882. *Antedon crenulata*, P. H. Carpenter, *Ibid.*, p. 746.
1882. *Antedon irregularis*, P. H. Carpenter, *Ibid.*, p. 746.
1882. *Antedon variipinna*, P. H. Carpenter, *Ibid.*, p. 746.
1884. *Antedon decipiens*, Bell, Rep. Zool. Coll. H.M.S. "Alert," Lond., 1884, p. 159, pl. xi. figs. B, a.
1884. *Antedon irregularis*, Bell, *Ibid.*, p. 161, pl. xiii. figs. A, a–c.

Centro-dorsal a low and slightly convex disk, bearing from fifteen to thirty cirri on its sides. They have twenty to thirty-five joints, some of the lower ones being longer than wide. The later joints are usually somewhat compressed laterally and rather sharply carinate in consequence, but they sometimes bear well-marked spines.

The first radials are never altogether invisible in a side view, and are often comparatively large and granulated externally. The second are short, wide, and laterally united, forming more or less of a prominence at the middle of their junction with the broadly pentagonal axillaries. The rays generally divide twice and sometimes three times, the distichal series consisting of three joints, the axillary with a syzygy, and the palmars (when present) of two joints, the axillary without a syzygy. The dorsal surface of these radial, distichal, and palmar joints is often considerably arched.

The arms vary in number from eleven (probably even ten) to twenty-five or more, and may have one hundred and eighty joints. The first six or eight brachials are relatively short and wide, nearly oblong in outline, and often much rounded dorsally.

The following joints are more triangular, with a variable tendency to overlap dorsally, and their broader ends project alternately on opposite sides of the arm to a greater or less extent. Further out they become more quadrate again, but remain relatively short and wide and more or less overlapping till almost the very end of the arm. A syzygy in the third brachial, and the next between the tenth and fifteenth, with others at intervals of six to twelve joints, usually nine or ten.

The first pinnules are comparatively small, and consist of about twenty short joints, the lowest of which are broad and slightly carinate. The distichal pinnule (if present) is smaller than that on the second brachial, and so is that on the third brachial. The following pinnules may reach nearly 15 mm. in length, with as many as twenty-five joints, which are both longer and stouter than in the lower pinnules. The relative sizes of the pinnules vary greatly. In the outer arm of each distichal pair the largest pinnules are generally those of the fourth and fifth brachials; but in the inner arm they are on the fifth and sixth, while in arms which are borne directly on the radial axillaries the third pair of pinnules (on sixth and seventh brachials) are usually the longest. All but the lowest of these large pinnules have strong and blunt lateral processes at their distal ends. The next pair of pinnules are generally considerably smaller, with relatively shorter joints, which gradually become more elongated in the slender distal pinnules, but lose the lateral processes at their ends.

Disk naked and much incised. Sacculi small, but abundant.

Colour in spirit,—ashy-grey, white, or pale flesh colour, with frequent bands or patches of purple or yellowish-brown; sometimes purple with whitish bands.

Disk 10 mm.; spread 20 cm.

Localities.—Station 186, September 8, 1874, Prince of Wales Channel; lat. 10° 30′ N., long. 142° 18′ E.; 8 fathoms; coral mud. Two specimens.

Arrou Islands. Two specimens.

Other Localities.—Canton; Borneo. H.M.S. "Alert" 1881,—Torres Strait; Prince of Wales Channel; Dundas Strait (17 fathoms); Arafura Sea (Station 160, 32 to 36 fathoms).

Remarks.—This is in some respects the most remarkable species of *Antedon* that I have yet seen. For it has a very considerable range of variation and has been described under four different names. The first of these, by which it must henceforth be known, was given by myself in 1882[1] to a tridistichate and bipalmar *Antedon* from Canton in the Hamburg Museum, with sharply spinous cirrus-joints, serrate arms, and a tolerably regular inequality in the relative sizes of the pinnules at the bases of the inner and outer arms of each ray, these lower pinnules having projections at the distal ends of their component joints. At the same time I described another new species, *Antedon crenulata*,[2] from Borneo, as having some of these peculiarities, but remarked that "it is altogether a larger species than *Antedon variipinna*, from which it is readily distinguished by its crenulated first radials, tubercular arm-bases, and smoother arms, while the inequality in the sizes of the lower pinnules is not of the same character in the two species." The Challenger collection contains two individuals from the entrance to Prince of Wales Channel in Torres Strait which agree with the two just mentioned in several points, but have no palmar series at all, while one of them has spines on the cirri, though those of the other are only carinate. At first sight, however, it did not seem advisable to unite these two forms in one specific type, the one having palmar series and the other not, though I now know that I was wrong. The same course was taken two years later

[1] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 506. [2] *Ibid.*, p. 507.

by Bell,[1] who described the two allied species *Antedon decipiens* and *Antedon irregularis*, the former with spiny cirri and no palmars, and the latter with palmars but unarmed cirri. But their other characters, especially the short arm-joints and the lateral projections on the lower pinnules, agree very closely with those of *Antedon crenulata*. Bell appears to have regarded the absence of palmars in *Antedon decipiens* and of cirrus-spines in *Antedon irregularis*, which has palmars, however, as sufficient to separate both these types from *Antedon crenulata*. They had been dredged by H.M.S. "Alert" on the north-east coast of Australia; and when in August last I began to revise the tridistichate species of *Antedon* in the Challenger collection, the descriptions of which had been written five or six years before, I found that a form closely allied to *Antedon decipiens* and an example of Bell's *Antedon irregularis*, but without palmars, had been figured on Pl. XLVIII. figs. 3–5 and Pl. XLIX. figs. 1, 2 respectively. Both alike had been obtained in Prince of Wales Channel, and had formerly seemed to me, as the "Alert" specimens from the same locality did to Bell, to represent two different specific types which could not be referred either to *Antedon variipinna* or to *Antedon crenulata*. A third form from the Arrou Islands also appeared to be new, and I figured it under the name of *Antedon dubia* (Pl. XXXVI. figs. 1–6), not being quite clear in my own mind as to whether its tridistichate condition is the normal one or merely due to regeneration of a ten-armed form, as is so often the case in *Antedon rosacea* and other species.

Lately, however, I have made a critical study of all the "Alert" material, and have also reconsidered my descriptions of *Antedon variipinna* and *Antedon crenulata*. The result is that I find myself unable to discover any characters which are sufficiently constant to be of specific value as distinguishing *Antedon irregularis* and *Antedon dubia* from *Antedon decipiens*, or any of these three from *Antedon variipinna* and *Antedon crenulata*. Bell[2] had himself remarked after describing *Antedon irregularis*—"This species has some resemblance to *Antedon decipiens*; but it may be distinguished from it by (α) the absence of spines from the joints of the cirri, (β) the broader lower pinnules, and (γ) the greater length of the more distal pinnules." He gave no details, however, respecting the relative sizes of the lower and distal pinnules respectively in the two types, and after examining his material I find a difficulty in attributing the difference to anything more than the size of the individual specimens, those of *Antedon decipiens* being generally smaller than those of *Antedon irregularis*. The presence of spines on the cirrus-joints of *Antedon decipiens*, and their absence on the more numerous joints of the cirri in *Antedon irregularis*, seemed, however, to be good specific characters. But when I came to examine the grey specimens from Prince of Wales Channel, which Bell had provisionally regarded as a variety of the white individuals obtained at the same locality, on account of their cirri being "rather more numerous and more jointed," I found

[1] "Alert" Report, pp. 159-162. [2] "Alert" Report, p. 162.

the cirrus-joints to be also unprovided with *definite* spines, though they have the same sharply carinate appearance as those of *Antedon irregularis*.

The first radials of these individuals are also mostly concealed, as is the case in *Antedon irregularis*, though in the type of *Antedon decipiens* from the Arafura Sea they are "quite distinct" as described and figured by Bell;[1] but they are much less distinct in the white individuals from Prince of Wales Channel. In all the specimens from this latter locality, therefore, the first radials resemble those of *Antedon irregularis* rather than the radials of *Antedon decipiens;* but some of them had spiny cirri as in the type of *Antedon decipiens*, while in the others the joints are only sharply carinate as in *Antedon irregularis*. The arms and pinnules of all these specimens, however, are most like those of *Antedon decipiens*.

It would seem impossible, therefore, to make any distinction between the two species in the characters of either the arms, the radials, or the cirri; and this conclusion is confirmed by the following considerations. The two individuals from the Arrou Islands, which I formerly referred to a new species, *Antedon dubia*, have about thirty-five cirrus-joints, with the later ones carinate as in *Antedon irregularis* (Pl. XXXVI. fig. 1; Pl. XLIX. fig. 1). But they have relatively large and conspicuous first radials with a sculptured surface (Pl. XXXVI. fig. 1), exactly as in Bell's figured specimen of *Antedon decipiens*, which, like these, has no palmars. The arm-bases of the smaller individual from the Arrou Islands resemble those of *Antedon decipiens*, while those of the larger one show more of the characters of *Antedon irregularis*. On the other hand, *Antedon variipinna* and *Antedon crenulata* both have palmar series and thirty or more spiny cirrus-joints, while the first radials are fairly distinct, those of *Antedon crenulata* being more or less sculptured. Neither species has specially rounded arm-bases, like those of *Antedon irregularis*, though the general outline of the joints is the same in all the types.

The variations in the characters of all these different forms may be conveniently expressed by letters as follows:—

Number of cirrus-joints, . . .	30 to 35,	A.	25,	a.
Characters of cirrus-joints, . . .	Distinctly spiny,	B.	Sharply carinate,	b.
First radials, ...	Distinct,	C.	Mostly concealed,	c.
Palmar series, ...	Present,	D.	Absent,	d.
Arm-bases, ...	Much rounded,	E.	Less rounded,	e.
Arms, ...	Serrate,	F.	Fairly smooth,	f.

[1] "Alert" Report, pl. xi. fig. B.

We then get the following expressions to denote the eight forms of this specific type, five of which have been regarded as representing different species :—

Name.	Characters.	Locality.
1. *Antedon variipinna*, . .	ABCDeF.	Canton.
2. „ *crenulata*, . . .	ABCDef.	Borneo.
3. „ *decipiens*, type ("Alert"), .	aBCdef.	Arafura Sea.
4. „ *decipiens*, var. ("Alert"), .	Abcdef.	Prince of Wales Channel.
5. „ *decipiens*, var. (Challenger),	ABcdeF.	Prince of Wales Channel.
6. „ *irregularis* (Challenger), .	AbcdEF.	Prince of Wales Channel.
7. „ *irregularis* ("Alert"), .	AbcDEF.	Torres Strait and Prince of Wales Channel.
8. „ *dubia* (Challenger), .	AbCdEF.	Arrou Islands.

With these facts before us it is difficult to avoid the conclusion that we are dealing with but one specific type ; and this conclusion is confirmed by the fact that in all these different forms the general shape of the arm-joints and the characters of the pinnules are respectively identical, though the latter vary considerably in the degree of their development. The distal arm-joints have the same shape throughout the whole series, as shown in the Challenger examples from the Arrou Islands and from Torres Strait (Pl. XXXVI. fig. 3 ; Pl. XLVIII. fig. 5). On the other hand, the alternating lateral projections of the joints in the lower parts of the arms is very marked in the form from Torres Strait, which Bell called *Antedon irregularis* (Pl. XLIX. fig. 1), and it is fairly distinct in those from the Arafura Sea and from the adjacent Arrou Islands (Pl. XXXVI. fig. 1). But it is comparatively insignificant in the other form from Torres Strait (Pl. XLVIII. fig. 5), which has much less convex radial and distichal series than the *irregularis*-form from the same locality (Pl. XLIX. fig. 1).

Another universal character of all the different varieties which I have referred to this species is the large size of the pinnules on the fourth and the two or three following brachials, and the lateral projections at the distal ends of their component joints (Pl. XXXVI. figs. 1, 4, 5, 6; Pl. XLVIII. fig. 3; Pl. XLIX. fig. 2). The distichal pinnule, when present, is comparatively small; but its successor on the second brachial is somewhat larger, though that on the next joint is smaller again. Beyond this point, however, there is much variation. The pinnules of the next three or four brachials are considerably longer and stouter than that of the second, being the largest pinnules on the arm (Pl. XXXVI. figs. 4–6 ; Pl. XLVIII. fig. 3). In those arms which spring directly from the radial axillary, so that there is no distichal pinnule, the largest pinnules are generally those of the sixth and seventh brachials. When, however, a distichal axillary is present, the arm borne on its inner face usually has its largest pinnules on the fifth and sixth brachials; while on the outer arm they are on the fourth and fifth. But this arrangement is very far from being a constant one. The next two pinnules after the large pair may also be of considerable size and composed of somewhat elongated joints

(Pl. XLVIII. fig. 3). But in other cases they show a considerable alteration both in the size and in the character of their component joints, as seen on the left side of fig. 1 on Pl. XXXVI.

The double row of lateral projections on the joints of these proximal pinnules is developed in rather a singular manner. Their basal joints are somewhat flattened against the arm, and the upper edge of their broad dorsal surface is sharpened, and more or less carinate, while its distal end is marked by a median process of variable prominence, as is well seen in Pl. XXXVI. figs. 4–6. As the following joints lose their flattened appearance, and become more rounded, the carination of the upper edge develops into a strong blunt process at the distal end of the joint on its inner side; while the medio-dorsal prominence passes into a corresponding process on the outer side (Pl. XLIX. fig. 2). There is much variation, however, in the exact nature and mode of development of these processes.

The frequency of the ray-divisions of this species, and therefore the number of arms, is subject to great fluctuations. A second post-radial axillary only occurs in the single specimens which I named *Antedon variipinna* and *Antedon crenulata* respectively, and sometimes also in the form which was described by Bell as *Antedon irregularis*. A large number of individuals were obtained by the "Alert," and the majority of them have two or more palmar series, though in others, as in the Challenger specimen (Pl. XLIX. fig. 1), palmars are entirely absent. Bell gives the number of arms as ranging from eleven to twenty-two, but seems to have overlooked one example in which there are twenty-five. The occurrence of an individual with only eleven arms makes it quite possible that a ten-armed variety of this protean type may be eventually discovered. In fact, the two individuals which I formerly called *Antedon dubia* are not improbably of this nature. The one has two distichal series, and the other only one. But in each case they result from regeneration of the arm at the syzygy in the third joint above the radial axillary. This may perhaps have originally supported a distichal axillary; or it may have given rise to one arm only, which was replaced by two after fracture, as is so often the case, an excellent instance of it having been described by Dr. Carpenter in *Antedon rosacea*.[1] Under these circumstances I have therefore thought it safer to assign *Antedon variipinna* a place among the ten-armed species, to which it can definitely be referred if ever an individual is found in which distichal series are entirely absent. No harm will be done if it never turns up, and should it do so, it will run less risk of being baptised as a new species, having undergone that process too frequently already.

There is one point relating to the extremely variable characters of this species, which seems to me to be of special importance. The variations which I have noticed above are not altogether due to difference of locality. Varieties Nos. 5 and 6 were found

[1] *Phil. Trans.*, 1866, p. 725, pl. xxxviii. fig. 8, B.

associated by the Challenger in Prince of Wales Channel. No. 7, which is only No. 6 with palmar series, was found associated with it by the "Alert" both in Torres Strait and in Prince of Wales Channel; and in the latter locality No. 4 was obtained as well.

This repeated occurrence of two or more varietal forms of *Antedon variipinna* in one and the same locality recalls the fact, that of the five varieties of the protean *Actinometra parvicirra*[1] which were dredged by Professor Semper among the Philippine Islands, two occurred at Ubay and two at Bohol; while examples of Pourtalès' two species, *Actinometra pulchella* and *Actinometra alata*, which I have been compelled to unite under the former name,[2] were frequently found by the "Blake" to be living together at the same locality in the Caribbean Sea. It is evident therefore that the cause of these remarkable variations in one and the same specific type must be attributed to something more than a mere change of local conditions.

The single example of *Antedon variipinna*, var. 5, which was obtained by the Challenger in Prince of Wales Channel, was serving as host to fourteen individuals of *Myzostoma*, which Professor von Graff has referred to the following species—*Myzostoma dentatum*, *Myzostoma filiferum*, and *Myzostoma quadriferum*. The name of the host is given in his Report[3] as *Antedon bidentata*, P. H. Carpenter, this being the MS. name which I had applied to the species before I became convinced of its identity with *Antedon variipinna*, or had the opportunity of identifying it with *Antedon decipiens*, Bell.

4. *Antedon quinduplicava*, n. sp. (Pl. IV. figs. 1, *a–d*; Pl. XLVII. figs. 4, 5).

Specific formula—$A.3.2.\frac{ab}{b}$.

Description of an Individual.—Centro-dorsal a thin disk, bearing about eighteen cirri on its sloping sides. They have thirty tolerably equal joints, the last few rather compressed, and faintly carinate; the penultimate with a slight spine.

First radials just visible; the second rather closely united, forming a median prominence with the pentagonal axillaries; and there is a similar but less marked prominence on the first two joints above the axillary. The rays may divide three times; three distichals with a syzygy, and two palmars without one. Sixteen arms of one hundred and fifty or more smooth joints, all but the terminal ones being wider than long; the lower ones subtriangular and the later ones quadrate or almost oblong. A syzygy in the third, and then between the eighth and fourteenth brachials; others at intervals of four to ten, usually seven or eight, joints.

The distichal pinnule is about equal to that on the second brachial. That on the third brachial is smaller again, while those on the fourth and fifth are both longer and

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. pp. 52, 53.
[2] *Bull. Mus. Comp. Zoöl.*, 1882, vol. ix. No. 4, p. 10.
[3] Zool. Chall. Exp., 1884, part xxvii. p. 17; *ibid.*, 1887, part lxi. p. 7.

stouter, reaching 11 mm., with about eighteen smooth joints, most of them longer than wide, and the lower ones carinate. The next pair are generally smaller again. But in arms borne on the radial axillary the sixth, and occasionally the seventh, brachials may have large pinnules like those of the two preceding joints.

Disk naked and much incised; sacculi abundant.

Colour in spirit,—the skeleton brownish-white and the perisome darker.

Disk 7 mm.; spread 16 cm.

Locality.—Station 212, January 30, 1875; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand. One specimen and one fragment.

Remarks.—I have had some doubts as to the propriety of separating this species from *Antedon anceps* (Pl. XXXV. figs. 1–3), which occurred at the same station. The general characters of the cirri, calyx, and the large lower pinnules are the same in both types. One individual of *Antedon anceps* has only ten arms; but another has three, and a third four distichal series. The outer parts of the arms are rather serrate and the distichal pinnule is distinctly smaller than that on the second brachial above it; on the other hand the two forms which I refer to *Antedon quinduplicava* each have palmar series, nearly smooth arms, containing longer syzygial intervals, and a distichal pinnule of about the same size as that on the second brachial.

Considering the remarkable series of variations in the characters of *Antedon variipinna*, I think it quite possible that we are here dealing with another case of the same kind; but in the absence of the necessary intermediate links I prefer to keep *Antedon quinduplicava* separate from *Antedon anceps* for the present. The only species that approaches them at all closely is *Antedon savignyi*, in which, curiously enough, palmars may or may not be present. But its more numerous and spiny cirri readily distinguish it from them both.

One of the two individuals of *Antedon quinduplicava* which was dredged by the Challenger was a mere fragment which had lost its cirri, disk, and most of its arms. As it was practically useless in this condition, I made a preparation of its calyx, with a somewhat surprising result. Each of the radial areas on the ventral surface of the centro-dorsal is marked at its proximal end by a large bilobate pit (Pl. IV. fig. 1*d*), so that every two pits are separated by an interradial ridge as seen in fig. 1*a*. These pits seem to be nothing but an unusual development of the radial pits which occur round the lip of the centro-dorsal in so many Comatulæ, as seen in Pl. IV. fig. 2*d*, and receive the lower ends of the axial radial canals; and so in fact they are. But their capacity is increased by the presence of corresponding pits on the under surface of the radial pentagon (Pl. IV. fig. 1*c*) into which the axial canals, contained between the inner faces of the radials and the spouts of the rosette, open directly. A possible explanation of this arrangement has already been discussed on pp. 8, 9. The only *Comatula* in which I have found any large cavity of a similar kind within the calyx is the type hitherto known as *Actinometra robusta*, of which I wrote as follows :[1]—"Just above the dorsal surface of the radial the axial furrow occupying the median line of its internal face gives off a large horizontal diverticulum into the substance of its calcareous tissue, which extends outwards for some distance between the central canal and the dorsal surface of the radial ; and, like the axial furrow, or canal as it is in the natural condition when the rosette is *in situ*, encloses a dorsal extension of the body-cavity or coelom."

In *Actinometra robusta*, therefore, the radial axial canal, though it terminates blindly at the top of the centro-dorsal, communicates with a large cavity in the lowest part of the radial ; while in *Antedon quinduplicava* this cavity is outside and below the first radial, between it and the centro-dorsal.

The presence or absence of this cavity may prove to be a point of some importance in assisting a future decision, as to whether *Antedon quinduplicava* is or is not identical with *Antedon anceps*, a question which must wait till a further supply of material is obtained.

Note on Antedon fluctuans.

Since the printing off of pp. 94–96, which contain the description of *Antedon fluctuans*, I have had occasion to revise the tridistichate species of *Antedon* that have been classified as having articulated radials. Among these is *Antedon elegans*, which was described by Bell in 1884 from three specimens obtained by the "Alert" at Port Molle in Queensland.[2]

I had made a cursory examination of the greater part of the Comatulæ dredged by the "Alert" some time previously, but had not been able to identify any representative of the type which appeared in my working list of new Challenger species as *Antedon fluctuans*. Subsequently, however, as pointed out on p. 95, I recognised this type in an imperfect specimen from Torres Strait, which was in too mutilated a condition for description with the rest of the "Alert" collection.

Bell noticed expressly[3] that among the species of *Antedon* which he did describe in the report, "in no case is the radial axillary a syzygy."

I have already pointed out, however, on p. 98, that there is a syzygy between the second and axillary radials of *Antedon microdiscus*, which is one of Bell's new species ; and I now find that the same is the case in all three examples of his *Antedon elegans*, which I examined in August last for the purpose of definitely making out its relation to the other tridistichate species of *Antedon* with articulated radials, before drawing up a classification of the group.

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. pp. 86, 87.

[2] "Alert" Report, p. 162. pl. xiii. figs. B, Ba.

[3] *Ibid.*, p. 155.

Bell's first formula for *Antedon elegans*[1] indicated that it had three distichals and sometimes three palmars, with syzygies in the axillaries; and I classified it accordingly.[2] His subsequent description[3] of the palmars says, however, that "if the arms divide again there are generally two joints, when the axillary is not a syzygy; but there may be three joints, and then the axillary is a syzygy." His figured specimen has four palmar series of two joints and one of three joints, and he gives the specific formula as including both varieties $\left(A.3.\frac{(2)}{(3)}.\frac{b}{c}\right)$. This is all very well in cases where two palmars occur on the outer, and three on the inner arms of the ray, as in *Actinometra nobilis* (Pl. LXV. fig. 1), but if it is done in every case where the arm-divisions are not quite regular, the formulæ would become so complex that we should do better without them. It is extremely rare for any tridistichate *Comatula* to have its secondary and subsequent arm-divisions all exactly uniform; and sometimes, as in *Actinometra parvicirra* (Pl. LXI. figs. 1, 5), there is the same variation in the distichal series. Hence all that we can do is to go by the majority of the distichal or palmar series respectively; and as Bell recognised this fact by omitting any mention of the two-jointed palmar series in *Antedon microdiscus*, I wonder that he thought it necessary to refer to the abnormal three-jointed series in *Antedon elegans*. His formula also omits any reference to the post-palmar series which occur on one of his specimens.

The corrected formula for *Antedon elegans* thus becomes $A.R.3.2.(2).\frac{b}{c}$, which is exactly the same as that given above for *Antedon fluctuans*; and the two species are in fact identical. Under these circumstances the type must be known for the future as *Antedon elegans*, Bell, although its most important distinctive character was omitted in his diagnosis. It is noteworthy that of the three examples obtained by the "Alert" at Port Molle, one is very considerably different from the other two, both in colour and in the amount of serration of the arms; while the Challenger's dredgings at Station 190 yielded four examples of the same type, three alike and one different.

The "Alert" found an intermediate form in Torres Strait; Semper's Philippine collection contains representatives of the type; and I have lately found a most valuable series of varying forms of this species among the Comatulæ dredged by Dr. Anderson in the Mergui Archipelago. In these last, as in the examples obtained by the "Alert" and Challenger, the ambulacra of the disk are very strongly plated, and also the inter-palmar areas at their sides, though this is less marked in the Philippine variety. I find the same extensive plating on the disk of another species from Mergui which has a syzygy between the two outer radials and a formula $A.R.2.2.2.\frac{b}{c}$. It thus differs altogether from *Antedon elegans*, *Antedon multiradiata*, and *Antedon microdiscus* in having but two articulated distichals, instead of three, with a syzygy in the axillary.

[1] *Proc. Zool. Soc. Lond.*, 1882, p. 534. [2] *Ibid.*, pp. 746, 747. [3] "Alert" Report, p. 162, pl. xiii. fig. B.

In each of these four species the disk is strongly plated, just as it is in the *Basicurva-*, *Spinifera-*, and *Granulifera-*groups (Pl. IX. fig. 2). But in all these three latter types the pinnule-ambulacra have a well-defined skeleton and the lower parts of the rays are flattened laterally; whereas in *Antedon elegans* and its three allies, which we may conveniently call the *Elegans*-group, these characters are absent, the plating of the perisome being confined to the disk. This seems to be a constant peculiarity of the multibrachiate species of *Antedon* which have a syzygy between the two outer radials; and I have not seen any species possessing a plated disk, but no ambulacral skeleton on the pinnules, which has articulated radials.

The *Comatula tessellata*, Müller,[1] seems, however, to be of this character. It has ten arms with forty-five cirrus-joints, the later ones spiny, and was described as having the "Haut der Scheibe mit kleinen Knochenplättchen bedeckt." Müller's type is (or was) in the museum at Bamberg, but I have never been able to get a sight of it, and it is the only one of all the described species of *Antedon* (if indeed it be an *Antedon*) which I have not personally examined. It may of course be an *Actinometra*, though the great number of its cirrus-joints rather precludes this supposition; and there is also a possibility that its two outer radials may be united by syzygy, though Müller said nothing to that effect. But its true position must remain uncertain for the present; and I would simply draw attention to the fact that the mode of union of the two outer radials must be carefully examined when an attempt is made to determine the systematic position of a multibrachiate *Antedon* with a plated disk; for the probability is that it belongs to Series I.

Genus 5. *Actinometra*, Müller, 1841; *emend.* P. H. Carpenter, 1887.

1758. *Asterias*, Linnæus (*pars*), Systema Naturæ, 10th ed., Holmiæ, 1758, t. ii. p. 663.
1783. *Asterias*, Retzius (*pars*), K. Svensk. Vetensk. Akad. Handl., År 1783, t. iv. p. 241.
1805. *Asterias*, Retzius (*pars*), Dissertatio, sistens Species Cognitas Asteriarum, Lundæ, 1805, p. 34.
1816. *Comatula*, Lamarck (*pars*), Histoire Naturelle des Animaux sans Vertèbres, Paris, 1816, t. ii. p. 530.
1830. *Comatula* (*Astrocoma*), de Blainville (*pars*), Dict. d. Sci. Nat., 1830, t. lx. p. 229.
1830. *Alecto*, Cuvier, Règne Animal, Paris, 1830, t. iii. p. 228.
1834. *Comatula* (*Astrocoma*), de Blainville (*pars*), Manuel d'Actinologie, Paris, 1834, p. 248.
1835. *Comatula*, Agassiz (*pars*), Mém. de la Soc. d. Sci. Nat. de Neuchatel, 1835, t. i. p. 193.
1835. *Comaster*, Agassiz, *Ibid.*, p. 193.
1840. *Comatula*, Müller (*pars*), Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1840, p. 91.
1841. *Actinometra*, Müller, *Ibid.*, 1841, p. 180.
1841. *Alecto*, Müller (*pars*), *Ibid.*, 1841, p. 182.
1843. *Alecto*, Müller (*pars*), Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1841 [1843], p. 203.
1843. *Actinometra*, Müller, *Ibid.*, p. 226.
1843. *Alecto*, Müller (*pars*), Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 131.
1843. *Actinometra*, Müller, *Ibid.*, p. 132.
1843. *Asterias*, Müller, *Ibid.*, p. 133.

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 251.

1846. *Actinometra*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1846, p. 178.
1846. *Comatula*, Müller (*pars*), *Ibid.*, p. 179.
1849. *Comatula* (*Alecto*), Müller (*pars*), Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 246.
1849. *Comatula* (*Actinometra*), Müller, *Ibid.*, p. 246.
1860. *Comatula*, Bronn (*pars*), Klassen und Ordnungen des Thierreichs, 1860, Bd. ii. p. 233.
1862. *Comatula*, Dujardin and Hupé (*pars*), Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 192.
1862. *Actinometra*, Dujardin and Hupé, *Ibid.*, p. 208.
1862. *Comaster*, Dujardin and Hupé (*pars*), *Ibid.*, p. 211.
1864. *Actinometra*, Lütken, Vid. Meddel. nat. Foren. Kjøbenhavn, 1864, p. 218.
1865. *Alecto*, E. C. and A. Agassiz (*pars*), Seaside Studies, Boston, 1865, p. 121.
1866. *Actinometra*, Böhlsche, Archiv f. Naturgesch., 1866, Jahrg. xxxii. Bd. i. p. 90.
1866. *Phanogenia*, Lovén, Öfversigt k. Vetensk.-Akad. Förhandl., 1866, No. 9, p. 231.
1869. *Antedon*, Pourtalès (*pars*), Bull. Mus. Comp. Zoöl., 1869, vol. i. No. 11, p. 355.
1869. *Comatula* (*Actinometra*), J. A. Herklots, Bijdragen tot de Dierkunde, 1869, ix. p. 10.
1875. *Comatula*, Grube (*pars*), 53e Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult., 1875, p. 74.
1875. *Actinometra*, Grube, *Ibid.*, p. 75.
1877. *Actinometra*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1877, vol. xiii. p. 442.
1878. *Antedon*, Pourtalès (*pars*), Bull. Mus. Comp. Zoöl., 1878, vol. v. No. 9, p. 214.
1879. *Actinometra*, P. H. Carpenter, Trans. Linn. Soc. Lond., ser. 2, 1879, vol. ii. p. 27.
1879. *Actinometra*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 385.
1879. *Phanogenia*, P. H. Carpenter, *Ibid.*, p. 394.
1879. *Antedon*, Rathbun (*pars*), Trans. Connect. Acad., 1879, vol. v. p. 157.
1880. *Actinometra*, P. H. Carpenter, Quart. Journ. Geol. Soc., 1880, vol. xxxvi. p. 41.
1880. *Actinometra*, Claus, Grundzüge der Zoologie, 4th ed., 1880, Bd. i. p. 335.
1880. *Phanogenia*, Claus, *Ibid.*, p. 335.
1880. *Actinometra*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1880, vol. xv. p. 198.
1881. *Actinometra*, P. H. Carpenter, Notes from the Leyden Museum, 1881, vol. iii. p. 176.
1882. *Actinometra*, Ludwig, Mém. Acad. Sci. Bruxelles, 1881 [1882], t. xliv. p. 6.
1882. *Actinometra*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 514.
1882. *Actinometra*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1882, vol. ix. No. 4, p. 13.
1882. *Actinometra*, Bell, Proc. Zool. Soc. Lond., 1882, p. 533.
1882. *Actinometra*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra*, Bell, Rep. Zool. Coll. H.M.S. "Alert," Lond., 1884, p. 155.
1884. *Actinometra*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 369.
1885. *Actinometra*, P. H. Carpenter, Zool. Chall. Exp., part xxxii. vol. ix. 1884 [1885], p. 137.
1885. *Actinometra*, Quenstedt, Handbuch der Petrefactenkunde, Aufl. 3, Tübingen, 1885, p. 913.
1885. *Actinometra*, Bell, Proc. Linn. Soc. N. S. Wales, 1884 [1885], vol. ix. p. 498.
1885. *Actinometra*, Ludwig, Lennis, Synopsis der Thierkunde, Dritte Auflage, Hannover, 1885, Bd. ii. p. 948.

Definition.—Centro-dorsal usually discoidal, and bearing fifteen or twenty marginal cirri, rarely more; sometimes pentagonal or stellate with no trace of cirri, but occasionally hemispherical and almost covered by them. Outer faces of the radials relatively wide, with small muscle-plates, and nearly or quite parallel to the vertical axis of the calyx.

Disk with an excentric mouth and a variable number of unequal ambulacra, at least two of which enclose the anal area in a horseshoe-shaped curve. Some of the arms, generally only the hinder ones, may be much shorter than the rest, ungrooved, and non-tentaculiferous. Neither arms nor pinnules have any distinct ambulacral skeleton, and sacculi are altogether absent. Some of the lower pinnules have terminal combs.

History.—This generic name was proposed by Müller[1] in 1841 for a fine specimen of *Comatula solaris*, Lamarck, which he had examined at Vienna in the previous year. He had not then seen the type of Lamarck's species, and seems to have assumed that it was an endocyclic form like *Pentacrinus* and the three European Comatulæ, *i.e.*, that the disk bore five ambulacral grooves converging upon a central mouth.

This is not the case, however, in reality, for Müller discovered on a later visit to Paris[2] that the disk has the same peculiarity in Lamarck's types of *Comatula solaris*, as in the large Vienna specimen "welche generisch von andern durch die Bildung ihres Scheitels verschieden zu sein schien. Auf dem Scheitel der mit blumenartigen Kalkblättchen bedeckt ist, ist keine Spur von den Furchen zu sehen die bei den Comatulen von den Armen zum Munde führen. Auch ist dort nichts vom Munde zu sehen. Die mitte der Bauchseite nimmt eine Röhre ein. Die Arme haben die ventrale Furche der Comatulen, die Furchen der 10 Arme münden aber in gleichen Abständen in eine die Scheibe am Rande umziehende Cirkelfurche. Diese eigenthümliche Bildung liesse sich durch eine unsymmetrische Vergrösserung desjenigen Intertentacularfeldes worin die Afterrörhe steht über den ganzen Scheitel, und auf Kosten der anderen Intertentacularfelder erklären, so dass der Mund aus der Mitte des Scheitels ganz an die Seite zwischen je 2 Armen geräth." Owing to the dry state of the Vienna specimen the exact position of the mouth could not be determined; and the same difficulty presented itself with the types of *Asterias multiradiata* and *Asterias pectinata*, Retzius, which Müller examined in the Retzian collection at Lund, and found to present "ganz dieselbe Bildung des Scheitels" as the Vienna specimen.[3]

In the absence of better-preserved material Müller hesitated to make a definite generic separation of these three Comatulæ from the ordinary endocyclic species. But in 1844 he visited the Paris Museum and there found several Comatulæ in spirit with the same arrangement of ambulacra on the disk as he had described in *Actinometra imperialis* and in the two Retzian species, *i.e.*, a circular furrow extending round the greater part of the margin of the disk, with the ambulacra of the primary arms opening into it at tolerably regular intervals, very much as in Pl. LVII. fig. 3. The number of ambulacra converging on the excentric mouth would thus be less than five, and in fact was reduced to three in two of the three individuals first seen by Müller. This character, and not the position of the mouth, was regarded by him as the most distinctive peculiarity of *Actinometra*. For he found that some species may have a central anal tube and excentric mouth "ohne dass die *Ambulacra* ihre symmetrische Vertheilung auf die 5 Armstämme einbüssen."[4]

[1] *Monatsber. d. k. preuss Akad. d. Wiss. Berlin*, 1841, p. 180.
[2] *Ibid.*, 1846, p. 178.
[3] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. pp. 132, 133.
[4] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1846, p. 177.

The number of ambulacra reaching the peristome was thus the sole character by which Müller proposed to separate *Actinometra* from the majority of the Comatulæ then known to him; and the discovery that five symmetrically distributed ambulacra might converge on an excentric mouth led him to regard the grouping of the ambulacra as a character of less systematic value than he had previously attributed to it, so that the name *Actinometra* was reduced from generic to subgeneric rank.

It is curious that Müller should have attached so much importance to the number of ambulacra converging on the peristome, and so little to the excentric position of the mouth and the accompanying enlargement of the anal interradius which he had described so clearly. For whether the number of primary ambulacra be three, four, or five, as he figured in *Comatula solaris*, *Comatula wahlbergi*, and *Comatula multiradiata* respectively, the mouth is always excentric, and the anal tube in the middle of the horseshoe-shaped curve formed by the two posterior ambulacra. The *Comatula multiradiata* which he figured[1] was not the dry Retzian type bearing this specific name which he had already referred to *Actinometra*, but a spirit specimen in the Paris Museum which had been identified with the *Comatula multiradiata* of Lamarck. It has an excentric mouth, but five primary ambulacra which Müller described as distributed symmetrically to the different groups of arms,[2] and it was therefore referred by him to the subgenus *Alecto*. Except as regards "die Bildung des Scheitels," however, his specific description of *Alecto multiradiata* was simply a reproduction of that which he had given of the dry *Asterias multiradiata*, Retzius. He had stated expressly that this showed the same horseshoe-like distribution of the ambulacra as his type species of *Actinometra*; and his subsequent reference of it to *Alecto* is therefore difficult to understand. The number of *Actinometra* species thus became reduced to three, viz.—(1) the type, *Comatula* (*Actinometra*) *solaris*, Lam., sp., with which Müller was inclined to unite *Asterias pectinata*, Retzius; (2) *Comatula* (*Actinometra*) *wahlbergi*, Müll.; and (3) *Comatula* (*Actinometra*) *rotalaria*, Lam., sp. All three of these had been previously referred by Müller to *Alecto*, which name he used in place of *Comatula*, Lamarck, as being one of older date; but when, later on, he referred them to a subgenus *Actinometra* in which the number of ambulacral grooves joining the excentric mouth is less than five, he used *Alecto* as a subgeneric name for the species with five grooves, irrespective of the position of the mouth. Fifteen species were definitely referred to this latter type in Müller's final memoir, and three to *Actinometra*, the remaining seventeen being simply mentioned as *Comatula*, without any further detail.

More than a dozen years elapsed after the publication of Müller's systematic work

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 245.

[2] Müller's diagram of the disk of this specimen is somewhat idealised, for it only represents forty arms disposed in five groups of eight each; whereas their number is really forty-nine, and the arrangement of the five primary ambulacra at the peristome is by no means so symmetrical as shown in his diagram.

on the Comatulæ before the characters of *Actinometra* again came under discussion. Messrs. Dujardin and Hupé followed the general lines of Müller's classification, but made some important alterations in it. Leach's name *Alecto* was abandoned altogether in favour of the later name *Comatula*, Lamarck; and *Actinometra* was restored to the generic rank which Müller had first proposed for it. But the French authors[1] found some difficulty in defining it properly, remarking that "ce genre ne diffère guère des vraies Comatules que par la position de l'anus au centre et de la bouche au bord du disque. Il en résulte que les gouttières ambulacraires, au lieu de se rendre à la bouche en suivant la direction des bras comme chez les Comatules, s'infléchissent et suivent le contour du disque." Dujardin and Hupé stated, however, that the mouth of *Comatula* was only "ordinairement au centre,"[2] so that its excentric position could not be regarded as especially distinctive of *Actinometra*, though this has since proved to be the case. The restoration of the latter type to a distinct generic position was nevertheless a considerable step in advance; but the mode in which the French authors disposed of some of Müller's species was very singular.

The type species of the genus, *Actinometra imperialis* of Müller, was subsequently discovered by him to be identical with *Comatula solaris*, Lamarck, or *Alecto solaris* as he called it at first. But in his concluding memoir[3] it appeared as *Comatula* (*Actinometra*) *solaris*, and Müller further expressed the opinion that *Asterias pectinata*, Retzius, which he had also found to be an *Actinometra*, is merely a varietal form of the same type. Dujardin and Hupé, however, regarded these three forms at Vienna, Paris, and Lund as respectively representing three different species. They referred the Lamarckian type at Paris to *Comatula*, but the other two forms to *Actinometra;* although Müller had expressly pointed out both in the Monatsbericht[4] (1846) and in the Abhandlungen[5] (1849) that Lamarck's originals were specifically identical with the type of his *Actinometra*.

Dujardin and Hupé gave no reason for their restoration of a specific name which Müller had withdrawn in favour of that established at an earlier date by Lamarck; and one can only conclude, therefore, that they had overlooked Müller's final references to the type, confining themselves to quoting those of 1841 and 1843, which were made before his visit to Paris.

On the other hand the French authors left *Asterias multiradiata*, Retzius, in the genus *Actinometra*, to which it had been originally assigned by Müller, though he subsequently withdrew it. But it would almost seem as if this were due to their not having consulted Müller's later writings, to which they made no reference. For no place was assigned in their classification to the individuals in the collections of Peron and of

[1] *Op. cit.*, p. 208.
[2] *Ibid.*, p. 194.
[3] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 248.
[4] *Loc. cit.*, p. 178.
[5] *Loc. cit.*, p. 248.

Quoy and Gaimard, which Müller had identified with *Asterias* (*Actinometra*) *multiradiata* owing to their having not three but two palmars with the axillary a syzygy; though he called them *Alecto* on account of the symmetrical distribution of the ambulacra on the disk of one specimen.[1]

In fact, the French authors seem as a rule to have only quoted Müller's complete Memoir "Ueber die Gattung *Comatula*, Lam., und ihre Arten" when dealing with species which were not described by him in either of his two preliminary communications of 1841 and 1843 respectively. They recognised that the *Alecto wahlbergi* of 1843 was in 1849 transferred by Müller to *Actinometra;* but they quite ignored the fact that he also transferred *Comatula rotalaria*, Lam., to the same generic type, although it was described as an *Actinometra* on the very same page (256) of the final memoir as *Comatula* (*Actinometra*) *wahlbergi*, and they simply refer to it as *Alecto rotalaria*, Müller, 1843. The French authors then recognised four species of *Actinometra;* but only one of these (*Actinometra wahlbergi*) was understood by them in the same sense as it had been by Müller. One of his species was restored by them to *Comatula;* while, on the other hand, they retained in *Actinometra* a type which he had erroneously transferred back again to *Alecto*. They also regarded the *Asterias pectinata* as a distinct species, instead of classifying it with *Comatula solaris*, Lamarck. This course is likewise adopted in the following pages, though the two forms are not placed in different genera, as was done by Dujardin and Hupé, but in one only, viz., *Actinometra*, just as they appear in Müller's memoir.

Nearly twenty years elapsed after Dujardin and Hupé wrote before the genus received much further notice. Isolated species were described by Böhlsche and Grube respectively, but no formal definition of its characters was ever published. Dr. Lütken, however, had the opportunity of examining a large number of Comatulæ which were collected in the Eastern Archipelago for the Godeffroy Museum; and he was led to the conclusion that the essential character of *Actinometra*, as distinguished from *Antedon*, is the excentric position of the mouth,[2] and that the number of ambulacra reaching the peristome is a character of no importance whatever, instead of being one of generic value, as Müller had supposed. Lütken further discovered that the proximal pinnules of all the exocyclic Comatulæ are provided with a terminal comb (Pl. LIII. figs. 3–6; Pl. LVI. figs. 2, 4; Pl. LXIII. figs. 5, 7; Pl. LXV. fig. 7; Pl. LXVII. figs. 2, 4; Pl. LXVIII. fig. 3), but that this is absent in the endocyclic species. The constant association of these two characters enabled him to recognise *Actinometra* as a good generic type; and various species of the genus were distributed from the Godeffroy Museum bearing Lütken's MS. names. Unfortunately, however, he was prevented by other engagements from ever publishing his descriptions of these species, or even a precise diagnosis of the genus.

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 261.
[2] See his Note in *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. p. 18.

During the winter of 1875–76 circumstances enabled me to examine the numerous Comatulæ which had been collected by Professor Semper among the Philippine Islands some years before. Among them were a dozen examples of one common species, together with several other well-defined types; and I was soon led to conclude, as Lütken had previously done, though unknown to me, that the essential difference between *Antedon* and *Actinometra* depends upon the position of the mouth and not upon the number of ambulacra reaching the peristome. In reply to the inquiries which I addressed to him upon the subject, Dr. Lütken was good enough to communicate to me his own observations, and also his discovery of the constant presence of a terminal comb on the lower pinnules of exocyclic Comatulæ. A few months later, by the kindness of Professor Perrier, I was enabled to verify Lütken's conclusion for myself on the fine collection of Comatulæ in the Paris Museum; while at the same time I succeeded in making out various other points of difference between *Antedon* and *Actinometra*, and referred seventeen of the *Comatula*-species then known to the latter genus.[1]

A subsequent study of the large collections obtained by the Challenger, the "Alert," and the "Blake," and also of the Comatulæ in the principal museums of the continent, has afforded ample verification of the earlier conclusions which had been reached by Dr. Lütken and myself; and it has likewise enabled me to make out some other distinctive characters both of *Antedon* and of *Actinometra*.

The genus *Phanogenia* was established by Lovén[2] in 1866, for a remarkable *Comatula* from Singapore which has a stellate centro-dorsal bearing but slight traces of cirri, a nearly central mouth, and a terminal comb on the lower pinnules. Several examples of *Actinometra* of different species, with a centro-dorsal like that of *Phanogenia*, were dredged by the Challenger (Pl. LVII. fig. 1; Pl. LXIII. fig. 6; Pl. LXV. figs. 1–6; Pl. LXVII. fig. 1); and I have seen others in different museums, many of them with the mouth unusually near the centre of the disk, and the ambulacra almost as uniformly distributed as in *Antedon;* but the interpalmar area containing the anal tube is always considerably larger than its fellows. This is also the case in Lovén's original specimens of *Phanogenia*, which I therefore referred to *Actinometra* in 1882,[3] for it became no longer possible to distinguish *Phanogenia* as a separate genus by the characters of its centro-dorsal only, as I have pointed out on pp. 13–16.

Remarks.—In by far the greater number of individuals which belong to the genus *Actinometra* the mouth is situated at some distance from the centre of the disk, which is occupied by the anal tube, and it is occasionally very close to the margin (Pl. LVII. fig. 3; Pl. LXII. fig. 4; Pl. LXIV. fig. 2; Pl. LXVIII. fig. 1; see also Part I., pl. lv. fig. 2; pl. lvi. figs. 7, 8). The peristome is usually fairly open and somewhat elongated

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. p. 27.
[2] *Öfversigt k. Vetensk. Akad. Förhandl.*, 1866, No. 9, p. 231.
[3] *Notes from the Leyden Museum*, 1882, vol. iii. p. 195.

from side to side, as is well seen in Pl. LXVIII. fig. 1; but it is sometimes very much restricted and not readily distinguishable from one of the larger ambulacra (Pl. LXIV. fig. 2). In a few exceptional cases the mouth is practically central, just as it is in *Antedon*, though in other individuals of the same species it is nearly marginal (Pl. LXII. figs. 2, 4).

In the endocyclic Crinoids the position of the mouth on the ventral side corresponds very closely with that of the centre of radiation on the dorsal side; though it is sometimes a little in front of the centre of the disk, as is well seen in *Atelecrinus* (Pl. VI. figs. 4, 6). But in any case the interambulacral area of the disk in which the anal tube is situated corresponds precisely with an interradius of the skeleton, and the ambulacrum opposite to it passes directly on to the joints of the corresponding ray, whether it is undivided as in *Eudiocrinus* (Pl. VI. fig. 2), or forks as in *Atelecrinus* (Pl. VI. figs. 4, 6) and *Antedon* (Pl. IX. fig. 2; Pl. XL. fig. 2; Pl. XLVII. fig. 2). In the latter genus the displacement of the mouth, if it is not quite central, is always in the direction of this anterior ambulacrum, and its position may therefore be described as radial.

This is also true of a great many forms of *Actinometra* (Fig. 6, A). Thus for example in the disk of an abnormal individual of *Actinometra fimbriata*, represented on Pl. LXII. fig. 2, a median vertical plane would be radial in front of the nearly central mouth, and interradial behind, where it would cut the anal tube. The same is the case in the more typical specimen which is shown in fig. 4 of the same plate. In each alike there is a short but wide anterior ambulacrum, which forks twice and so sends a branch to each of the four arms on the anterior ray. Four more grooves leave the peristome in each individual. But whereas in the one (fig. 2) each primary groove supplies all the arms of one ray, just as in *Antedon* (Pl. IX. fig. 2), this is not the case in the other (fig. 4). For each of the two antero-lateral grooves supplies but two arms of the corresponding ray; and the two remaining arms receive their ambulacra as offshoots of the two primary grooves, which supply the two postero-lateral rays, and together form a sort of horseshoe enclosing the anal interradius. This is much larger than in the endocyclic forms (Pl. LXII. fig. 4), as the two hinder ambulacra curve outwards from one another towards the margin of the disk, and so greatly reduce the size of the remaining interambulacral areas. The anal tube is at the centre of the disk, and a vertical plane, cutting mouth and anus, would pass along the short ambulacrum in front of the mouth, which is therefore radial in position, just as in *Eudiocrinus* and *Antedon* (Pl. VI. fig. 1; Pl. XL. fig. 2). This condition may be traced, though less clearly, in the disk of *Actinometra elongata* (Pl. LVII. fig. 3).

On the other hand, there are a great many forms of *Actinometra*, as shown in the diagram (Fig. 6, B), which have a distinctly interradial mouth. Two grooves start from the sides of the peristome, instead of one from its anterior border (Fig. 6, A), and supply the oral arms of the two corresponding rays (A_2, B_1); while the ambulacra of their aboral arms may start directly from the peristome (B_2 on Fig. 6, B), or come off from one of the large furrows which supply the posterior and the two lateral rays (A_1 on Fig. 6, B). The furrow on the right or western side of the disk supplies the radi E and D, as in the species with a radial mouth (Fig. 6, A); but it is longer and has a larger curve than in these forms, as the D ray is exactly behind the mouth (Fig. 6, B), and the corresponding posterior furrow thus extends round three-fifths of the disk instead of round but one half of it. The shape of the peristome in a species with interradial mouth is well seen in *Actinometra regalis* (Pl. LXVIII. fig. 1); while the origin of the primary ambulacra is also seen in *Actinometra belli*, though the peristome of this specimen is so much contracted that the position of the mouth on the disk is only indicated by the point of convergence of the ambulacra (Pl. LXIV. fig. 2).

I was led to think at one time that the situation of the mouth, whether radial or interradial, might serve as a character of specific value. But wider experience has

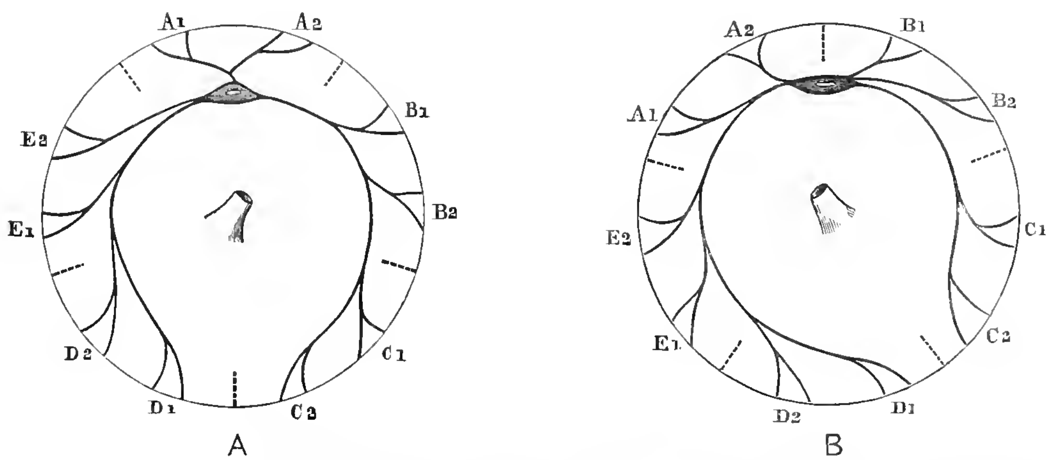

FIG. 6.—Diagrams showing the different positions of the mouth in *Actinometra*; A, with a radial mouth; B, with an interradial mouth. The dotted lines mark the interambulacral regions of the disk. A_1, A_2, ... E_1, E_2, the five pairs of secondary ambulacra.

shown me that too much reliance must not be placed upon it. For although the mouth generally has a constant position in any given species, it sometimes happens that some individuals of the species have an interradial mouth and others a radial one. Thus, for example, the mouth is radial in nearly all the specimens of *Actinometra pectinata* which I have seen, as it almost invariably is in the *Solaris*-group; but it is interradial in the three individuals dredged by the Challenger, one in Torres Strait, and two at Samboangan. On the other hand the mouth is interradial in the examples of *Actinometra lineata* which were dredged at Bahia, but in another individual which I have seen from Barbados its position is radial.

There is another character which very commonly presents itself in *Actinometra*, and seems to be correlated with the excentric position of the mouth. I refer to the very frequent absence of the ambulacral groove and its associated tentacular apparatus on more or fewer of the arms. This is well shown both in *Actinometra belli* and in *Actinometra regalis* (Pl. LXIV. fig. 2; Pl. LXVIII. fig. 1), and also in *Actinometra magnifica* (Part I., pl. lvi. fig. 7). The number of arms is very great in the last-named species, and there are some without grooves on every ray, a condition which also occurs in *Actinometra nobilis.* But as a general rule the ungrooved arms are those which come off from the posterior part of the disk. Thus, for example, some or all of the four posterior arms are very frequently ungrooved in the ten-armed types, *Actinometra solaris* and *Actinometra pectinata;* while in other individuals of the same species all the arms are provided with grooves, just as in *Antedon.* The same is the case in the multibrachiate forms. I have seen one individual of *Actinometra parvicirra* in which nineteen out of thirty-one arms were entirely devoid of an ambulacral groove and tentacular apparatus, while in other specimens there is a groove on every arm.

It is then the potential, rather than the constant presence of ungrooved arms which must be regarded as one of the distinguishing characters of *Actinometra;* and the same may be said of another peculiarity which is frequently associated with it, viz., the difference in length of the anterior and posterior arms. This is less apparent in the ten-armed than in the multibrachiate species, in which, however, it is sometimes very distinct, *e.g.*, *Actinometra belli*, *Actinometra nobilis*, and *Actinometra regalis.* The anterior arms are much longer, taper more slowly, and contain far more joints than the posterior arms, though these often have their genital glands better developed than the anterior arms. In *Actinometra simplex* the tentaculiferous anterior arms have one hundred joints, while there are only forty-five in the hinder arms, which have no ambulacral groove nor tentacles. The two characters are not always associated, however, for in the single specimen of *Actinometra elongata* all the arms are grooved and tentaculiferous, but the posterior ones have only fifty-five joints and reach but 4·5 cm. long, while the anterior arms with one hundred and twenty joints reach 11 cm.

This species is also remarkable for the presence in the later pinnules of the posterior arms of those curious brown cellular bodies that I have supposed to be sense-organs (Pl. LVII. fig. 4). I found them first in some specimens of *Actinometra parvicirra* from the Philippines,[1] and have since detected them in an example of this species from Banda, in *Actinometra elongata* from the same locality, and in *Actinometra simplex* from the Admiralty Islands; while they also occur in examples of *Actinometra meridionalis* from two localities on the American coast. They are not always present in either species and are generally confined to the pinnules of the hinder arms, sometimes to one or two arms only; but in one case I found them on all the arms except the two immediately adjoining the mouth. I know not what these brown "ovoid bodies"

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. p. 40, pl. ii. fig. 6, *a*, *b*.

may be; but as they occur in four species of *Actinometra*, one American and three from the Eastern Archipelago, and are unknown in *Antedon*, they provide us with another potential character of the former genus which has a certain systematic value.

The presence of a terminal comb on the lower pinnules is, however, an absolutely constant character of *Actinometra*. It varies much in its development (Pl. LIII. figs. 3–6; Pl. LVI. figs. 2, 4; Pl. LXI. figs. 8–10; Pl. LXIII. figs. 5, 7; Pl. LXVI. figs. 3, 5; Pl. LXVII. figs. 2, 4; Pl. LXVIII. fig. 3), but it is always present; and this peculiarity, together with the invariable absence of sacculi on the ventral perisome, enables single arms of *Actinometra* to be recognised with the utmost certainty.

The arms and pinnules of this genus are never provided with the ambulacral skeleton which is so well developed in many species of *Antedon;* and the character which is so often associated with this, viz., the lateral flattening of the lower parts of the rays, is also entirely absent in *Actinometra*. This indeed is only to be expected, for the three groups of *Antedon*-species which present these combined characters are almost entirely limited to the abyssal and continental regions, while *Actinometra* is essentially a shallow-water genus, having only been obtained nine times at depths exceeding 200 fathoms.

In certain localities, however, *e.g.*, Cape York and Port Curtis in Queensland, species of *Actinometra* occur with the disk very completely plated, although it may be entirely membranous in the same species elsewhere. This is especially noteworthy in the cases of *Actinometra solaris, Actinometra pectinata*, and *Actinometra paucicirra;* but however well plated the disk may be, there is no ambulacral skeleton on the arms and pinnules, any more than there is in those species of *Antedon* like *Antedon elegans* and *Antedon multiradiata*, which have the two outer radials united by syzygy and a thickly plated disk (Pl. IX. fig. 2; Part I., pl. lv. figs. 3, 4). The essential characters of the radials of *Actinometra* have been fully explained on pp. 24–26, and need not therefore be further discussed.

The centro-dorsal is very often only a thin flattened disk, with an imperfect double row of cirrus-sockets round its margin (Pl. IV. fig. 4*a;* Pl. V. figs. 1*b*, 1*d*, 2*b*, 2*d*, 2*e*, 2*d;* Pl. LII. figs. 1, 2; Pl. LIII. fig. 1, 2, 15; Pl. LXII. figs. 1, 2; Pl. LXIV. figs. 1, 3) There are not often more than about twenty functional cirri on the centro-dorsal at the same time; but this number is sometimes exceeded (Pl. LX. figs. 1–3; Pl. LXVI. fig. 4). On the other hand, the centro-dorsal is occasionally reduced to the condition of a mere flat plate without any trace of cirrus-sockets (Pl. LIV. figs. 1–8), and it is often separated from the radial pentagon by more or less definite slits (Pl. LVII. fig. 1; Pl. LXI. fig. 1; Pl. LXIII. fig. 6; Pl. LXV. figs. 1, 5, 6; Pl. LXVII. fig. 1). It has been pointed out above that the new genus *Phanogenia* was established by Lovén for a species of *Actinometra* possessing these characters; and the nature of the change which produces them has already been noticed on pp. 13–16. It need not therefore be further considered here, but as it never occurs in *Antedon*, it affords another good potential character of the genus *Actinometra*.

The distribution of the genus, both in space and in time, has been discussed already on pp. 35-40.

Classification.—The species of *Actinometra*, like those of *Antedon*, fall into certain very well defined series, as shown above on pp. 57-59. But the various series do not altogether correspond in the two genera. Each has a ten-armed, a bidistichate, and a tridistichate series. But the first two of these are quite small in *Actinometra*, although they together contain three-fourths of the described species of *Antedon*. On the other hand, the tridistichate series of the former genus is remarkable for the number and variety of the forms which it includes, though it is poorly developed in *Antedon*. There are, however, three tridistichate species of *Antedon* with a considerable number of arms; but in all three alike the two outer radials are united by syzygy, and each arm-division above the distichal axillary consists of two or three joints, in the latter case with a syzygy in the axillary (Pls. VIII., IX.; Pl. XXXVII. fig. 4). This combination of characters does not present itself in any *Actinometra* yet known. In all the four tridistichate species of this genus which have the two outer radials united by syzygy, each arm-division above the distichal axillary consists of two joints, which are themselves united by syzygy, as the radials are (Pl. LV. fig. 1; Pl. LVI. fig. 3; Pl. LVII. fig. 1). In another group the two outer radials and the first two distichals, palmars, and brachials are respectively united by syzygy (Pl. LIV. figs. 1, 2); while in a third the radials and brachials have the same characters, but distichals are undeveloped, so that there are only ten arms (Pl. LIII. figs. 2, 15). Neither of these three types is represented in the genus *Antedon* at all, and they are all strictly limited to the Eastern Archipelago, ranging from Mergui on the west to Fiji on the east, but scarcely passing the limits of the tropics. Neither of them is at all rich in species, though the range of variation within the limits of a single specific type is in some cases very considerable. They may be classified as follows:—

Series I.

The two outer radials, and the first two brachials respectively united by syzygy.

Ten arms, ...	1. *Solaris.*
Two distichals united by syzygy, ...	2. *Paucicirra.*
Three distichals, the axillary a syzygy, ...	3. *Typica.*

1. The *Solaris*-group.

Ten arms. The two outer radials and the first two brachials respectively united by syzygy.

A. Less than twenty-five cirrus-joints. The basal joints of the lower pinnules usually have more or less prominent keels.
  Nine to fifteen cirrus-joints, ... 1. *pectinata*, Retz., sp.
  Seventeen to twenty-three cirrus-joints, ... 2. *solaris*, Lam., sp.

B. Thirty to thirty-five cirrus-joints. The basal joints of the lower pinnules not specially distinguished, ... *brachiolata*, Lam., sp.

Seven other species besides the three contained in the above list have been referred to this group at different times, viz., *Actinometra hamata*, Herklots, *Actinometra imperialis*, Müller, *Actinometra intermedia*, Bell, *Actinometra purpurea*, Müller, sp., *Actinometra robusta*, Lütken, MS., *Actinometra rosea*, Müller, sp., and *Actinometra strota*, P. H. Carpenter, MS. The first four are synonyms of either *Actinometra pectinata* or *Actinometra solaris*, while the only character on which Müller relied as separating *Comatula rosea* from *Comatula brachiolata* was the absence in the latter of a terminal comb on the oral pinnules; and I have since found this comb to be present in the type specimens, both at Berlin and at Vienna. *Alecto purpurea* is a small form which was described by Müller in 1843, before he had himself examined Lamarck's types at Paris, but it afterwards appeared to him to differ from *Actinometra solaris* only in showing two radials externally instead of three; and he thought that the difference might possibly be due to the immaturity of the specimen, which he regarded as probably a young form of *Actinometra solaris*. Both the Paris and Vienna specimens of this type have twenty cirrus-joints; and Müller described *Alecto purpurea* as having only twelve, so that it should probably be referred to *Actinometra pectinata*.

Comatula (*Actinometra ?*) *hamata* was the name given by Herklots[1] to a specimen in the Leyden Museum from Cape Bantano, which was figured by Kuhl and van Hasselt, but is not, however, sufficiently distinct from the general type of *Actinometra solaris* to justify the establishment of another species. I believe now that the same may be said of *Actinometra imperialis*, Müller, of Lütken's MS. species *Actinometra robusta*, of the form which I have hitherto called *Actinometra strota*, and also of *Actinometra intermedia*, Bell. This may seem to be a somewhat comprehensive statement; but it is the result of a careful and often-repeated examination of a very large amount of material, including the type specimens at Lund, Paris, Berlin, Vienna, Leyden, Copenhagen, and in the British Museum, besides numerous isolated specimens in other collections. My

[1] Échinodermes peintes d'après nature par les soins de Kuhl, van Hasselt, et Sal. Müller, Bijdragen tot de Dierkunde, 1869, Bd. ix. p. 10, pl. ix.

conclusions, however, are chiefly based on the very large series of specimens belonging to the *Solaris*-group which were collected by H.M.S. "Alert" at various localities in Torres Strait and on the Queensland coast. They are now in the British Museum, and have been placed unreservedly at my disposal by Professor F. J. Bell, to whom my best thanks are due for the ready way in which he has always done his utmost to facilitate my work.

Two years after Müller first described *Actinometra imperialis* from his own examination of the Vienna specimen with an excentric mouth, he gave a description of *Comatula*, or as he called it, *Alecto solaris*, which had been drawn up by Dr. Troschel as the result of his own examination on Müller's behalf of the Lamarckian types of *Comatula solaris* at Paris. Müller knew nothing about the structure of the disk in these last, nor even that the two outer radials are united by syzygy; and it was not till he subsequently visited Paris himself that he found Lamarck's specimens to be both specifically and generically identical with that which he had previously called *Actinometra imperialis*. He therefore withdrew the specific name *imperialis*, replacing it by *solaris*, Lamarck, which he redescribed.[1] All subsequent writers have accepted this identification, with the exception of Dujardin and Hupé, who described the two forms, not only as distinct species, but also as distinct genera.[2]

The "Neue Beiträge" in which Troschel's diagnosis of *Alecto solaris* was published, also contained a careful description, by Müller himself, of a specimen in the Retzian collection at Lund which had been referred by Retzius to the *Asterias pectinata* of Linnæus, an identification which was subsequently adopted in Gmelin's edition of the Systema Naturæ. Müller[3] described it under the name of *Asterias pectinata*, Retzius, recognising, however, its generic identity with his own *Actinometra imperialis*, though he still regarded the latter as distinct from *Comatula solaris*, Lamarck. But after examining Lamarck's type, he united the two species and also came to the conclusion that *Asterias pectinata*, Retzius, "scheint eine Farbenvarietät dieser Art zu sein . . . . Die Farbenzeichnung ist aber sehr eigenthümlich. Auf der Rückseite der Arme sehr regelmässig zwei schwarze Längslinien, die in der Mitte durch eine helle Linie getrennt sind."[4]

I certainly cannot attach any specific importance to this peculiar marking, which I have seen in several individuals from very different localities, amongst others in that from Hong Kong which served as the basis of my own redescription of *Actinometra solaris* in 1882.[5] In this form, however, there are over twenty cirrus-joints. Müller gave the number as twenty in the Vienna specimen,[6] while Troschel's description

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 248.
[2] *Op. cit.*, pp. 200, 209.
[3] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 133.
[4] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 249.
[5] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 514.
[6] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1841, p. 181.

mentioned thirty (which is clearly a misprint for twenty) in Lamarck's type at Paris.[1] But the number of cirrus-joints in the original of *Asterias pectinata*, Retzius, was stated by Müller as only thirteen, and that of the cirri as sixteen.[2] I have lately examined a large number of specimens from eighteen different localities, all of which agree in having no more than sixteen cirri with a small number of joints, and in a generally less robust appearance than that of the type specimens of *Actinometra solaris*. In the majority of cases the number of cirrus-joints is eleven or twelve (Pl. LIII. fig. 15), but it may fall as low as nine, though it occasionally rises to fifteen. This reduction in number is not due to immaturity, as in the case of the small specimen represented in Pl. LIII. fig. 1, the very youthful condition of which is indicated by the shape of its arm-joints, as compared with those of the larger individual shown on the same plate (fig. 2). But it is a character of much constancy, accompanied by others which will be noticed immediately; and as such it will serve, I think, for the separation of the two species *Actinometra pectinata* and *Actinometra solaris*.

To those who know the extent of the variation in the number of cirrus-joints within the limits of individual species of *Antedon*, the difference between an average of twelve and another of eighteen or twenty may seem altogether insufficient to serve as a basis of specific distinction. But it must be remembered that as the number of cirrus-joints in *Actinometra* rarely exceeds twenty-five, it has but a very slight range of possible variations. The number does vary in each of these two types—from nine to fifteen in the one and from seventeen to twenty-three in the other,—while there are other characters which also help to separate them. There may be as many as twenty-five cirri in *Actinometra solaris*, which is a much more robust species than *Actinometra pectinata*, *i.e.*, it has stouter joints, both in the cirri and in the arms and pinnules. Thus, for example, taking an immature individual of *Actinometra solaris* with about the same "spread" as an *Actinometra pectinata* from the same locality, I found the corresponding pinnules with nearly the same number of joints to be one-third longer in the former than in the latter, while the arm-joints were also wider.

The two species present a parallel series of colour-variations. They are sometimes a deep purple, and sometimes brown in various shades, greyish, reddish, and blackish, or occasionally more or less mottled purple and brown. Müller described the medio-dorsal line of the arms in *Actinometra pectinata* as marked by a white band with a dark one on either side. I have seen this also in examples of *Actinometra solaris* from Hong Kong and Billiton. In the dry state the arms of *Actinometra pectinata* have a slightly raised ridge in the medio-dorsal line which is hidden by the white band just mentioned, when this is present. But the ridge always exists and is very frequently visible in spirit specimens, though sometimes, as in that dredged by the Challenger, it is scarcely visible till the arm is dried. It is never so marked in *Actinometra solaris*, however, as it may be

[1] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 135. [2] *Ibid.*, p. 133.

in *Actinometra pectinata*, and is sometimes almost indistinguishable, even on the dry arm.

In Müller's own description of *Actinometra solaris* he noticed that the lower joints of the second pinnule "zeichnen sich durch ihre Erweiterung aus."[1] He had made nearly the same statement in his previous description of *Asterias pectinata*;[2] and when re-describing the former species, from a specimen in the Hamburg Museum,[3] I pointed out that in the pinnules of the fourth to seventh brachials the second and third joints are wide, with strong and expanded dorsal keels, mentioning at the same time the variations of this character which I had found in the original types of the species at Paris and Vienna. Neither of these forms had any indication of a keel on the lower joints of the first pair of pinnules; and this character, together with the larger number of cirrus-joints (over twenty), then appeared to me to constitute the special marks of *Actinometra solaris* as distinguished from *Actinometra pectinata*, with its thirteen cirrus-joints and traces of keels on the basal joints of both the first pinnules, in addition to those on the second pair.

Since examining all the "Alert" collection I find that this view will still hold good, except for one point, the occasional presence of a distinct keel on the pinnule of the third brachial in *Actinometra solaris*. I have only found it in three individuals from Billiton and in one from Port Molle. As a rule, however, there is no more indication of it than is shown in Pl. LIII. fig. 10, and the base of this pinnule, like that of its predecessor on the second brachial, is not specially marked (Pl. LIII. figs. 3, 4). On the fourth and fifth brachials, however, the case is different. The second and third, with sometimes the fourth and even the fifth joints of their pinnules, have large and prominent keels (Pl. LIII. figs. 11, 12), traces of which may generally be found on the pinnule of the sixth and sometimes on that of the seventh brachial. In *Actinometra pectinata*, on the other hand, there are never more than two joints, and sometimes only one, which has a definite keel, and this keel may appear on the pinnule of the second brachial, as in some individuals from Bohol. It is usually present on those of the third to fifth brachials, and sometimes on that of the sixth as well (Pl. LIII. figs. 17–20). But as a rule it is absent in the latter case, and I have never seen any individual with the other characters of *Actinometra pectinata*, which has any sign of a keel on the pinnule of the seventh brachial. Broadly speaking, then, we may say that there are not more than two, and sometimes only one carinate joint on the lower pinnules of *Actinometra pectinata*; that keels are generally present on the pinnules of the third, fourth, and fifth brachials, and sometimes on those of the second and sixth, but never on that of the seventh brachial. On the other hand, *Actinometra solaris* generally has two carinate joints, and occasionally sometimes three or even four, on the pinnules of the fourth, fifth, and sixth brachials, sometimes on those of the third or seventh, but never on that of the second.

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 248. [2] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 134.
[3] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 515.

When I re-described *Actinometra solaris* in 1882, I added a diagnosis[1] of the form which had been long known in the catalogues of the Godeffroy Museum as *Actinometra robusta*, Lütken, MS. The chief character distinguishing it from *Actinometra solaris*, apart from its generally more robust nature, seemed to me to be the entire absence of any expanded keels on the lower joints of its second and third pairs of pinnules. The examination of the "Alert" collection has shown, however, that this distinction will no longer hold good. The "Alert" dredged large specimens at Prince of Wales Channel, Port Molle, and Port Curtis, which are indistinguishable from *Actinometra robusta* in almost every other character but those of the lower pinnules. All of them have three, and that from Port Molle as many as five pinnules with keeled basal joints; and for reasons which will appear immediately, we have, I think, no other course open to us but to refer them all, together with *Actinometra robusta*, to one and the same type, *Actinometra solaris*. When describing the Comatulæ obtained by the "Alert," Bell proposed, in the following terms,[2] to establish a new species, *Aetinometra intermedia*:—"As Mr. Carpenter has pointed out, it appears to be possible, in part at any rate, to distinguish *A. solaris* from *A. robusta* by the character of the keels, which, in the former, are so strikingly developed on the basal joints of the second pinnule. Basing myself on the theory that the keel is constantly present on the basal joints of the second pinnule of *A. solaris*, and that it is never found on those of *A. robusta*, I venture to think that, in the case of *A. intermedia*, we have to do with a form in which constantly the keels are never as well developed as in *A. solaris*, and never so slightly as in *A. robusta*, while at the same time there are considerable differences in the extent of the development of the keel, not only within the limits of the species, but even of the individual."

I have made a careful examination of the half dozen specimens which Bell referred to *Aetinometra intermedia*, and I find it impossible to differentiate them from *Actinometra solaris*. They present a great amount of variation in the carination of the basal pinnules, but not more so than I have found in a number of specimens collected by the Challenger in Torres Strait, which I now refer to *Actinometra solaris*, though, like Bell, I formerly considered them as representing a new species (which I called *Actinometra strota*), intermediate between *Actinometra solaris* and *Actinometra robusta*. The Challenger specimens from Booby Island and Albany Island, and Bell's *Actinometra intermedia* from the latter locality, agree in every respect except colour. The lower pinnules are sometimes almost as slightly keeled as in the *robusta*-form (Pl. LIII. figs. 3–6); while, on the other hand, they may have all the characters of the pinnules in the typical *Actinometra solaris* (Pl. LIII. figs. 9–12), and the development of the keel is not constant in any individual specimen. They all agree, however, in having from eighteen to twenty cirrus-joints, and in the indistinct nature of the medio-dorsal ridge;

[1] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 517.
[2] "Alert" Report, p. 166.

while when the lower pinnules have keels, they are developed like those of *Actinometra solaris*, *i.e.*, on two or three joints (Pl. LIII. figs. 11, 12), and not on one only as is so usual in *Actinometra pectinata* (Pl. LIII. figs. 17–20).

We have already seen that there are similar variations, though of a somewhat more extensive character, among the largest specimens of all which would naturally be referred to *Actinometra robusta;* and I do not think therefore that any other course is possible than to consider *Actinometra intermedia* and *Actinometra robusta* as identical with *Actinometra solaris.* The variation in the extent of development of the keel—from almost nothing but a mere sharpened dorsal edge to large projections on two or three joints of from two to five pinnules—then becomes itself a character of specific value, just as Bell pointed out for *Actinometra intermedia.* For so far as my experience goes the basal pinnules of *Actinometra pectinata* are much more uniformly carinate than in *Actinometra solaris.* With the possible exception of the immature specimen which is the type of *Alecto purpurea*, Müller, I have never seen any individual which would be referred to *Actinometra pectinata* on account of its cirrus-characters, with so slightly developed keels on the lower pinnules, as are shown in Pl. LIII. figs. 5, 6; and I know of none which are absolutely keelless, like the form which I described as *Actinometra robusta*, but now refer to *Actinometra solaris.*

The habit of *Actinometra brachiolata* is only known vaguely as "Australia"; but the geographical range of *Actinometra solaris* and *Actinometra pectinata* is very much better defined. They are limited to quite shallow water, 12 fathoms or less, in the Eastern Archipelago, scarcely extending, however, beyond the limits of the tropics.

Actinometra pectinata ranges as far west as Java and Singapore, and has also been found among the Philippines and Moluccas. It likewise occurs along the north-west coast of Australia, in the Arafura Sea, and on the Queensland coast from Cape York to Port Curtis. I have seen examples of *Actinometra solaris* from the China Sea and from Hong Kong, Singapore, and Billiton; but I know of no other localities for it between Java and Torres Strait. Like *Actinometra pectinata*, it is abundant at Cape York and down the Queensland coast to Port Curtis, in lat. 24° S. But with this exception, I have never heard of either of these two species occurring to the south of the Tropic of Capricorn, abundant as they are on the northern shores of the continent. They represent perhaps the most characteristic type of the Crinoid fauna of the Eastern Archipelago, not extending eastwards to Fiji, nor even to Mergui on the west; though these localities have representatives respectively of the other two groups of *Actinometra*-species which have the radials united by syzygy. A form like *Actinometra paucicirra* occurs at Mergui, while *Actinometra typica* extends from Malacca to Fiji.

But so far as my present knowledge goes not one of these three types of structure is represented among the Comatulæ of Southern Australia. *Actinometra paucicirra* abounds at Cape York, was found by Jukes on the reef of Atagor, and is recorded from

Port Molle; but it is not known from any locality further south. Port Molle is likewise the southern limit of two other widely distributed species. (1) *Antedon milberti*, which extends as far west as Mergui. (2) *Actinometra parvicirra*, which is still more widely distributed in the Eastern Archipelago, and also occurs on the coast both of South Africa and of Peru. Then again two members of the large *Palmata*-group occur at Port Molle, but the group is not represented further south.

Thus then, not one of these common tropical species enters into the fauna of Southern Australia; and, on the other hand, the two Comatulæ which are especially characteristic of this region do not extend into the tropics. *Antedon macronema* occurs at King George's Sound, Port Jackson, and Port Stephens, while *Actinometra trichoptera* has been found at King George's Sound, Port Philip, and Port Jackson; but neither of them reaches Port Curtis.

These facts confirm in a very striking manner the views of Günther and Bell respecting the independence of the marine fauna of Southern Australia, as compared with that of the north-eastern and northern shores of that continent. The following statement which was made by Bell[1] as the result of his studies of the Asterids, Ophiurids, and Urchins, is equally true of the Crinoids:—"The species found on the northern and north-eastern shores of Australia have a wide range eastward and westward, but gradually disappear as we pass southwards. In fine, an Australian Echinoderm-fauna, as conterminous with the Australian shores, does not exist."

The Crinoid fauna of Western Australia is still almost completely unknown; but from what little I have seen of it, I believe it to be essentially identical with that of the Eastern Archipelago.

1. *Actinometra pectinata*, Retzius, sp. (Pl. LIII. figs. 15–22).

Specific formula—a.R.$\frac{br}{2}.\frac{ab}{a}$.

1758. *Asterias pectinata*, Linnæus (*pars*), Systema Naturæ, 10th ed., Holmiæ, 1758, t. ii. p. 663.
1783. *Asterias pectinata*, Retzius (*pars*), K. Svensk. Vetensk. Akad. Handl., År. 1783, t. iv. p. 241.
1788. *Asterias pectinata*, Linnæus (*pars*), Systema Naturæ, ed. 13, cura J. F. Gmelin, Lipsiæ, 1788, t. i. pars vi. p. 3166.
1805. *Asterias pectinata*, Retzius (*pars*), Dissertatio sistens Species Cognitas Asteriarum, Lundæ, 1805, p. 43.
1843. *Alecto purpurea*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 132.
1843. *Asterias pectinata*, Müller, *Ibid.*, p. 133.
1849. *Comatula* (*Actinometra*) *solaris*, var.? Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 249.
1862. *Comatula purpurea*, Dujardin and Hupé, Hist Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 202.
1862. *Actinometra pectinata*, Dujardin and Hupé, *Ibid.*, p. 210.

[1] "Alert" Report, p. 175.

1879. *Actinometra pectinata*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 27, pl. v. figs. 5–9; pl. viii. figs. 5–8.
1879. *Comatula purpurea*, P. H. Carpenter, *Ibid.*, p. 27.
1879. *Actinometra purpurea*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 386.
1882. *Actinometra affinis*, Lütken, MS., Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 517.
1882. *Actinometra affinis*, P. H. Carpenter, Proc. Zool. Soc. Lond., 1882, p. 747.
1882. *Actinometra pectinata*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra purpurea*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra solaris*, Bell (*pars*), Rep. Zool. Coll. H.M.S. "Alert" Lond., 1884, p. 164.
1884. *Actinometra* sp. juv., Bell, *Ibid.*, p. 170.

Centro-dorsal a thin disk, bearing from ten to eighteen marginal cirri. These have nine to fifteen joints, usually eleven or twelve, the later ones smooth and generally but little longer than wide.

First radials more or less visible; the second very short, closely joined laterally, and united by syzygy to the widely pentagonal axillaries. Ten arms, which are widest about the tenth or twelfth brachial. They consist of some hundred and fifty subtriangular joints, nearly twice as wide as long, and provided with a tolerably distinct median ridge, the later joints becoming more quadrate. The posterior arms are sometimes non-tentaculiferous and taper more rapidly, with only about sixty joints.

A syzygy between the first two brachials, and another in the third; the next syzygy is anywhere between the eighth and twelfth brachials, with others at intervals of two to ten joints, generally four or five, but sometimes only two in the lower parts of the arms.

The first pair of pinnules (on second and third brachials) may reach 14 mm. long, with forty-five joints, mostly shorter than wide. The terminal comb is sometimes very large, more than half the joints taking part in its formation. The second pair of pinnules are shorter, with fewer and smaller joints, but are also combed; the third pair still shorter with stouter and wider joints, the dorsal edge sharply serrate, but not forming a true comb. The following pinnules are long again with stouter joints. The second, or sometimes the second and third, joints of the pinnules on the fourth and fifth brachials have the dorsal edge raised into a prominent keel. This is generally also present on the pinnule of the third brachial, sometimes on that of the sixth, and rarely on that of the second.

The mouth is generally radial; the disk sometimes quite naked, and sometimes a good deal plated, both along the ambulacra and between them.

Colour in spirit,—purple; reddish, greyish, or blackish-brown, passing into brownish-white. The arms of brown specimens may have a median band of white between two darker ones.

Disk 13 mm.; spread 18 cm.

Localities.—Cape York, September 7, 1874; channel between Albany Island and Somerset; 8 to 12 fathoms. One specimen.

Samboangan; 10 fathoms. Two specimens.

Other Localities.—Indian seas (Retzius); Australian seas (Peron and Lesueur); Singapore; Java; the Moluccas; North Celebes; Banka; Billiton; Bohol; North-west Australia; the Arafura Sea; Dundas Strait; Warrior Reef; Thursday Island; Prince of Wales Channel; Fitzroy Island; Port Molle; Port Curtis.

Remarks.—Müller associated this species with the name of Retzius,[1] referring only to the latter author's famous dissertation which was published in 1805. The name, however, had been used by Linnæus in the tenth edition of the Systema Naturæ (1758), the first in which species were characterised;[2] and it was also employed by Retzius[3] in 1783. Linnæus referred to *Asterias pectinata* the two ten-armed Comatulæ figured by Linck,[4] which are the British and the Mediterranean varieties of *Antedon rosacea*, and also the *Stella chinensis* of Petiver. But except for his mention of the type as belonging to the Indian seas, there is no evidence of his having associated the specific name *pectinata* with any particular form from this locality. This, however, was done by Retzius in 1783 and again in 1805, when he separated *Asterias tenella* from *Asterias pectinata*, and his type specimens of both species are still in existence. He added a description in Swedish to the Linnæan diagnosis of *Asterias pectinata*, and his reference to the number and characters of the cirri indicates that he was not speaking of a European *Comatula*, but of the specimen from the Indian seas in the Retzian collection; while he eventually only included under this name one of Linck's two species, *Decacnemos barbata*, from the Mediterranean, remaining in doubt as to the position of the British *Decacnemos rosacea*.[5]

Lamarck made no allusion whatever to Retzius' two descriptions of *Asterias pectinata*, although the first one was quoted in Gmelin's edition of the Systema Naturæ on the same page (3166) as that to which Lamarck referred in the case of *Asterias tenella*. De Blainville also left it without notice as an eastern species, though he quoted Adams' use of the name for the British *Comatula;* and it remained in obscurity till Müller's visit to Lund in 1841. After examining Retzius' type specimen, he gave a careful and perfectly recognisable description of it, one of the best, in fact, which he ever wrote.[6] He eventually came to the conclusion, however, that it seemed to be a colour variation of *Comatula solaris*, Lamarck,[7] and he put *Asterias pectinata* into the synonymy of this type, but with a (?). I believe myself that the two species really are distinct; but should it ever become necessary to unite them under one name, that name must be *pectinata* and not *solaris*. Lamarck's description of *Comatula solaris* is as insufficient as that of

[1] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 133.
[2] *Op. cit.*, t. ii. p. 663.
[3] *K. Svensk. Vetensk. Akad. Handl.*, År. 1783, t. iv. p. 241.
[4] *Op. cit.*, Tab. xxxvii. figs. 64, 66.
[5] *Op. cit.*, p. 34.
[6] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 133.
[7] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 249.

Asterias pectinata by Linnæus, and the essential characters of the latter species were described by both Retzius and Müller before the latter author visited Paris and saw the Lamarckian types for himself, so that his diagnosis of them did not appear till six years after he had properly described *Asterias pectinata*.[1]

Dujardin and Hupé deserve the credit of having definitely restored *Asterias pectinata*, Retzius, to specific rank on the basis of Müller's description of it, though they erroneously state that it corresponds to *Comatula pectinata* and *Comatula barbata* of other authors.[2] Both these names were given to varieties of the European *Antedon rosacea*, which are altogether different from the type of *Asterias pectinata* from the Indian seas in the Retzian collection at Lund.

Remarks.—Little need be said about this species, as its essential characters have been fully discussed already. The centro-dorsal rarely conceals the first radials entirely (Pl. LIII. fig. 15), and it is sometimes relatively smaller than in any other *Comatula;* while each of the radial areas on its surface has a deep marginal hollow which corresponds to one on the surface of the radial above it.[3] It thus shows an approximation towards the characters of *Actinometra typica* and the other species which have more or less definite openings around the margin of the centro-dorsal (Pl. LVII. fig. 1; Pl. LXIII. fig. 6; Pl. LXV. figs. 1–6; Pl. LXVII. fig. 1). The three Challenger specimens are remarkable for having an interradial mouth, as it is radial in most examples of the type that I have seen, just as in *Actinometra solaris*.

The Copenhagen Museum contains a specimen from Java which bears the MS. name *Actinometra affinis*, Lütken. I was at first inclined to regard it as distinct from *Actinometra pectinata;* but since examining the "Alert" collection I have no doubt that the two forms are identical. The Java specimen is remarkable for the carination of the lower joints of the first pinnule, as in some individuals from Bohol in Semper's collection; while it has eleven arms, owing to one of the normal second brachials being replaced by an axillary, *i.e.*, there are two distichals united by syzygy, just as in *Actinometra paucicirra* (Pl. LIV. figs. 1, 2).

This, of course, is what might naturally be expected from the characters of the type.

[1] Troschel's description of *Alecto solaris* in 1843 omits all mention of the syzygies in the radials and lower brachials, and so is useless for the recognition of the species; while it appears two pages later than Muller's more detailed description of *Asterias pectinata*, which noticed this point and also the presence of the keel on the second pinnule, of which Troschel said nothing.

[2] *Op. cit.*, p. 209.

[3] See *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, pp. 67, 89–91, pl. v. figs. 6–9; pl. viii. figs. 5–8.

2. *Actinometra solaris*, Lamarck, sp. (Pl. V. figs. 4, *a–c*; Pl. LIII. figs. 1–14; Part I. pl. liv. figs. 10, 11; pl. lv. fig. 2).

Specific formula.—a.R.$\frac{br}{2}.\frac{ab}{ab}$.

1816. *Comatula solaris*, Lamarck, Histoire Naturelle des Animaux sans Vertèbres, Paris, 1816, t. ii. p. 533.
1834. *Comatula solaris*, de Blainville, Manuel d'Actinologie, Paris, 1834, p. 249.
1841. *Actinometra imperialis*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 181.
1843. *Actinometra imperialis*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 132.
1843. *Alecto solaris*, Müller, *Ibid.*, p. 135.
1843. *Actinometra imperialis*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1841 [1843], p. 226.
1849. *Comatula* (*Actinometra*) *solaris*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, 1847 [1849], p. 248.
1862. *Comatula solaris*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 200.
1862. *Actinometra imperialis*, Dujardin and Hupé, *Ibid.*, p. 209.
1869. *Comatula* (*Actinometra?*) *hamata*, Herklots, Bijdragen tot de Dierkunde, 1869, Bd. ix. p. 10, pl. ix.
1879. *Actinometra solaris*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 27, pl. i. fig. 2; pl. v. figs. 1–4.
1879. *Actinometra robusta*, P. H. Carpenter, *Ibid.*, p. 27, pl. v. figs. 10–15.
1881. *Actinometra solaris*, P. H. Carpenter, Notes from the Leyden Museum, 1881, vol. iii. p. 192.
1882. *Actinometra solaris*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 514.
1882. *Actinometra robusta*, P. H. Carpenter, *Ibid.*, p. 517.
1882. *Actinometra albonotata*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra solaris*, Bell, *Ibid.*, p. 535.
1882. *Actinometra albonotata*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra robusta*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra solaris*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra solaris*, Bell (*pars*), Rep. Zool. Coll. H.M.S. "Alert" Lond., 1884, p. 164, pl. xvi. fig. A, a.
1884. *Actinometra solaris*, var. *albonotata*, Bell, *Ibid.*, p. 165.
1884. *Actinometra intermedia*, Bell, *Ibid.*, p. 166, pl. xvi. fig. A, b.
1884. *Actinometra robusta*, Bell, *Ibid.*, p. 167, pl. xvi. fig. A, c.
1884. *Actinometra strota*, Bell, *Ibid.*, p. 167.
1885. *Actinometra solaris*, Bell, Proc. Linn. Soc. N. S. W., 1884 [1885], vol. ix. p. 498.
1885. *Actinometra intermedia*, Bell, *Ibid.*, p. 498.

Centro-dorsal a thin disk, bearing from ten to twenty-five marginal cirri. These have from seventeen to twenty-four joints, usually about twenty, the later ones smooth and sometimes much longer than wide.

First radials mostly concealed; the second very short, closely joined laterally, and united by syzygy to the widely pentagonal axillaries. Ten arms, which have more or less distinct alternate tubercular elevations at their bases, and are widest about the twelfth joint, reaching 5 mm. They may have nearly two hundred subtriangular joints, twice as wide as long, with but little or no indication of a median ridge, the later ones becoming more quadrate. The posterior arms are sometimes non-tentaculiferous, with fewer joints, and taper more rapidly. A syzygy between the first two brachials, and another in the third; the next anywhere between the eighth and twelfth, with others at intervals of three to ten, generally four or five joints.

The first pair of pinnules (on second and third brachials) may reach 25 mm. long, with about sixty joints, most of which are a good deal longer than wide, the latter half forming a large terminal comb. The second pair are shorter with fewer and smaller joints, but are also combed. The third pair are still shorter, with smaller basal joints, but the succeeding ones are wider, and somewhat saucer-shaped. Their dorsal edges often stand up prominently, but do not generally form a true terminal comb. The following pinnules are long again, with wider and more massive joints, which project laterally beyond their successors and are more or less sharpened along the medio-dorsal line.

The second and the two or three following joints of the pinnules on the fourth and fifth brachials have a sharpened dorsal edge, which is generally produced into a more or less prominent keel. The pinnule of the sixth brachial usually has the same character as the two previous ones, while keels may also be present on the second or more of the lower joints of the pinnules of the third and seventh brachials. Occasionally, however, there is no keel at all.

Mouth radial; disk sometimes quite naked, and sometimes very extensively plated both along the ambulacra and between them.

Colour in spirit,—deep purple or rose-colour, more or less relieved by patches of white and brown; light reddish-brown, the arms with a median band of white between two dark ones; or greyish-white with dark spots.

Disk 15 to 25 mm.; spread 25 to 30 cm.

Localities.—Cape York, September 7, 1874; Channel between Albany Island and Somerset; 8 to 12 fathoms. Several specimens.

Station 187, September 9, 1874; off Booby Island; lat. 10° 36′ S., long. 141° 55′ E.; 6 fathoms; coral mud. Abundant.

Other Localities.—"Indien" (Mus. Wien); Australian Seas (Peron and Lesueur); Hong Kong; China Sea; Singapore; Billiton; Prince of Wales Channel; Albany Island; Port Molle; Port Curtis.

Remarks.—This is a large and extremely handsome species when fully developed. The centro-dorsal of the form which has been hitherto known as *Actinometra robusta* may reach 7 mm. in diameter; and with the exception of this type and of *Antedon* *eschrichti*, there are few recent Comatulæ with a calyx which at all approaches that of many fossil species in size.

The centro-dorsal of the large Vienna specimen has lost all trace of its cirrus-sockets on one side, and is almost reduced to a level with the radials; while in an "Alert" specimen from Port Molle the sockets are all obliterated, leaving nothing but a thin flat plate, very much as in some forms of *Actinometra paucicirra* (Pl. LIV. figs. 1–4). The calyx of the form from Cape York, which I have hitherto called *Actinometra strota*, is represented in figs. 4, *a–c*, on Pl. V. Except for the almost entire absence of a basal star (fig. 4*c*), it is not greatly different from that of the individual from Singapore which I figured in 1879;[1] but it is very much smaller than the calyx of *Actinometra robusta*, which reaches 7 mm. in diameter, while 5 mm. is the maximum size of the Challenger specimens; and none of them show any trace of the curious diverticulum of the axial canal into the substance of the radial which occurs in that variety.[2]

The large "Alert" specimen from Port Molle is also remarkable for having the disk perfectly soft and membranous; while in others from Port Curtis and Torres Strait it is covered with minute polygonal plates, and the ambulacra are also strongly plated as shown in Part I., pl. liv. figs. 10, 11. The ambulacral plating ceases entirely, however, where the arms come off at the margin of the disk, and they have nothing at all like the ambulacral skeleton which is often so fully developed in *Antedon* and in the Pentacrinidæ.

A large number of this species were obtained by the Challenger at Booby Island, including several in a more or less immature condition. One of the smallest of these is represented on Pl. LIII. fig. 1, and is noteworthy for the great relative length of its arm-joints, as compared with those of the adult (fig. 2).

Bell has given the varietal name *albonotata* to a specimen from Albany Island with twenty to twenty-five cirri and but slightly keeled basal joints on the lower pinnules, in which the coloration consists of white spots on a dark ground.[3] But the colour variations of this species, even in one and the same locality, are almost as numerous as those of *Antedon carinata;* and I cannot see much use in giving varietal names even to forms which may seem to reach "the extreme limit of the species." Differences of colour are in fact quite useless for the purpose of specific discrimination among the Comatulæ.

2. The *Paucicirra*-group.

Bidistichate species, with twenty arms or more; the two outer radials and the first two joints after each axillary respectively united by syzygy.

Remarks.—This group includes only two species, which are closely allied to the

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. pl. v. figs. 1–4.
[2] *Ibid.*, p. 86.
[3] "Alert" Report, p. 165.

Solaris-group, but have twenty or more arms. The two outer radials, the two distichals, the two palmars (if present), and the first two brachials are respectively united by syzygy. One of these species was obtained at Mergui by Dr. J. Anderson, F.R.S., and is as yet undescribed. The other is *Actinometra paucicirra*, which is abundant in Torres Strait, and nearly always has its complete set of ten distichal axillaries (Pl. LIV. figs. 1, 2). On the rare occasions when one of these is absent there is still the syzygy between the two lower brachials, just as in *Actinometra solaris* and *Actinometra pectinata* (Pl. LIII. figs. 2, 15); while when distichals are abnormally developed in these forms there are two joints united by syzygy, just as in *Actinometra paucicirra*.

Actinometra paucicirra, Bell (Pl. IV. figs. 6, *a*, *b*; Pl. V. figs. 3, *a–c*; Pl. LIV.; also Part I., pl. lv. fig. 1).

Specific formula—a.R.$\frac{d.(p).br.}{2}.\left(\frac{a}{a}\right)$.

1879. *Actinometra Jukesii*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 390.
1882. *Actinometra paucicirra*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra jukesi*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra paucicirra*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra jukesi*, Bell, Rep. Zool. Coll. H.M.S. "Alert," Lond., 1884, p. 168.
1884. *Actinometra paucicirra*, Bell, *Ibid.*, p. 169.
1885. *Actinometra jukesi*, Bell, Proc. Linn. Soc. N.S.W., 1884 [1885], vol. ix. p. 498.

Centro-dorsal small and discoidal in young individuals, and bearing five to ten slender marginal cirri. These have twelve to eighteen smooth joints, most of which are longer than wide, the penultimate with a slight spine. In mature individuals the centro-dorsal is a flat pentagonal plate, flush with the radials and devoid of all trace of cirri.

Three radials visible, the two outer ones united by syzygy. The second are widely oblong but free laterally in young individuals, trapezoidal and closely united in the adult. Axillaries nearly pentagonal in the young, but almost triangular in the adult. Eighteen to twenty-three arms, but generally twenty, each ray bearing two distichal series, which consist of two joints, united by syzygy. The palmar series, if present, of the same character.

The first two brachials are united by syzygy, and the two outside arms of each ray also have a syzygy in the third brachial. The next syzygy is in the eighth or tenth brachial, the latter being common in the outer arms, and others follow at intervals of one to six, usually three or four joints. About one hundred and fifty brachials, the first five or six nearly oblong, the following ones more triangular and wider than long, becoming more quadrate towards the ends. The second brachial bears a long tapering pinnule with a large terminal comb. It may reach 20 mm. long, and consists of about sixty short joints, the lowest rather wide and stout, with prominent dorsal edges. The next four or five brachials bear similar pinnules with smaller combs and decrease rather rapidly in size, two or sometimes three of the basal joints becoming rather strongly keeled. The succeeding pinnules have stouter joints and increase a little in length.

The mouth is radial and almost marginal; and the anal area is more or less thickly covered with irregular plates, but the ambulacra are unprotected.

Colour in spirit,—reddish- or greyish-brown, bleaching to white, often with a dark medio-dorsal line.

Disk 18 mm.; spread 20 cm.

Localities.—Cape York, September 7, 1874; Channel between Albany Island and Somerset; 8 to 12 fathoms. Several specimens.

Station 187, September 9, 1874; off Booby Island; lat. 10° 36′ S., long. 141° 55′ E.; 6 fathoms; coral mud. Several specimens.

Arrou Islands. Three specimens.

Other Localities.—H.M.S. "Alert," Prince of Wales Channel; Albany Island, 3 to 4 fathoms; Port Molle, 12 fathoms.

Remarks.—This is one of the most easily recognisable species of *Actinometra*, owing to the entire absence of cirri in its adult state (Pl. LIV. figs. 1–7). After making a preliminary examination of the Challenger material I found that the type was already in the national collection, having been dredged by Jukes on the north-east coast of Australia; and I therefore proposed to call it "*Actinometra Jukesii*," under which name it was noticed in my Preliminary Report.[1] When the "Alert" collection reached the British Museum, it proved to contain several examples of this type which Professor Jeffrey Bell left undescribed, as he knew that I should publish its diagnosis in the present Report. The "Alert" also dredged some smaller individuals which resembled *Actinometra jukesii* in every respect except for the presence of half a dozen short cirri on the small centro-dorsal. It did not strike me, however, during my first and somewhat cursory examination of the "Alert" material, that these might be young individuals of *Actinometra jukesii*, like those which I had already noticed in my Preliminary Report; and they were eventually described and figured by Professor Bell under the name of *Actinometra paucicirra*,[2] by which the species must in future be known.

Two other immature specimens, differing somewhat from the type, were obtained by the Challenger at the Arrou Islands; and the centro-dorsal of one of them is figured on Pl. IV. fig. 6, *a*, under the specific name of *aruensis*, which should be changed to *paucicirra*, as I am now convinced that they belong to this species, though I regarded them as distinct when the plate was lettered, six years ago. The changes which take place in the centro-dorsal of the young *Actinometra paucicirra* during its growth to

[1] *Proc. Roy. Soc.*, 1879, vol. xxviii. p. 390.

[2] "Alert" Report, p. 169, pl. xvii. fig. A, a.

maturity have been already described on p. 14, and are illustrated on Pl. LIV. The young centro-dorsal is a rounded plate with a flattened ventral surface bearing relatively large basal grooves (Pl. IV. fig. 6*a*). These lodge the well-developed basal star, an isolated ray of which is seen in Pl. IV. fig. 6*b*. In the adult, however, the ventral surface of the centro-dorsal is much more convex, as it fits into the inverted funnel formed by the ring of radials (Pl. V. fig. 3*c*), no part of it being visible in a side view of the calyx (fig. 3*b*). Its dorsal surface is flush with that of the radials, which is often marked by the origin of a dark medio-dorsal line extending outwards over the calyx and the bases of the arms (Pl. LIV. fig. 2). These are most frequently twenty in number. Among fifty individuals I have only found one which had not got its full complement of distichal axillaries, one ray (which wants a second radial) being entirely without them, so that the number of arms is reduced to eighteen. Thirty-two examples have twenty arms; nine have twenty-one, seven twenty-two, and one twenty-three. The palmar series, when present, always resemble the distichals in consisting of two joints which are united by syzygy (Pl. LIV. fig. 2).

The arrangement of the syzygies at the bases of the arms is somewhat peculiar. There is always one between the first two brachials, even in the case where distichals are absent, so that the type then reverts to that of the *Solaris*-group, in which the distichal series, when abnormally present, resemble those of *Actinometra paucicirra*.

In both the members of the *Solaris*-group there is also a syzygy in the third brachial (Pl. LIII. figs. 1, 2, 15); and this is sometimes the case in *Actinometra maculata* (Pl. LV. fig. 2). It appears in one of the two arms of the single abnormal ray of the one individual of *Actinometra paucicirra* which has no distichal series. In normal individuals, however, the third brachial is very regularly a syzygial joint in the two outer arms of the ray, the normal sequence of the syzygies thus being 1–2, 3, 11, 15; whereas on the inner arms it is 1–2, 9, 13 (Pl. LIV. figs. 1, 2). This is a very distinct peculiarity of the species; but the syzygies are rather obscure in young individuals and it seems therefore to have escaped the notice of Bell, who makes no reference to it either in his diagnosis or in his figure of an immature specimen.

The two outside arms of each ray in young individuals are often much smaller than the inner pair (Pl. LIV. fig. 10). This is especially distinct in those from the Arrou Islands, in one of which, with a spread of 20 cm., the outside arms on some of the rays are so small as to look like unusually developed pinnules. But their true nature is shown by the fact that they bear small pinnules themselves. In the youngest of these small arms there is a relatively large pinnule on the second, and a very small one on the third brachial; but there are none on the next four joints, though they reappear again on the eighth. This is altogether in accordance with the mode of development of the pinnules in other Comatulæ, which I have described elsewhere.[1]

[1] *Bull. Mus. Comp. Zoöl.*, 1881, vol. ix. No. 4, pp. 14, 15.

The amount of carination of the lower pinnules varies considerably, just as it does in *Actinometra solaris* (Pl. LIII. figs. 3–22). As a general rule the first pair of pinnules have their basal joints somewhat produced towards the dorsal side, and in the next two pairs the second and third joints have rather prominent keels, traces of which are sometimes visible as far as the twelfth or fifteenth brachial. The terminal comb, which is very well developed on the basal pinnules, becomes gradually smaller and disappears about the sixth or seventh brachial.

The visceral mass of *Actinometra paucicirra*, like that of *Actinometra solaris*, which occurs at the same locality, is somewhat readily detached from the calyx, and it was occasionally dredged in an isolated condition. It is not so completely plated as that of *Actinometra solaris* often is. For the ambulacra are unprotected, and the interradial areas are covered by larger and more nodular plates than in the latter species (Part I., pl. liv. figs. 10, 11; pl. lv. fig. 1). Both species, however, may sometimes have the calcareous deposits considerably reduced in extent, though they are rarely entirely absent (Part I., pl. lv. fig. 2). The figured specimen of *Actinometra paucicirra* shows a small *Anilocra* living in the anal tube.

One tetra-radiate individual of this species occurred among all those dredged by the Challenger. An examination of the disk shows that the anterior ray A is missing, so that the mouth comes to be interradial, between the radii E and B, while the anus as usual lies between C and D. The only other species which presents the same arrangement of the arm divisions as occurs in *Actinometra paucicirra* is a new form from Mergui, which differs from it in having normally two, and sometimes three, postradial axillaries, and also in the presence of some thirty cirri on the centro-dorsal.

3. The *Typica*-group.

Tridistichate species with the radial axillaries and all the post-distichal axillaries united to the preceding joints by syzygy.

Remarks.—This group contains four of those abnormal species in which the two outer radials and the first two joints above the distichal and every subsequent axillary are respectively united by syzygy; while the distichal series itself consists of the usual three joints, with the axillary a syzygy. They are all confined to the Eastern Archipelago and Western Pacific, three of the four being purely littoral species; while *Actinometra typica* was also obtained by the Challenger in the neighbourhood of Fiji, from a depth of over 200 fathoms. The rays of this species, and also those of *Actinometra multibrachiata* divide very frequently, the number of postradial axillaries being sometimes as many as seven (Pl. LVI. fig. 3; Pl. LVII. fig. 1); whereas in *Actinometra distincta* there is no axillary beyond the palmar (Pl. LV. fig. 1). The mutual relations of the four species may be expressed as follows :—

A. Two post-radial axillaries. Twelve cirrus-joints, ... 1. *distincta*, n. sp.
B. Three or more post-radial axillaries.
  I. Centro-dorsal stellate, and without functional cirri, . . . 2. *typica*, Lovén, sp.
  II. Centro-dorsal bears functional cirri.
    a. Three or four post-radial axillaries. Cirri few, . . . *novæ-guineæ*, Müll., sp.
    b. Six or eight post-radial axillaries. Cirri well developed, . . 3. *multibrachiata*, n sp.

1. *Actinometra distincta*, n. sp. (Pl. LV. fig. 1).

Specific formula—a.R.3.$\frac{p.br.}{2}.\frac{b}{a}$.

Description of an Individual.—Centro-dorsal a thick rounded disk, bearing about thirty marginal cirri with a dozen joints, nearly all of which are longer than wide. The later joints have faint spines.

First radials just visible; the two outer ones short, wide, and united by syzygy. The second are also closely joined laterally. The rays may divide three times; three distichals, the third axillary with a syzygy; the two palmars and the first two brachials are respectively united by syzygy.

Thirty-six arms, of triangular joints which are wider than long and overlap slightly, the terminal ones becoming more quadrate. The anterior arms are long, slender, and slowly tapering, of one hundred and twenty to one hundred and fifty joints, while the posterior are short and taper rapidly, with only sixty to eighty segments.

A syzygy between the first two brachials; the next about the eighth or tenth, with others at intervals of two or three joints.

The pinnules decrease in length from that on the second distichal to those of the fourth and fifth brachials, and then become larger again. The first eight or nine pinnules on each side have a terminal comb, which may occur at intervals as far as the thirtieth brachial.

Mouth interradial and the anal tube almost marginal; a few small calcareous nodules on the disk.

Colour in spirit,—brownish-white, with dark spots on the medio-dorsal line of the rays and their branches as far as the first brachials; there are also lateral spots on the junction lines of the outer radials and lower distichals.

Disk 11 mm.; spread about 12 cm.

Locality.—Samboangan; 10 fathoms. One specimen.

Remarks.—Except for the characters of the rays and their subdivisions, this little species presents no special peculiarities, the shape of the arm-joints being that which is most common in the genus, while the lower joints of the pinnules are not carinate or otherwise distinguished. The absence of any axillary above the palmar separates it altogether from the multibrachiate species next to be described (Pl. LVI. fig. 3; Pl. LVII. fig. 1), while it is distinguished from *Actinometra paucicirra* by the greater number of distichal joints. All the arms seem to be tentaculiferous; but there may be nearly twice as many joints in the anterior as in the posterior arms.

2. *Actinometra typica*, Lovén, sp. (Pl. LVII. fig. 1).

Specific formula—a.R.3.$\frac{p.p_{,}'p_{,}'' \ldots p_{,}^{v}br.}{2}$.

1866. *Phanogenia typica*, Lovén, Öfversigt k. Vetensk.-Akad. Förhandl., 1866, No. 9, p. 231.
... *Actinometra stellata*, Lütken, MS., Museum Godeffroy.
1879. *Phanogenia typica*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 20.
1879. *Actinometra stellata*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 386.
1881. *Actinometra typica*, P. H. Carpenter, Notes from the Leyden Museum, 1881, vol. iii. p. 195.
1882. *Actinometra typica*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra typica*, P. H. Carpenter, *Ibid.*, p. 747.

Centro-dorsal stellate, with little or no trace of cirrus-sockets, and nearly flush with the radials, from which it is separated by distinct clefts, sometimes being even below their level. A syzygy between the two outer radials, which are both short and wide, the second being almost completely united laterally; but beyond this point the rays are quite free. Sometimes as many as seven postradial axillaries; the distichal series normally of three joints with a syzygy in the axillary, while the palmar and subsequent series are each of two joints united by syzygy. The first two brachials are united by syzygy and there may also be one in the third brachial. The next is about the eighth or tenth brachial, and others follow at intervals of two joints.

Eighty or more relatively short and slender arms of slightly overlapping, triangular joints. The first pinnule, on the second distichal, is long but rather slender, and composed of numerous short joints. The next, which is normally on the second brachial, is of the same character, but smaller, and the next few pinnules are of decreasing length, becoming longer and stouter again about the sixth brachial. The lowest pinnules have a well-defined terminal comb which extends to about the twelfth brachial, and occasionally appears further out on the arms. The joints of the middle and later pinnules are fringed with strong spines.

The mouth is usually subcentral and radial, with the primary ambulacra arranged very much as in *Antedon*, but the anal interradius is considerably the largest, with the anus near its margin. Both interradial and interpalmar areas are often much plated.

Colour in spirit,—brown.

Disk 20 mm.; spread reaching 25 cm.

Locality.—Station 174B, C, or D, August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms;[1] coral mud; bottom temperature at 610 fathoms, 39° F. One mutilated specimen.

Other Localities.—Malacca; Jobie; Zebu; Fiji; Kingsmill Islands.

Remarks.—This species is the one for which the genus *Phanogenia* was established by Lovén[2] on account of its stellate centro-dorsal and exposed first radials. The same peculiarity was noted by Dr. Lütken in an *Actinometra* of the Godeffroy collection from Fiji, to which he gave the MS. name *Actinometra stellata*; and duplicates of the type have been distributed from the Godeffroy Museum under this name. Having examined some of these duplicates, and also by the kindness of Professor Lovén his original specimens of *Phanogenia*, I came to the conclusion, as Dr. Lütken had previously done, that the two types are identical. Lovén's generic name thus becomes a synonym of *Actinometra*, while his specific name is that by which the type must be known for the future. It is a sufficiently remarkable species, apart altogether from the peculiarities of its radials and centro-dorsal. For the mouth is at no great distance from the centre of the disk, and the arrangement of the ambulacra in five primary divisions is almost as regular as in the Endocyclic Crinoids. The anal interradius is therefore by no means so large and conspicuous as it usually is in *Actinometra* (Pl. LVII. fig. 3; Pl. LXVIII. fig. 1).

Lovén described the two outer radials of this type as articulated bifascially;[3] but I believe them to be really united by a syzygy of much the same character as occurs in *Pentacrinus* and *Rhizocrinus*, viz., with the apposed faces almost smooth and devoid of the radial striation which is so marked in the syzygies of *Antedon*. The result is that the junction line of the two joints is simple, instead of being more or less interrupted as in the syzygies of the later ray-divisions in this type and in most other Comatulæ. Lovén gave a sketch of the distal face of a second radial in *Actinometra typica*[4] which seems to have a median vertical ridge like that which he figures in the corresponding part of *Antedon eschrichti*.[5] In reality, however, there is not an articular ridge with a fossa on either side of it for the reception of a muscular or ligamentous bundle, but merely a division between the two sides of the joint-face, which has a slight general convexity; and there is a corresponding concavity, which is divided into two parts by a median line, on the proximal face of the axillary radial. If the two joints were really articulated each face would have a median ridge and lateral fossæ instead of fitting into one another by a slight curvature. The median line

[1] The exact station, and consequently the exact depth, is not recorded.
[2] *Öfversigt. k. Vetensk. Akad. Förhandl.*, 1866, No. 9, p. 231.
[3] *Ibid.*, p. 228.
[4] *Ibid.*, p. 230, fig. *c*.
[5] *Ibid.*, p. 230, fig. *k*.

represented by Lovén in his figure of the second radial also appears on an undoubted syzygial face from further out on the ray; and I have no doubt whatever that the union of the two outer radials is really a syzygial one, though the usual radiating ridges and furrows, which are so characteristic of syzygies in Comatulæ, are not present on the apposed faces. Traces of them are sometimes visible, however, as a series of little elevations which radiate outwards from the central canal and produce the appearance of a syzygial face with its ridges interrupted at intervals. But in other cases the apposed faces are almost smooth, just as in the syzygies of *Pentacrinus* and *Rhizocrinus*. The syzygies further out on the rays, however, are more normal in character.

There is a considerable amount of variation in the general features of this species. The form which comes nearest to it is *Actinometra novæ-guineæ*; but this is not known to have more than four post-radial axillaries, while *Actinometra typica* may have as many as seven. Furthermore the centro-dorsal of Müller's unique specimen of *Actinometra novæ-guineæ* was described by him as having "15 Ranken und mehr"; though it shows traces of clefts at the sides and approximates therefore towards the condition reached in *Actinometra typica*. Even in this last it may bear a few rudimentary cirri, as in the specimen figured by Lovén;[1] and there is a considerable amount of variation in the extent to which it is sunk within the radial funnel.

As in other species of *Actinometra* the tridistichate series is not unfrequently replaced by a bidistichate one. This occurs on both sides of two rays in the Challenger specimen (Pl. LVII. fig. 1); and the Copenhagen Museum contains one anomalous individual from Fiji in which eight out of the ten distichal series consist of but two joints. I believe them to be articulated, and not united by syzygy, as one would rather expect them to be. But then, it sometimes happens that there are three joints in a palmar or post-palmar series, instead of the normal two; and the first two of these are syzygially united, a condition which is altogether anomalous for a three-jointed series (see Rules 2, 6). On the other hand, however, it seems only natural that the terminal faces of the two joints borne on any axillary should have the same character, so that the normal syzygy of the one is accompanied by the abnormal syzygy of the other.

The range of this species, as at present known, extends from Malacca through the Philippine Group, to Fiji, in all of which localities it belongs to the purely littoral fauna. It was, however, obtained by the Challenger at a depth of over 200 fathoms, viz. 210, 610, or 255 fathoms. I imagine for many reasons that it did not occur at the greatest of these depths, no *Actinometra* having been yet obtained from below 600 fathoms.

[1] *Öfversigt k. Vetensk. Akad. Förhandl.*, 1866, No. 9, p. 230, fig. *a*.

3. *Actinometra multibrachiata*, n. sp. (Pl. LVI. figs. 3, 4).

Specific formula—a.R.3.$^{p.p' \ldots p^{vi}.br.}_{\quad 2}$. $\frac{b.}{a}$.

Description of an Individual.—Centro-dorsal a pentagonal disk with incurved sides which project somewhat over the smooth radials. Its dorsal surface is deeply hollowed in the centre, and bears about twenty-five cirri. These have fourteen to sixteen joints, nearly all of which are longer than wide, the penultimate with a small spine. Three radials visible. The first are raised at the angles, but deeply hollowed in the centre where they fail to meet the upper surface of the centro-dorsal. The two outer radials are short, wide, and united by syzygy. The second are only partly united laterally and the whole of the rays above them are quite free. Three distichals, the axillary a syzygy, and two palmars, united by syzygy. There may be six subsequent divisions which are normally similar to the palmars.

Arms slender, but very numerous, thirty or more to each ray, composed of some hundred and fifty triangular and overlapping joints with very spinous edges. The first two brachials are united by syzygy, and there is sometimes another in the third brachial; the next is about the tenth or twelfth, and others follow at intervals of two or three joints.

The first pinnule on the second distichal is very long and slender, reaching 20 mm, with numerous short joints; the next one, normally on the second brachial, is of the same character, but much smaller, and the next few are of decreasing length, after which there is but little increase. The lowest pinnules have a well-defined comb which extends to about the twelfth brachial, and sometimes appears quite far out on the arms; the joints of the middle and later pinnules are very spiny.

Colour in spirit,—dark brown.

Spread probably nearly 30 cm.

Locality.—Banda; 17 fathoms. One mutilated specimen.

Remarks.—Only a single mutilated example of this remarkable species was obtained, but its characters are sufficiently distinct to show that it cannot be referred either to *Actinometra novæ-guineæ* or to *Actinometra typica*. It resembles the latter form in the frequency of its ray-divisions, but differs from it altogether in having a relatively large centro-dorsal bearing over twenty well-developed cirri. On the other hand there are probably three times as many arms as in *Actinometra novæ-guineæ*, each of the rays which are preserved bearing thirty or more; while the centro-dorsal is larger with more numerous cirri than occur in that type. Its angles rest upon the raised marginal portions of the radials, which are deeply hollowed in the centre and do not therefore come in contact with the upper surface of the centro-dorsal, so that it overhangs them considerably when the calyx is viewed from the dorsal side.

Two of the rays only are preserved, the three others having broken away above the radial axillaries. One of them seems to have been of much smaller size than the rest, to judge from the two joints of it which remain (Pl. LVI. fig. 3). I am not sure, however, that this is simply a case of regeneration from the primary radials. For the small first radial in this case differs somewhat from its fellows; and its flattened central portion, which bears the small second radial, projects outwards a little beyond the general line of the radial pentagon. There may be some meaning in this asymmetry; but as the disk is lost it is impossible to determine whether it is related in any way to the position of the anus.

The character of the union between the first two distichals of this type has puzzled me greatly. It has very much the appearance of a syzygy, but I have not liked to attempt to settle the point by an actual examination of the joint-faces, as it would have involved so much further mutilation of an already imperfect specimen. This has been possible, however, in *Actinometra typica*, which has the usual bifascial articulation between the first two distichals; and as there are so many points of resemblance between this species and *Actinometra multibrachiata*, it is by no means improbable that the latter may be in the same condition, though the external characters seem to indicate the presence of a syzygy. This would be a new type of structure altogether; though it occurs abnormally in the distal parts of the rays of *Actinometra typica* (Pl. LVII. fig. 1), as I have already pointed out.

For the present, therefore, it will be safer to leave *Actinometra multibrachiata* in the same group with *Actinometra typica*, until the question can be definitely settled by the examination of more material.

Actinometra, Series II.

The two outer radials articulated. Ten arms.

Remarks.—This is a small series and contains but one group, which may be called the *Echinoptera*-group, after the name of its first described species. The Müllerian type of this species is in the University Museum at Berlin, where it was deposited by Captain Wendt many years ago, though no locality was recorded for it. I was permitted to examine it in 1880, and have since come to the conclusion that it is a Caribbean species, and not improbably identical with one of the many variations of the type which was described by Pourtalès in 1869 under the name *Antedon meridionalis*, A. Agassiz, MS., from the coast of South Carolina. This conclusion is strengthened by the fact, for which I am indebted to the kindness of Professor E. von Martens, that the Berlin Museum also contains some other Caribbean Echinoderms which were deposited by Captain Wendt.

Three of the five remaining species of the *Echinoptera*-group are also members of the Caribbean fauna, viz., *Actinometra pulchella*, Pourtalès, sp., *Actinometra rubiginosa*, Pourtalès, sp., and *Actinometra blakei*, an MS. species of my own, which is the host of *Myzostoma areolatum*, von Graff. These will all be described and illustrated in my Report on the "Blake" Comatulæ, where I hope to work out the relations of *Comatula echinoptera*, Müller, to the later described *Actinometra meridionalis*.

Actinometra pulchella is also a bidistichate species, while tridistichate series occasionally occur in *Actinometra rubiginosa*. The unique specimen of *Actinometra coppingeri*, Bell, has but twelve arms; and it is therefore not improbable that this species should be referred, like *Actinometra rubiginosa*, to the ten-armed series, as well as to the tridistichate one. It was obtained by the "Alert" at Flinders, Clairmont. Another specimen dredged by the "Alert" at Port Molle has been referred by Bell to *Actinometra cumingi*, Müll., sp., which was brought to the Berlin Museum from Malacca. But no member of this group was obtained by the Challenger in the Eastern Archipelago; and I have not seen more than half a dozen other individual representatives of it in addition to the three already mentioned, although I have visited all the chief continental collections. The type is evidently a rare one in the Eastern Archipelago, although so abundant in the Caribbean Sea and on the Brazilian coast. Most of the species of *Actinometra* which occur in the Eastern seas belong to the tridistichate type; and the ten-armed forms are almost exclusively represented by the *Solaris*-group, which is rich in individuals, though poor in species. But it does not occur at all in the Caribbean Sea where the *Echinoptera*-group is so extensively developed.

4. The *Echinoptera*-group.

Actinometra meridionalis (A. Agassiz), Pourtalès, sp. (Pl. IV. figs. 4, *a–c*; Pl. LVI. figs. 1, 2).

Specific formula—a.$\frac{b}{a}$.

1865. *Alecto meridionalis*, A. Agassiz, MS., Seaside Studies, Boston, 1865, p. 121, figs. 153, 154.
1866. *Antedon meridionalis*, Verrill, Proc. Bost. Soc. Nat. Hist., 1866, vol. x. p. 339.
1869. *Antedon meridionalis*, Pourtalès, Bull. Mus. Comp. Zoöl., 1869, vol. i. No. 11, p. 355.
1878. *Antedon meridionalis*, Pourtalès, *Ibid.*, vol. v. No. 9, p. 214.
1879. *Comatula meridionalis*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. pp. 20, 27.
1879. *Antedon meridionalis*, Rathbun, Trans. Connect. Acad., 1879, vol. v. p. 157.
1881. *Actinometra meridionalis*, P. H. Carpenter, Bull. Mus. Comp. Zoöl., 1881, vol. ix. No. 4, p. 6.
1882. *Actinometra meridionalis*, Ludwig, Mém. Acad. Sci. Bruxelles, 1882, t. xliv. p. 6.
1882. *Antedon meridionalis*, Bell, Proc. Zool. Soc. Lond., 1882, p. 533.
1882. *Actinometra meridionalis*, P. H. Carpenter, *Ibid.*, p. 747.

Locality.—Bahia; 7 to 20 fathoms. Fourteen specimens.

Other Localities.—South Carolina; West of Tortugas, and off French Reef in Florida

Strait, 35 to 45 fathoms; Caribbean Sea, abundant between 50 and 262 fathoms; off Cape Frio, Brazil, 35 to 45 fathoms (Hassler).

Remarks.—This species has been figured for the sake of comparison with the other ten-armed species of *Actinometra* which belong to the *Solaris*-group (Pl. LII. figs. 1, 2, 15). The essential difference between them is the absence in the *Echinoptera*-group of the syzygies between the two outer radials and the two lower brachials respectively, these joints being articulated as in most species of *Antedon*.

The examples of this species obtained by the Challenger at Bahia were the first representatives of the genus which I had seen from the Brazilian coast; and as I could not identify them with any form then described, I proposed to call the type *Actinometra brasiliensis*. The calyx is figured under this name on Pl. IV., which was printed off before I received the "Blake" collection containing the original examples of *Actinometra meridionalis*, and also a very large series of variations on the same general type. The exact number of specific forms belonging to this type which are represented in the Caribbean Sea, is a point which I propose to work out in my "Blake" report; and for the present therefore the Challenger species may be known under the name *Actinometra meridionalis*, though it is quite possible that this may have to be discarded in favour of *Actinometra echinoptera*, Müller, sp.

The dimorphism of the arms which is so common in the eastern forms of the genus is very well marked in some of the Challenger specimens of *Actinometra meridionalis*, the hinder arms being ungrooved and consisting of but half the number of joints which occur in the anterior arms. But none of them possess the problematical "sense-organs" on the pinnules which occur both in some individuals from Cape Frio and in others from French Reef on the Florida coast.

The calyx is that of a very typical *Actinometra*. The centro-dorsal is small and discoidal (Pl. IV. fig. 4*a*), and the articular faces of the radials are set vertically with small muscle-plates, so that their ventral aspect shows a widely open central funnel (fig. 4*c*); while there is a well-developed basal star, an isolated ray of which is shown in Pl. IV. fig. 4*b*.

Actinometra, Series III.

Two articulated distichals.

Remarks.—This corresponds to Series III. of the *Antedon*-species, and comprises the multibrachiate forms in which there are but two distichal joints united by a bifascial articulation like that between the two outer radials. There may be no further division as in *Actinometra maculata*, *Actinometra simplex*, and in some forms of *Actinometra pulchella* (Pl. LII. fig. 2; Pl. LV. fig. 2; Pl. LIX. fig. 1). But in other examples of *Actinometra pulchella* and in *Actinometra stelligera* there are palmar series like the distichals (Pl. LII. fig. 1; Pl. LVIII. fig. 1), and I have seen a Philippine specimen with two other divisions of the same character. On the other hand *Actinometra rotalaria* and *Actinometra valida* have the palmar and subsequent series of three joints, the axillary with a syzygy (Pl. LIX. figs. 2, 3). In these two species, and also in *Actinometra simplex* (Pl. LIX. fig. 1), the first syzygy in the free arm is that in the third brachial; but in *Actinometra pulchella*, *Actinometra maculata*, and *Actinometra stelligera* the first two brachials above the last axillary are normally united by syzygy (Pl. LII. figs. 1, 2; Pl. LV. fig. 2; Pl. LVIII. fig. 1). This is also the case in *Actinometra solaris*, *Actinometra paucicirra*, and *Actinometra typica* (Pl. LIII. fig. 2; Pl. LIV. fig. 1; Pl. LVII. fig. 1); but all these forms have a syzygial union between the two outer radials, which is not the case in those belonging to Series III.

This series thus falls into two very well defined groups according as there is a syzygial union or a bifascial articulation between the first two brachials of the free arm. The first of these is altogether unrepresented in *Antedon*, having a general formula— $a.2.(2.2.2.).\frac{br}{2}$.—and may be called the *Stelligera*-group, after a comparatively large and well-defined species from Fiji and Samoa (Pl. LVIII. fig. 1). It also includes the widely distributed *Actinometra pulchella*; but as this is a dimorphic type which also occurs in the ten-armed *Echinoptera*-group, the use of its name to denote a multibrachiate group might lead to confusion.

The more normal type of bidistichate species which have the first syzygy in the third brachial of the free arm is but poorly represented in *Actinometra*, though it includes a considerable number of *Antedon*-species. It is confined entirely to the Eastern Archipelago, not occurring at all in the Caribbean Sea, where every bidistichate *Actinometra* belongs to the protean type of *Actinometra pulchella*. There may be no palmars at all, as in *Actinometra elongata* and *Actinometra simplex* (Pl. LVII. fig. 2; Pl. LIX. fig. 1), or there are three with the axillary a syzygy, as in *Actinometra valida*, which has a further division of the same character (Pl. LIX. fig. 3). This being the best-developed species of the four members of the group which were obtained by the Challenger, it may be conveniently called the *Valida*-group.

5. The *Stelligera*-group.

Two articulated distichals. The palmars and subsequent series, when present, are of the same character; but the first two brachials are united by syzygy.

Remarks.—This is a very well defined group, although its type of structure is extremely anomalous and does not occur at all in *Antedon*, all the bidistichate species of which have the first two brachials articulated, whereas they are united by syzygy in *Actinometra stelligera* and its allies (Pl. LVIII. fig. 1).

This type has normally one and sometimes two post-distichal axillaries; while there are three in an undescribed species (*Actinometra nigra*) which was brought by Professor Semper from the Philippines. On the other hand there are none in *Actinometra maculata* (Pl. LV. fig. 2), and this is usually also the case in *Actinometra pulchella*, though palmars may be occasionally present (Pl. LII. fig. 1). This remarkable type occurs on both sides of the Atlantic, and possibly also in the Eastern Archipelago; but all the remaining members of the group are limited to the latter region and to the Western Pacific. Two of them, *Actinometra maculata* and *Actinometra stelligera*, were obtained by the Challenger, but the group is not represented in the "Alert" collection, though Dr. Coppinger dredged in two localities, Bowen and Torres Strait, where examples of it had previously been obtained.

The following scheme shows the mutual relations of the four species belonging to the *Stelligera*-group:—

A. Arm-joints triangular and of moderate length, ... 1. *pulchella*, Pourtalès, sp.
B. Arm-joints relatively short, becoming rather saucer-shaped.
  I. The first, and parts of the second radials concealed.
    a. No post-distichal axillaries. The later cirrus-joints bluntly spinous, ... 2. *maculata*, n. sp.
    b. One or two post-distichal axillaries. The cirri scarcely spinous, ... 3. *stelligera*, n. sp.
  II. The first radials partly visible, and the second entirely so. Three post-distichal axillaries, ... *nigra*, Semper, MS.

1. *Actinometra pulchella*, Pourtalès, sp. (Pl. IV. figs. 5, *a–c*; Pl. LII. figs. 1, 2).

Specific formulæ—$a.\frac{a}{b}.$; and—$a.2.(2).\frac{br}{2}.\frac{a}{b}.$

1878. *Antedon alata*, Pourtalès, Bull. Mus. Comp. Zoöl., 1878, vol. v. No. 9, p. 215.
1878. *Antedon pulchella*, Pourtalès, *Ibid.*, p. 216.
1881. *Actinometra pulchella*, P. H. Carpenter, *Ibid.*, 1881, vol. ix. No. 4, p. 10.
1882. *Antedon alata*, Bell, Proc. Zool. Soc. Lond., 1882, p. 532.
1882. *Actinometra pulchella*, Bell., *Ibid.*, p. 535.
1882. *Actinometra pulchella*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra pulchella*, P. H. Carpenter, Proc. Roy. Soc. Edin., 1884, vol. xii. p. 369.

Localities.—H.M.S. "Porcupine": Station 25, July 27, 1870; near Cape St. Vincent; lat. 37° 11′ N., long. 9° 7′ W.; 374 fathoms; rock; bottom temperature, 53°·5 F. One mutilated specimen.

Station 31, August 1870; lat. 35° 56′ N., 7° 6′ W.; 477 fathoms; clay; bottom temperature, 50°·5 F. One mutilated specimen.

H.M.S. Challenger: August 1873, St. Paul's Rocks. One specimen.

Station 192, September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud. One doubtful specimen.

Other Localities.—S.S. "Dacia," 1883; lat. 34° 57′ N., long. 11° 57′ W.; 533 fathoms.

The "Talisman," off Rochefort; 1500 metres.

The Caribbean Sea; abundant from 73 to 278 fathoms.

Remarks.—This singular species will be fully described and its variations illustrated in the Report on the Comatulæ of the "Blake" dredgings. It was first obtained by the "Porcupine" in 1870, though I never saw the type till 1883, nearly five years after it had been described by Pourtalès from the dredgings of the "Hassler" expedition at Barbados in 1872; and the Challenger had taken it at St. Paul's Rocks in the following year. The "Hassler" specimens were described by Pourtalès under the specific name *alata;* but at the same time he described an apparently different form from an unknown Caribbean locality as *Antedon pulchella;*[1] and when I subsequently found reason, after examining the rich material obtained by the "Blake" in 1878–79, to unite the two forms under one specific name,[2] *pulchella* seemed more appropriate than *alata.* I therefore described the type as *Actinometra pulchella.* It has been found at over thirty localities in the Caribbean Sea, ranging from 73 to 278, and possibly to 380, fathoms; while it presents a very singular instance of dimorphic specific characters. Some individuals have ten arms, each with a syzygy in the third brachial; but others have twenty, with two articulated distichals and the first two brachials united by syzygy. The "Blake" material contains numerous intermediate conditions between these two extremes, *e.g.*, individuals with twelve or fifteen arms, owing to the distichal series only occurring on some of the rays. The Challenger specimen from St. Paul's Rocks has twenty arms, with its full complement of ten distichal series. In the figured "Porcupine" example, however, there are but nine distichal axillaries; so that the number of arms would only be nineteen, but for the presence of a single palmar axillary, which brings the total up to twenty (Pl. LII. fig. 1).

This species is often an extremely difficult one to make out, owing to the obscurity of the syzygial union between the first two brachials, as long as the arms remain whole; but when they drop away and the syzygial faces are exposed there can be no mistake about the characters of the type. In some cases they have broken at the syzygy in the third brachial; though this is not always a syzygial joint, except perhaps in the two outer arms of the ray.

The Challenger's discovery of this species at St. Paul's Rocks extended its geographical range very considerably, and has probably also brought its bathymetrical range up to less than 70 fathoms, the specimen having been obtained at some depth between 10 and 80 fathoms. In like manner the presence of this species among the "Porcupine" collection, from 374 and 477 fathoms near the entrance to the Straits of Gibraltar, brings it into the

[1] *Bull. Mus. Comp. Zoöl.*, 1878, vol. v. No. 9, pp. 215, 216. [2] *Ibid.*, 1881, vol. ix. No. 4, p. 10.

European fauna, and adds nearly 200 fathoms to its bathymetrical range, which is still further increased to 533 fathoms by the dredgings of the telegraph ship "Dacia," some four degrees more to the west. Judging from a figure published in La Nature[1] I imagine that it was also obtained by the "Talisman" in 1500 metres off Rochefort.

Among the numerous Comatulæ which were dredged at Station 192 in the Arafura Sea was a single mutilated specimen which has given me very great trouble (Pl. LII. fig. 2). Three of the rays which are preserved have bidistichate series, and the first two brachials above the axillaries are clearly united by syzygy, the radiating ridges being very distinct on the exposed distal faces of two of the first brachials. But I have had much difficulty in determining the nature of the union between the two outer radials and the two distichals respectively; and after repeated changes of opinion, I have come to the conclusion that there is a bifascial articulation in each case. The specific formula thus becomes the same as that of *Actinometra pulchella*, and in the absence of better preserved material it seems best to refer the individual in question to this protean species. The eastern form has fewer cirrus-joints, with larger and blunter spines than may occur in the Caribbean type; and the characters of the lower pinnules do not seem to be quite the same in the two cases. But I have been unable to make out any differences which would serve to separate the two forms specifically, though it is quite possible that they may reveal themselves when better preserved material is examined. On the other hand there is no *a priori* reason why *Actinometra pulchella*, which occurs on both sides of the Atlantic, should not also inhabit the Eastern seas. Another common Caribbean species, *Antedon carinata*, is widely distributed through the Indian Ocean and also occurs in the Pacific; while *Antedon quinquecostata*, which was dredged by the Challenger at Station 192, together with the doubtful form under consideration, is very closely allied to the Caribbean *Antedon spinifera*.

On the whole, then, it appears most probable that the specimen obtained by the Challenger in the Arafura Sea really does belong to *Actinometra pulchella*, though one would like to see a more perfect specimen before definitely making such a large addition to the geographical range of the Caribbean type. It is also possible, on the other hand, that we are here dealing with a varietal form of *Actinometra maculata* from Torres Strait (Pl. LV. fig. 2); but I rather doubt this being the case, as its arm-joints are relatively longer than those of that type, and the terminal cirrus-joints are more compressed laterally. The Copenhagen Museum contains a form from Bowen with very much the same characters, which bears the MS. name *Actinometra fusca*, Lütken. This may be either *Actinometra pulchella* or *Actinometra maculata*, but the question of its specific identity must be left for a future decision.

[1] See H. Filhol, Explorations sous-marines, *La Nature*, 1884, 12 Ann. p. 329.

2. *Actinometra maculata*, n. sp. (Pl. V. figs. 1, *a–d*; Pl. LV. fig. 2).

Specific formula—$a.2.\frac{br}{2}.\frac{br}{ab}$.

Centro-dorsal a wide disk bearing twenty-five to thirty-five cirri of about twenty joints. A few of the lower joints are longer than wide, but the remainder are short, laterally compressed, and bluntly spinous.

The first radials are concealed, and also part of the second, which are closely united laterally. Two distichals, the axillary not a syzygy.

Twenty arms, of about one hundred and twenty shortly triangular joints, which overlap slightly and are sometimes almost saucer-shaped. The first two brachials are united by syzygy, and there may be another in the third brachial. The next is about the tenth or twelfth joint, and others follow at intervals of two or three joints.

The second brachial has a pinnule some 15 mm. long, with a well-defined terminal comb; and the length gradually decreases to the pinnules of the eighth or tenth brachials, which are stouter, but not specially short, and have no comb.

The two basal joints of the first four pinnules on each side are more or less carinate.

Mouth radial; disk naked.

Colour in spirit,—dark reddish-brown, somewhat mottled with patches of yellowish-green.

Disk 12 mm.; spread 14 cm.

Locality.—Station 186, September 8, 1874; Prince of Wales Channel; lat. 10° 30′ S., long. 142° 18′ E.;. 8 fathoms; coral mud. Two specimens, one much mutilated.

Remarks.—This elegant species differs from *Actinometra pulchella* in the shortness of its arm-joints, a character in which it resembles *Actinometra stelligera* (Pl. LV. fig. 2; Pl. LVIII. fig. 1). It is possibly identical with Lütken's MS. species, *Actinometra fusca*, from Bowen, in the Copenhagen Museum.

The calyx has many resemblances to that of the allied species *Actinometra stelligera* (Pl. V. figs. 1, 5, *a–d*). In both cases the centro-dorsal is wider than the radial pentagon, so as to conceal part of the second radials (figs. 1*a*, 5*a*), while the basal star is very well defined (figs. 1*c*, 5*d*). The under surface of the centro-dorsal in *Actinometra maculata* is marked by five indistinct elevations which correspond in position with the low ridges beneath the basal grooves in its internal cavity.

3. *Actinometra stelligera*, n. sp. (Pl. V. figs. 5, *a–d*; Pl. LVIII. figs. 1, 2; also Part I. pl. lvi. fig. 8).

Specific formula—a.2.2.(2).$\frac{br}{2}.\frac{bc}{ab}$.

... *Actinometra tenax*, Lütken, MS., Museum Godeffroy.
1880. *Actinometra stelligera*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1880, vol. xv. pl. xii. fig. 26.

Centro-dorsal a wide and rather thick disk bearing some thirty marginal cirri, with twenty joints, a few of the lower ones being longer than wide. From the twelfth onwards they are wider than long, sometimes with slight indications of a blunt dorsal spine, which is more marked on the penultimate.

First radials concealed, and also part of the second, which are closely united laterally. Two distichals, two palmars, and sometimes two post-palmars; each division of two joints, the axillary not a syzygy.

Thirty to forty arms, consisting of about one hundred and twenty slightly overlapping triangular joints, which are much wider than long, especially in the middle and outer parts of the arms.

The first two brachials are united by syzygy; and in the two outer arms of each ray the third brachial is generally a syzygial joint. The next syzygy is in the tenth or twelfth brachial, and others follow at intervals of two or three joints.

The second brachial has a pinnule about 16 mm. long, with a well-defined terminal comb; and the length gradually decreases to those of the eighth and ninth brachials, which are short and have no comb. The two basal joints on the pinnules of the third and the six or seven following brachials are more or less distinctly keeled.

Mouth generally radial; the anal area often rather thickly plated.

Colour in spirit,—reddish or blackish-brown.

Disk 15 mm.; spread 18 cm.

Locality.—Station 174B, C, or D, August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 610, or 210 fathoms;[1] coral mud; bottom temperature at 610 fathoms, 39° F. Seven specimens.

Other Localities.—Tonga; Fiji; Samoa; Reef of Atagor (Jukes).

Remarks.—I believe this fine species to be identical with the type which has been distributed by the Godeffroy Museum under the name of *Actinometra tenax*, Lütken, but I did not discover the fact till after some of the plates illustrating its structure had been lettered and printed off. The name which it now bears relates to the appearance of the basal star, which stands out in white from a brownish background when the centro-dorsal is removed from the radials. The ends of the star sometimes appear

[1] The exact station, and consequently the exact depth, are not recorded.

externally between the angles of the radials, as seen in Pl. V. fig. 5*b*. The radials somewhat resemble those of *Actinometra maculata* in not completely covering the centro-dorsal (Pl. V. figs. 1*a*, 5*a*); but the ventral pair of muscle-fossæ on their articular faces is even more reduced than in that type (Pl. V. figs, 1*b*, 5*b*, 5*c*). The two species are closely allied, however, and may eventually prove to be connected by intermediate forms. *Actinometra stelligera* is the larger of the two, and has a greater number of arms, palmars being always developed, and sometimes post-palmars also; while there are no post-distichal axillaries in the two examples of *Actinometra maculata*, which also has rather more spinous cirri. The two species further present the same sort of difference in the carination of the basal pinnules as occurs between *Actinometra solaris* and *Actinometra pectinata*. In *Actinometra maculata* there may be keels on the pinnules of the second to ninth brachials, whereas in *Actinometra stelligera* there is no sign of carination on the basal joints of the first pinnule, though there may be on that of the fifth on the same side (10th br.).

Reversions to the more normal type of arm-structure sometimes occur. Thus, for example, the outer arm of the right hand ray in the figured specimen of *Actinometra stelligera* (Pl. LVIII. fig. 1) has the first two brachials articulated like the radials and distichals; whereas in the other arm borne on the same distichal axillary, and in three similar arms of the centre ray, these two joints are united by syzygy. Two curious abnormalities of the disk have also come under my notice. In one case there are two mouths and two anal tubes, as shown in Part I. pl. lvi. fig. 8; while in the other the anal tube is close up to the peristome, a little to one side of the median line, and not central as is usually the case.

The depth at which this species was dredged is not known with certainty; but it was probably either 210 or 255 fathoms, the third depth at this locality being an improbable one for an *Actinometra*, especially as the type belongs to the littoral fauna at Fiji, Samoa, and Tonga. There is a closely allied, if not identical, species from Zebu in the Museums at Dresden and Vienna. Semper's Philippine collection also contains a fine species belonging to this group, which differs from *Actinometra stelligera* in the presence of a third axillary beyond the distichals, and in the relatively smaller size of the centro-dorsal, so that not only the second radials, but also portions of the first, are visible externally. It is the type to which I have occasionally referred as *Actinometra nigra*, Semper, MS., and is remarkable for the great development of the branches of the axial cords of the arms and of the par-ambulacral network which is connected with them in the ventral perisome, and also for the large size of the radial blood-spaces beneath the ambulacra, the existence of which in *Antedon rosacea* has recently been denied by Messrs. Vogt and Yung.[1] Figures illustrating these points were given in Part I. pp. 121, 122, and pl. lxi. fig. 6.

[1] Traité d'Anatomie comparée pratique, 1886, Livr. vii. p. 538.

6. The *Valida*-group.

Two articulated distichals; the first arm-syzygy in the third brachial.

Remarks.—Two somewhat different types of structure are comprised in this group, viz., forms with two palmars like the distichals, and forms with three palmars of which the axillary is a syzygy. In addition to these there are also the species, like *Actinometra elongata* and *Actinometra simplex*, which have normally no palmar series at all (Pl. LVII. fig. 2; Pl. LIX. fig. 1). With one exception, which is in the National Collection, these are the only species of the genus which have such a simple ray-structure; and I do not know of any other form which has its subsequent arm-divisions of the same character as the distichals. This is in remarkable contrast to the number of *Antedon*-species which have the same general formula and belong to the *Spinifera*- and *Palmata*-groups.

On the other hand a few *Actinometra*-species like *Actinometra rotalaria* and *Actinometra valida* have one or more arm-divisions beyond the distichal axillary, each consisting of three joints with the axillary a syzygy, an arrangement which does not occur in *Antedon*. Some of the individuals which have been distributed by the Godeffroy Museum, under Lütken's MS. names *Actinometra intricata* and *Actinometra trachygaster*, are of this character; but other specimens bearing the same names are tridistichate, and therefore resemble *Actinometra parvicirra* (Pl. LXI. figs. 1, 5). The two types are so intimately connected, however, that it is impossible to consider them as representing separate groups. Thus, for example, I have described examples of *Actinometra parvicirra* in which half the distichal series consisted of two, and the other half of three joints; and a specimen in the Vienna Museum presents a similar variation. Then again, two (or more) three-jointed distichal series occur in the unique specimens of *Actinometra elongata* and *Actinometra valida*, and in the figured one of *Actinometra rotalaria* (Pl. LVII. fig. 2; Pl. LIX. figs. 2, 3); while in the two last two-jointed palmar series may also present themselves as a variation on the normal three-jointed type.

Under these circumstances it is clear that these variations in structure are not morphologically equivalent to the changes in the position of the arm-syzygies which characterise the *Stelligera*- and *Fimbriata*-groups (Pl. LVIII. fig. 1; Pl. LXII. fig. 3), the former having a syzygy *between* the first two brachials, while the latter has a syzygy *in* the second brachial; and until the discovery of hitherto unknown species renders the number of forms comprised in the *Valida*-group much more considerable than it is at present, we shall do best to include in it all those bidistichate species which have the first arm-syzygy in the third brachial, whether the palmar series consists of two or of three joints.

All the members of the group, as at present constituted, are confined exclusively to the Eastern Archipelago, including the Fiji and the Friendly Islands.

The following key shows the mutual relations of the species described in this Report :—

A. No post-distichal axillaries.	
First radials visible ; arm-joints relatively long, ...	1. *elongata*, n. sp.
First radials concealed ; arm-joints short and wide, ...	2. *simplex*, n. sp.
B. Three palmars, the axillary a syzygy.	
No post-palmars ; ten cirri of ten or twelve joints, ...	3. *rotalaria*, Lam., sp.
Post-palmars like palmars ; fifteen cirri of fifteen joints, . . .	4. *valida*, n. sp.

1. *Actinometra elongata*, n. sp. (Pl. LVII. figs. 2–4).

Specific formula—$a.2.\frac{a}{a}$.

Description of an Individual.—Centro-dorsal a small thin disk, bearing about ten cirri of twelve or fourteen joints, a few of which are longer than wide. Three radials visible ; the second partly united laterally, the remainder of the rays being well separated. Two distichals, the axillary without a syzygy.

Eighteen arms, which are all tentaculiferous, but dimorphic. The anterior arms taper slowly, reaching 11 cm. in length, and consist of one hundred and twenty quadrate segments, the middle and later ones of which are very long. The posterior arms reach only 4·5 cm., and taper rapidly, with about fifty-five shorter but still quadrate joints.

A syzygy in the third brachial ; the next between the sixth and tenth, with others at intervals of about three joints.

The pinnules diminish in length from the first one on the second brachial, which reaches 8 mm., to those of the fifth and sixth, and then increase again, becoming very long and slender at the ends of the arms. The first six or eight have a slight terminal comb, which occurs at intervals to far out on the arm. The later pinnules of the posterior arms have "ovoid bodies" on their dorsal edge.

Mouth nearly radial ; disk naked.

Colour in spirit,—greenish grey.

Disk 11 mm.; spread nearly 20 cm.

Locality.—Banda ; October 1, 1874.

Remarks.—This is a singular type in many ways. It differs altogether from the majority of species of *Actinometra* in the great length of its arm-joints, which is especially evident in the longer anterior arms (Pl. LVII. fig. 2) ; though the joints of the posterior arms are also relatively long. The only form which comes at all near it in this respect is the tridistichate *Actinometra quadrata* (Pl. LXII. fig. 1). The great difference in length between the anterior and posterior arms is the more remarkable, as they are all tentaculiferous, none of them being unprovided with an ambulacral groove, as is so often the case. But the distal pinnules in at least five of the posterior arms are provided with the curious ovoid bodies on their dorsal aspect which I have noticed in some forms of *Actinometra parvicirra*.[1] In the latter type the pinnules which bear these bodies are generally non-tentaculiferous; but this is not the case in *Actinometra elongata*.

The centro-dorsal of this form is very thin, with much reduced cirrus-sockets, and is evidently in process of transformation into the *Phanogenia*-condition shown on the same plate (Pl. LVII. figs. 1, 2). One of the arms has been broken at the syzygy in the third brachial, and the new epizygal is an axillary, as is so frequently the case. This fact may possibly indicate that when palmars are developed in this type, there are normally three with a syzygy in the axillary, so that it would then be allied to *Actinometra rotularia* and *Actinometra valida* (Pl. LIX. figs. 2, 3).

The terminal comb on the oral pinnules is rather a small one, but it may occur at intervals to some way out on the arms. The disk is very large and prominent, without any trace of calcareous deposits, and the radial position of the mouth is not very distinct (Pl. LVII. fig. 3).

2. *Actinometra simplex*, n. sp. (Pl. LIX. fig. 1).

Specific formula—a.2. $\frac{b}{a}$.

Description of an Individual.—Centro-dorsal a thin disk bearing about fifteen marginal cirri with fourteen to seventeen segments, a few of which are longer than broad. First radials concealed, and also portions of the second, which are partly united laterally. Two distichals, the axillary without a syzygy.

Eighteen arms; the anterior with one hundred joints, as compared with forty-five in the posterior arms, some of which are non-tentaculiferous. The joints are short, subtriangular, and slightly overlapping, becoming more elongated at the ends of the anterior arms. A syzygy in the third brachial, and the next about the tenth brachial, with others at intervals of two to four joints.

The second brachial bears a pinnule about 7 mm. long, and the following pinnules diminish to those on the fifth and sixth brachials, afterwards increasing again. The terminal pinnules of the anterior arms are very long and slender, those of the posterior arms being shorter and stouter. The first four pinnules on each side have a small terminal comb, which is found at intervals till near the ends of the arms.

Mouth interradial; a few calcareous granules on the disk.

Colour in spirit,—the skeleton a dull green, and the ventral perisome deep brown.

Disk 8 mm.; spread 9 cm.

Locality.—The Admiralty Islands; 16 to 25 fathoms. One specimen.

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1879, vol. ii. p. 40, pl. ii. fig. 6, *o.b.*

Remarks.—This is a curious little species, which differs altogether from *Actinometra elongata* in the shortness of the arm-joints and in the non-appearance of the first radials externally. It has many resemblances to *Actinometra parvicirra*, but is separated from that type by its smaller number of distichal joints. It presents, however, the same difference in the lengths of the anterior and posterior arms as occurs both in *Actinometra parvicirra* and in *Actinometra elongata;* but some of the hinder arms are non-tentaculiferous, which is not the case in *Actinometra elongata.* Their distal pinnules may have dark spots in the centre of the dorsal surface which appear to be rudimentary forms of the "ovoid bodies" that occur in *Actinometra parvicirra* and *Actinometra elongata.* They are comparatively small and insignificant, and do not occur on the pinnules of the anterior arms.

3. *Actinometra rotalaria*, Lamarck, sp. (Pl. LIX. fig. 2).

Specific formula—a.2.3.$\frac{a}{a}$.

1816. *Comatula rotalaria*, Lamarck, Histoire Naturelle des Animaux sans Vertèbres, Paris, 1816, t. ii. p. 534.
1834. *Comatula rotularia*, de Blainville, Manuel d'Actinologie, Paris, 1834, p. 249.
1841. *Alecto rotalaria*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 184.
1843. *Alecto rotalaria*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 136.
1849. *Comatula (Actinometra) rotalaria*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 256.
1862. *Comatula rotularia*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 204.
1879. *Actinometra rotalaria*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 27.
1882. *Actinometra rotalaria*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra rotalaria*, P. H. Carpenter, *Ibid.*, p. 747.

Centro-dorsal a small, thin disk, bearing about ten cirri, of ten or twelve joints, none of which are much longer than wide.

First radials just visible; the second closely united laterally. Two distichals, the second axillary without a syzygy, and three palmars, the third axillary with a syzygy, Twenty to thirty arms, of about eighty subtriangular and overlapping joints; some of the hinder arms may be non-tentaculiferous.

Syzygies in the third, tenth, and fourteenth segments, with others at intervals of three or four joints.

The second palmar, when present, has a moderately long pinnule with rather stout lower joints. The next pinnule is nearly as long, but that of the third brachial is much smaller; and the next pair are also small, after which the pinnules increase considerably in both length and stoutness. The terminal comb is rather small, and does not extend beyond the sixth brachial.

Mouth apparently radial; disk naked.

Colour in spirit,—light brownish-white.

Disk 6·5 mm; spread 8 cm.

Locality.—Samboangan: 10 fathoms. Two specimens.

Other Localities.—Australia (Péron and Lesueur).

Remarks.—I believe these two specimens to be identical with the form to which Lamarck gave the name *Comatula rotalaria.* According to Müller's diagnosis,[1] "Die Radien bestehen aus 2 durch Syzygie verbundenen Gliedern. Auf diese folgen unmittelbar wieder [illegible]ia, die wieder mit Syzygie versehen sind. Dann folgt nur noch selten weitere Verästelung, also 20 Arme die Grundzahl."

When I visited the Paris Museum in 1876 I found that it contained no specimen bearing Lamarck's name, but that a form which had been brought from Australia by Péron and Lesueur, and appeared to be the original type of Lamarck's species as redefined by Müller, was labelled *Comatula brevicirra*, Troschel.

The first radials are not very distinct, but they are undoubtedly present, and there is no syzygy either between the two outer radials, or between the two distichal joints, as described by Müller according to Troschel's diagnosis; while the two palmar series which are present each consist of three joints, the axillary with a syzygy.

The two individuals obtained by the Challenger at Samboangan present the same characters and also retain their cirri, which are lost in the Lamarckian type. As is sometimes the case in *Actinometra pectinata*, there are five pairs which are placed interradially or nearly so (Pl. LIX. fig. 2), and have only ten or twelve joints. Tridistichate series occur abnormally in both examples, while there are sometimes only two palmars instead of three.

The only type which resembles *Actinometra rotalaria* in the characters of its arm-divisions is *Actinometra valida* (Pl. LIX. fig. 3), which is altogether a larger form with more arms and more cirri. *Actinometra simplex* is also bidistichate but has no palmars, while the cirri are longer and more numerous (Pl. LIX. fig. 1).

4. *Actinometra valida*, n. sp. (Pl. LIX. fig. 3).

Specific formula—a.2.3.3.$\frac{b}{a}$.

Description of an Individual.—Centro-dorsal a thin circular disk, bearing about fifteen cirri, which have some fifteen tolerably uniform joints; the terminal ones laterally compressed with a faint dorsal spine.

First radials just visible; the second closely united laterally. The rays are wide, and

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 256.

the adjacent distichal series are in close contact. The distichals, palmars, and lower brachials have rather flattened sides. Two distichals without a syzygy, three palmars, and sometimes three post-palmars, the axillary with a syzygy.

Forty-six arms of subtriangular and somewhat overlapping joints, which become more discoidal towards the middle of the arms and squarer towards the ends; one hundred and twenty joints in the anterior, and eighty in the posterior arms.

Syzygies in the third, tenth, and fourteenth brachials, and afterwards at intervals of three or four joints.

The second joints after the distichal and subsequent axillaries bear long and rather stout pinnules, the first one reaching nearly 25 mm. The pinnule of the third brachial is smaller than that on the second, but the following ones are stouter, with rather large joints. The terminal comb is small and much obscured by perisome.

Mouth radial; disk naked, with several non-tentaculiferous arms.

Colour in spirit,—dark greyish-green.

Disk 21 mm.; spread probably 22 cm.

Locality.—Station 186, September 8, 1874; Prince of Wales Channel; lat. 10° 30′ N., long. 142° 18′ E.; 8 fathoms; coral mud. One specimen.

Remarks.—This is a fine individual which is allied to Lütken's MS. species *Actinometra trachygaster*, and *Actinometra intricata* from Fiji, Tonga, and Samoa. I propose to describe these at some future time, when it will be necessary to fix their characters more precisely; for I have seen specimens bearing these names which do not altogether correspond with Lütken's types in the Copenhagen Museum. *Actinometra valida* is much larger than *Actinometra rotalaria*, having an additional axillary, and also larger and more numerous cirri; while the rays are wide and generally in close lateral contact, the sides of their lower joints being somewhat flattened, though much less so than in *Antedon*. At first sight there appears to be no terminal comb on the lower pinnules. This is due to its being obscured by the thickness of the perisome, but it becomes more apparent in the dry state, though it is nothing like so well developed as in many smaller individuals of other species.

Actinometra, Series IV.

Three distichals, the first two articulated, and the third axillary with a syzygy.

Remarks.—More than half the described species of *Actinometra* belong to this series, which, both in the abundance and in the variety of its specific forms, presents a very strong contrast to the corresponding series in *Antedon*. The articulation of the two outer radials, as compared with their syzygial union in the *Typica*-group, which is also tridistichate, is associated with the fact that the first two joints beyond the distichal and all subsequent axillaries are articulated, and not united by syzygy as in *Actinometra typica* and its allies. Furthermore, the first syzygy in the free arms is not between the first two brachials, as in *Actinometra typica* and *Antedon inæqualis*, but in the second brachial as in *Actinometra fimbriata* and *Actinometra multiradiata* (Pl. LXII. fig. 3; Pl. LXVI. fig. 1), or in the third as in *Actinometra parvicirra* and *Actinometra divaricata* (Pl. LXI. figs. 1, 5; Pl. LXIII. fig. 6).

The numerous species of this series thus fall into two very well defined groups, each of which contains forms with no axillary beyond the distichal, and others with two or sometimes with three.

The first arm-syzygy in the second brachial, ...	6. *fimbriata.*
The first arm-syzygy in the third brachial, ...	7. *parvicirra.*

7. The *Fimbriata*-group.

Tridistichate species with a pinnule on the first brachial and a syzygy in the second. The palmar and post-palmar series, when present, consist of two joints, the first bearing a pinnule, and the second axillary with a syzygy.

Remarks.—The position of the first brachial syzygy in this group is altogether an anomalous one. In ordinary Comatulæ the third and fourth joints of the primitive arm become closely united by suture, eventually forming a syzygy, while the pinnule of the former remains undeveloped, like that of the first brachial. But in the *Fimbriata*-group the first joint above the distichal and every subsequent axillary, whether it be a palmar or a free brachial, bears a pinnule; and the syzygial union occurs between the primitive second and third brachials, instead of between the third and fourth (Pl. LX. fig. 1; Pl. LXII. fig. 3), *i.e.*, there is a syzygy in the second instead of in the third brachial of the mature arm. When, however, there are no distichals, so that the arms spring directly from the radial axillary, we usually find a reversion to the more primitive type, with a syzygy in the third brachial, *i.e.*, the epizygal of this syzygy bears a single arm, instead of being an axillary (Pl. LX. fig. 2; Pl. LXVI. fig. 1). I have very rarely met with any instance of a pinnule on the first and a syzygy in the second brachial above a primary radial axillary. As a general rule this arrangement only occurs after a secondary or tertiary axillary (*i.e.*, distichal or palmar).

The *Fimbriata*-group is only represented in the genus *Antedon* by a single species, *Antedon porrecta*. It includes a considerable variety of specific forms, all of which, with two exceptions, are limited to the Indian Ocean, the Eastern Archipelago, and the North-west Pacific. *Actinometra lineata* and *Actinometra discoidea* were dredged by the "Blake" in the Caribbean Sea, while the former was likewise found by the Challenger at Bahia. It possibly ranges down to 88 fathoms, while *Actinometra* *discoidea* occurs between this depth and 118 fathoms. But all the remaining species of the group belong to the purely littoral fauna of the Eastern seas. One of them is the only described *Actinometra* which I have not personally examined. It is the *Actinometra borneensis* of Grube, whose type-specimen has disappeared since his death, and I am, therefore, uncertain about its proper place in the following scheme.

A. Arm-joints short and discoidal, ... 1. *fimbriata*, Lamarck, sp.
B. Arm-joints shortly triangular, becoming more quadrate or discoidal.
  I. No palmars.
    a. Less than twenty-four cirrus-joints, . . . 2. *coppingeri*, Bell.
    b. More than twenty-four cirrus-joints, . . . *borneensis*, Grube.
  II. Two palmars, the axillary a syzygy.
    a. Less than thirty cirrus-joints; no post-palmars, . . 3. *multiradiata*, Linn., sp.
    b. More than thirty cirrus-joints; post-palmars, like the palmars, 4. *sentosa*, n. sp.
C. Arm-joints triangular, nearly as long as wide, ... 5. *lineata*, n. sp.
D. Arm-joints almost quadrate, ... 6. *discoidea*, Carpenter, MS.

1. *Actinometra fimbriata*, Lamarck, sp. (Pl. LXII. figs. 2–4).

Specific formula—$a.3.2br.\frac{b}{ab}$.

1816. *Comatula fimbriata*, Lamarck, Hist. Nat. des Animaux sans Vertèbres, Paris, 1816, t. ii. p. 534.
1834. *Comatula fimbriata*, de Blainville, Manuel d'Actinologie, Paris, 1834, p. 249.
1841. *Alecto fimbriata*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 185.
1843. *Alecto fimbriata*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 136.
1849. *Comatula* (*Alecto*) *fimbriata*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 258.
1862. *Comatula fimbriata*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 204.
1879. *Actinometra fimbriata*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1877, vol. xiii. p. 443.
1879. *Actinometra fimbriata*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, p. 27.
1882. *Actinometra fimbriata*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra fimbriata*, P. H. Carpenter, *Ibid.*, p. 747.

Centro-dorsal a moderately thick disk bearing fifteen or eighteen marginal cirri of twenty to twenty-four joints, the lower ones longer than wide, and the later joints more or less spinous, sometimes considerably so.

First radials barely visible; the second short, wide, and closely united laterally. Three distichals, the axillary a syzygy.

Eighteen to twenty arms, which are all tentaculiferous and sometimes dimorphic, the anterior having one hundred and seventy joints as compared with one hundred and fifty in the posterior arms. The joints are all short and wide, with nearly transverse articulations, so as to become almost oblong after about the thirtieth, and generally overlapping a little. The later joints become more square, and finally somewhat elongated. A syzygy in the second brachial, except after the radial axillary, when it is in the third; the next from the thirteenth to twenty-sixth, usually about the sixteenth brachial; others at intervals of three to twelve joints, generally six or seven.

The second distichal and the first brachial bear tolerably equal pinnules about 10 mm. long, the first one being a little stouter at the base. Their lowest joints may be slightly carinate. The next pair are somewhat shorter and the following pair more so. The lowest pinnules have a fairly large terminal comb, which occurs on all the pinnules as far as the tenth brachial and sometimes even to the twentieth or thirtieth.

Mouth radial; the disk may have a few calcareous nodules.

Colour in spirit,—blackish- or reddish-brown.

Disk 14 mm.; spread 25 cm.

Localities.—Banda, 17 fathoms. Three specimens.

Station 208, January 17, 1875; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud. One specimen.

Other Localities.—Sunda Strait (Regnault); Australian Seas (Péron and Lesueur); Angio, Java; Nicobar Islands; Madagascar (?).

Remarks.—The Lamarckian type of this species is a dry specimen with twenty arms which was brought by Péron and Lesueur from the Australian Seas; but the name *Comatula fimbriata* was also applied by J. S. Miller to the common ten-armed *Antedon* of Milford Haven, which is usually called *Antedon rosacea.* Johannes Müller examined Lamarck's original in the Paris Museum, where he also found three spirit specimens presenting the same characters which had been obtained by Regnault in 1829. Müller gave Trincomalee as the locality for this form;[1] but when I visited the Paris Museum in 1876 I found it labelled as having come from Sunda Strait. It bore the MS. name *Comatula brevicirra*, Troschel; while Péron's example, the type of the species, still bore the same designation, *Comatula multiradiata*, Lamarck, as it did when Müller examined it in 1844. The later cirrus-joints of this specimen bear several small spines on their dorsal border. But they are much more distinct in some cirri than in others; while in Regnault's specimen they are of smaller size and appear on fewer joints. In the Challenger individual from the Philippines there is a small spine at the distal edge of the fifth cirrus-joint; and in the following joints it gradually develops into a crest bearing a variable number of spinelets, which sometimes give rise to a double opposing spine on the penultimate. Two of three forms from Banda have a similar armature on the cirri; but in the third there is little or no trace of it (Pl. LXII. fig. 3). This species appears to be one in which palmars are not developed, so that the number of arms does not exceed twenty, and may be less. The latter condition is unusual, however, distichal axillaries being generally developed all

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 258.

round the calyx, though four of them are missing in one of Regnault's specimens. The Philippine example presents a curious abnormality, the second distichal of one ray being axillary, though not a syzygy; while one of its two arms having been broken and regenerated has developed a palmar series. But with this exception, I have never seen any specimen which presents the general characters of *Actinometra fimbriata* and possesses palmar series. Its most important distinctive character is the shape of the lower brachials. The first half-dozen joints are nearly oblong in outline, as in almost all Comatulæ; but their successors do not become triangular or quadrate as is generally the case. For they remain short and wide, with nearly equal sides, so that their ends are much less oblique than usual (Pl. LXII. fig. 3). It is this character more especially which distinguishes *Actinometra fimbriata* from *Actinometra coppingeri* and *Actinometra multiradiata* (Pl. LX. figs. 1, 2; Pl. LXVI. fig. 1). By the twenty-fifth brachial, or sooner, the joints are almost perfectly oblong, and they remain as thick disks till near the end of the arm, where they become squarer and finally slightly elongated. The joints of the middle and lower parts of the arms overlap one another to a greater or less extent, and their edges are fringed with small spines; but there is much variation in both characters.

This thickly discoidal shape of the arm-joints appears to be their highest form of development. A study of regenerated arms of different sizes shows that the joints are at first elongated as they are in the Pentacrinoid, and that their gradual increase in width makes them at first quadrate, then triangular, and finally more or less distinctly oblong, this being the shape which is characteristic of the Pentacrinidæ and of many fossil Crinoids. We may perhaps say then that *Actinometra coppingeri* and *Actinometra multiradiata*, with their more triangular joints at the bases of the arms (Pl. LX. figs. 1, 2; Pl. LXVI. fig. 1), are permanently immature forms of *Actinometra fimbriata* (Pl. LXII. fig. 3), standing to it in the same relation as *Antedon quadrata* to *Antedon eschrichti*.

The mouth of *Actinometra fimbriata* is radial, being usually distinctly excentric, and sometimes quite close to the margin of the disk, the anal tube being central or nearly so (Pl. LXII. fig. 4), while the hinder ambulacra embrace it in a horseshoe-like curve. But in the Philippine specimen the mouth is almost central, the anal tube greatly reduced, and the ambulacra grouped like those of *Antedon*. The two primary ambulacra of the B ray are separately connected with the peristome, the outer one supporting but a single arm, as distichals are undeveloped, while the posterior one is connected to the peristome by a short trunk which is common to it and to the single groove that supplies the whole of the postero-lateral ray C (Pl. LXII. fig. 2).

The lower pinnules of this individual have somewhat carinate basal joints, but the extent of the carination varies greatly, and it seems to be almost entirely absent in one of the Banda specimens, though present in the others. It occurs in a form from Madagascar, which, so far as I can judge from my notes of its other characters, appears to be identical with *Actinometra fimbriata*, as I have redefined it above. This example was brought to the Paris Museum by Rousseau in 1841, and I found it bearing the museum name *Comatula coccodistoma;* but it differs from the other examples of *Actinometra fimbriata* that I have seen in the interradial position of the mouth. The Copenhagen Museum contains three specimens which also seem to belong to this type. Two are from Angio in Java, and have overlapping arm-joints; while the third was obtained by the "Galathea" at the Nicobar Islands, and has a less marked overlap.

2. *Actinometra coppingeri*, Bell (Pl. LX. figs. 1, 2).

1882. *Actinometra coppingeri*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra coppingeri*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra coppingeri*, Bell, Rep. Zool. Coll. H.M.S. "Alert," London, 1884, p. 168, pl. xvi. fig. B.

Specific formula—$a.3.2br.\frac{\ }{ab}$.

Centro-dorsal a wide flat plate, bearing some fifteen to twenty-five marginal cirri of fifteen to twenty-two tolerably uniform joints, with traces of double dorsal spines. Second radials closely united laterally and only partially visible. Three distichals, the third axillary with a syzygy.

Twelve to twenty arms, the fifth and following joints almost triangular, much wider than long, gradually becoming blunter and more quadrate. The first syzygy is usually in the second brachial, but is in the third if the arm springs directly from the radial axillary. The next may be between the fifth and fourteenth brachials; and others follow at intervals of three to nine, usually four or five joints.

The second distichal bears a pinnule about 15 mm. long; that on the first brachial is slightly shorter, and its successors diminish gradually to about the third pair. The terminal comb may stop at the eighth brachial or go on to the fifteenth.

Mouth radial; all the arms tentaculiferous. A few calcareous granules on the disk.

Colour in spirit,—reddish- or blackish-brown.

Disk 16 mm.; spread 15 cm.

Localities.—Banda, 17 fathoms. One specimen.

Samboangan, 10 fathoms. One specimen.

Other Localities.—H.M.S. "Alert," Flinders, Clairmont; Singapore; Amboina; the China Sea.

Remarks.—The essential difference between this species and *Actinometra fimbriata* lies in the more triangular shape of its arm-joints, which become quadrate and eventually cuboid, but are never so nearly oblong as is the case in *Actinometra fimbriata* (Pl. LX. figs. 1, 2; Pl. LXII. fig. 3). The two Challenger specimens from Banda and Samboangan respectively differ somewhat in their characters, and I was at first inclined to regard them as specifically distinct; but they are linked together by another form from Singapore, which was kindly given to me by my friend Professor Charles Stewart.

I cannot separate these three specimens from the type which was described by Bell as *Actinometra coppingeri*.[1] It is represented by a single individual with twelve arms, owing to the presence of two distichal axillaries; and as one of these is clearly due to regeneration at the syzygy in the third joint above the radial axillary, Bell was to a certain extent justified in saying that the normal number of arms "is probably ten." The epizygal of this syzygy may, however, have been an axillary originally, and the second axillary, which is figured by Bell, is so well developed that I believe it to be a normal one. Furthermore, in all the four arms borne upon these two distichal axillaries, whether regenerated or not, the first brachial bears a pinnule, and the second is a syzygial joint. These characters escaped the notice of Bell, whose figure is incorrect, as it shows a pinnule on the second brachial and a syzygy in the third joint above the distichal axillary. On the strength of this figure I assigned a place to *Actinometra coppingeri* in the *Parvicirra*-group, and gave a different name to the Challenger species. But when I came to examine Bell's type for the purpose of determining its relations to *Actinometra parvicirra*, I was surprised to find it identical with the form which I had been accustomed to call *Actinometra stewarti;* so that it adds another to the list of species which were dredged both by the "Alert" and by the Challenger.

The arms are largest in the Challenger individual from Samboangan, but its cirri are considerably smaller than in the other two, especially in that from Singapore, which approaches it most nearly in the characters of the arms. The latter also has the longest lower pinnules, and the terminal comb may extend to nearly the twentieth brachial; while it is rarely found after the eighth brachial in the Samboangan form which has twenty arms. That from Singapore has eighteen, and the Banda one only fourteen, as three of the rays have no distichals at all, and the first syzygy is therefore in its normal position in the third brachial (Pl. LX. fig. 2).

The museums at Berlin and Copenhagen each contain a specimen which I believe to belong to this type. There are not more than eighteen cirrus-joints, as in the examples from Banda and Singapore; though that from Samboangan may have twenty or twenty-two. This limitation in the number of cirrus-joints in specimens from five different localities seems to indicate that the type is not identical with *Actinometra borneensis*, Grube, which has twenty-two to twenty-eight joints.[2] Grube also says of the arm-joints "Die Glieder sind etwas kürzer als breit, und laufen nur anfangs in leichten Zick-Zack weiterhin parallele." His type specimen has unfortunately disappeared. Professor Schneider has been unable to find it at Breslau, and it is equally unknown at Berlin,

[1] "Alert" Report, p. 168, pl. xvi. fig. B.

[2] 53*e Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult.*, 1875, p. 75.

where some of his other types are. I imagine, however, that it differs both from *Actinometra fimbriata* and from *Actinometra coppingeri*, the middle arm-joints becoming more oblong, and not remaining quadrate as in the latter type; while the obliquity of their surfaces in the lower joints seems to separate this form from *Actinometra fimbriata*, which it rather resembles in the number of its cirrus-joints. But there is a difficulty in coming to a satisfactory conclusion about this point in the absence of Grube's type-specimen.

3. *Actinometra multiradiata*, Linn., sp. (Pl. LXVI. figs. 1–3).

Specific formula—a.3.2.$[p.(p').br.].\frac{b}{b}$.

1758. *Asterias multiradiata*, Linnæus, Systema Naturæ, ed. 10, Holmiæ, 1758, t. ii. p. 663.
1783. *Asterias multiradiata*, Retzius, K. Svensk. Vetensk. Akad. Handl., År 1783, t. iv. p. 241.
1788. *Asterias multiradiata*, Linnæus, Systema Naturæ, ed. 13, Lipsiæ, 1788, pars vi. p. 3166.
1805. *Asterias multiradiata*, Retzius, Dissertatio, sistens species cognitas Asteriarum, Lundæ, 1805, p. 35.
1816. *Comatula multiradiata*, Lamarck (*pars*), Histoire Naturelle des Animaux sans Vertèbres, Paris, 1816, t. ii. p. 533.
1834. *Comatula multiradiata*, de Blainville (*pars*), Manuel d'Actinologie, Paris, 1834, p. 249.
1843. *Asterias multiradiata*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 133.
1849. *Comatula* (*Alecto*) *multiradiata*, Müller (*pars*), Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 261.
1862. *Actinometra multiradiata*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 210.
1879. *Actinometra multiradiata*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1879, vol. ii. p. 27.
1882. *Actinometra multiradiata*, P. H. Carpenter (*pars*), Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 521.
1882. *Actinometra multiradiata*, Bell, Proc. Zool. Soc. Lond., 1882, p. 533.
1882. *Actinometra multiradiata*, P. H. Carpenter (*pars*), *Ibid.*, p. 747.

Centro-dorsal a thick circular disk, often hollowed in the centre, and bearing fifteen to twenty stout marginal cirri of twenty-two to twenty-six joints. The basal ones are very broad, the sixth and seventh longer than wide, and from the tenth onwards the joints bear dorsal spines.

The ends of the basal rays are more or less visible. The first radials are almost entirely concealed and sometimes parts of the second, which are imperfectly united laterally. Three distichals, the third axillary with a syzygy; two palmars, the second axillary with a syzygy. Post-palmars, resembling the palmars, are but rarely present.

Eighteen to twenty-four arms, of about one hundred and twenty to one hundred and fifty short overlapping joints, which are triangular at the arm-bases, but become discoidal towards the middle of the arm; their distal margins are very spinose.

A syzygy in the second brachial; the next between the fifteenth and fortieth, with others at intervals of four to nine joints.

The second distichals, first palmars (when present), and first brachials bear long tapering pinnules; the first one reaching 18 mm., while the others are rather smaller. That of the third brachial is considerably so, and the next three pinnules are of decreasing size. The lowest pinnules have a well-marked comb, which may extend out to the twentieth or twenty-fifth brachial. The basal joints of the lower pinnules may be somewhat carinate, and in the following pinnules the edges of the joints project laterally.

Mouth radial; disk naked, or with scattered calcareous nodules.

Colour in spirit,—blackish-brown; the disk sometimes mottled with white.

Disk 19 mm.; spread reaching 25 cm.

Locality.—Station 186, September 8, 1884; Prince of Wales Channel; lat. 10° 30′ N., long. 142° 18′ E.; 8 fathoms; coral mud. One specimen.

Other Localities.—Indian Seas (Linnæus); Australian Seas (Péron and Lesueur); Sumatra; Bohol; China Sea; Kagoshima Bay, Japan.

Remarks.—The type of this species is a dry and somewhat mutilated *Actinometra* in the Retzian collection at Lund, on which Linnæus seems to have based his brief description of *Asterias multiradiata*.[1] He also referred to it the *Caput-Medusæ cinereum* and the *Caput-Medusæ brunnum* of Linck; but the exact specific relations of these two forms must remain uncertain, as Linck's figures are not sufficiently clear for the characters of their arm-divisions to be made out.

Retzius gave a more detailed description of the original type of *Asterias multiradiata* in 1783,[2] stating the number of arms as thirty to forty, and that of the cirrus-joints as twenty-three. He noticed it again in 1805;[3] while in 1816 Lamarck established the species *Comatula multiradiata*,[4] under which he placed *Asterias multiradiata*, Linn., with a (?) appended. He described it as having fifty to sixty, or even more arms, and referred to the Indian seas as its locality. Some years later Goldfuss[5] applied the name *Comatula multiradiata*, Lamarck, to a many-armed specimen, the distichal and palmar series of which each consisted of three joints, with the axillary a syzygy. Müller,[6] regarding this form as "die zuerst genau beschriebene," proposed in 1841 to retain the specific name *multiradiata* for it alone, and on the basis of Troschel's examination of the Paris collection, he published a description of *Comatula multiradiata*, Lamarck, under the name of *Alecto multifida*. He distinguished this type from that of Goldfuss by its palmar and post-palmar series each consisting of but two joints, with the axillary not a syzygy. He went to Sweden, however, in the

[1] Systema Naturæ, ed. 10, Holmiæ, 1758, t. ii. p. 663.
[2] *K. Svensk. Vetensk. Akad. Handl.*, År 1783, t. iv. p. 241.
[3] Dissertatio, sistens species cognitas Asteriarum, Lundæ, 1805, p. 35.
[4] Hist. Nat. des Anim. sans vertèbres, Paris, 1816, t. ii. p. 533.
[5] Petrefacta Germaniæ, t. i. p. 202, pl. lxi. fig. 2.
[6] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1841, p. 188.

same year, and examined at Lund the original of *Asterias multiradiata*, Linn. This he found to have a pinnule on the first and a syzygy in the second joint above the distichal and palmar axillaries, *i.e.*, there are two palmars, with the axillary a syzygy. He gave a careful description of this form,[1] to which, after his visit to Paris he added some details derived from his personal examination of some examples collected by Péron and Lesueur and by Quoy and Gaimard. His final diagnosis was headed *Comatula* (*Alecto*) *multiradiata*, Nobis;[2] though, as we have already seen, he had referred the Retzian specimen to the type of his new genus *Actinometra*. Dujardin and Hupé described it under the latter name,[3] entirely on the basis of Müller's diagnosis of it; but they made no mention of the specimens obtained by Péron and Lesueur and by Quoy and Gaimard, which resemble the Retzian individual in having syzygies in all the axillaries.

I have already separated off one of these forms as *Actinometra peroni*,[4] owing to its palmar series consisting of three joints, instead of only two as in the Retzian type, which has no post-palmars and not more than twenty-five cirrus-joints. One of Péron's specimens presents the same characters as *Asterias multiradiata*, and I have since met with a considerable number of similar individuals. But the spirit-specimen brought from the Moluccas by Quoy and Gaimard, which was referred by Müller and afterwards by myself[5] to *Actinometra multiradiata*, must, I think, be separated from this species on account of its larger number of cirrus-joints, and more numerous arms, owing to the presence of post-palmar series.

Two examples of it were obtained by the Challenger at Banda, and will be described immediately as *Actinometra sentosa* (Pl. LXVI. fig. 4).

I have had some doubts as to the propriety of separating *Actinometra coppingeri* from *Actinometra multiradiata*, the chief difference between the two being the absence of palmars in the former and their presence in the latter. The character seems to be a fairly constant one, however, as the two forms have not hitherto been found associated together in one locality. *Actinometra coppingeri* is known from East Australia, Singapore, Amboina, Banda, the China Sea, and Samboangan; while palmars occur in three examples of *Actinometra multiradiata* from Bohol, another Philippine locality, in two from Japan, in one from Sumatra, and in one from Torres Strait. It is a generally more robust form than *Actinometra coppingeri*, with the lower brachials relatively shorter and more overlapping; while the spines on the cirri are of a much more definite character than in that species. The second syzygy also is much further from the calyx than in *Actinometra coppingeri*, especially in the Philippine examples of *Actinometra multiradiata* and in the Retzian type, in which last it may not occur till the thirty-ninth brachial.

[1] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 133.
[2] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1847 [1849], p. 261.
[3] *Op. cit.*, p. 210.
[4] *Notes from the Leyden Museum*, 1881, vol. iii. p. 214.
[5] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 523.

The Hamburg Museum contains the fragmental remains of a dry specimen from Sumatra which seems to belong to *Actinometra multiradiata*. There are only twenty to twenty-five cirrus-joints, but a single post-palmar series is present in one ray. This, however, is the only example which I have seen that has a post-palmar axillary as in *Actinometra sentosa*, with the cirri of *Actinometra multiradiata*; and the additional axillary is not improbably due to regeneration, as is so often the case.

Two very fine examples of this type, with somewhat smoother arms than usual, were dredged by Dr. Döderlein in Japan. Apart from their large size, they are also remarkable for the peculiar mottled appearance of the disk, which is naked, and without the calcareous concretions that occur in the examples from further south and in the original type of the species.

The basal star seems to be pretty well developed in *Actinometra multiradiata*. Nearly all the specimens of it which I have seen show more or less indication of the star between the centro-dorsal and the radials. None of them have any non-tentaculiferous arms, and there appears to be no great difference in length between those coming off from opposite poles of the disk.

Except for the presence of palmar axillaries, the three individuals from Bohol correspond very well with Müller's description of *Comatula fimbriata*; and they were referred to that species by Professor Semper, who found them to be the hosts of *Myzostoma lobatum*, von Graff.[1] I have since found one *Myzostoma* in the pharynx of one of these individuals, its edge being just visible through the mouth.

4. *Actinometra sentosa*, n. sp. (Pl. LXVI. figs. 4–6).

1849. *Comatula* (*Alecto*) *multiradiata*, Müller (*pars*), Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 261.
1882. *Actinometra multiradiata*, P. H. Carpenter (*pars*), Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 521.
1882. *Actinometra multiradiata*, P. H. Carpenter (*pars*), Proc. Zool. Soc. Lond., 1882, p. 747.

Specific formula—a.3.2.$(p.p'.br).\frac{b}{b}$.

Centro-dorsal a thick disk, sometimes almost columnar, with the dorsal pole partially hollowed, and bearing twenty to thirty moderately stout marginal cirri. These have twenty-six to forty joints, of which the fifth is usually longer than wide, and the next two or three the longest, least markedly so in the older cirri; the later joints are nearly square and somewhat compressed laterally, small spines appearing near their distal edges, which increase in distinctness up to the penultimate joint.

First radials visible, least so in the larger specimens. The second partly united

[1] See von Graff, Das Genus Myzostoma, Leipzig, 1877, p. 19, and also Zool. Chall. Exp., part xxvii. p. 57, 1884.

laterally; the rays and their subdivisions are well separated from one another. Three distichals, the axillary a syzygy. Palmar and post-palmar series of two joints, the axillary with a syzygy. Forty to sixty-five arms, of one hundred and twenty to one hundred and fifty joints, the first few nearly oblong; the following ones overlapping and shortly triangular, with coarsely spinous distal edges. From about the fortieth onwards, the joints become more oblong, as the arms narrow, and their terminal joints are squarer. The anterior arms may be slightly the longer.

A syzygy in the second brachial; the next from the fifteenth to thirtieth, usually about the twentieth, with others at intervals of four to eight, usually five or six, joints.

The pinnules on the second distichals are nearly 30 mm. long, and moderately stout at the base, but soon become more slender. The following pinnules are on the first joints after each axillary, and the length decreases to those of the fifth and sixth brachials which are not specially small. Their successors increase again slowly. The lowest pinnules have a large terminal comb, which may extend out to the fifteenth brachial; and the edges of the pinnule joints are fringed with spines.

Mouth radial or nearly so; disk naked or with a few calcareous nodules.

Colour in spirit,—blackish-brown.

Disk 15 mm.; spread 25 cm.

Locality.—Banda; two specimens.

Other Localities.—Moluccas (Quoy and Gaimard).

Remarks.—This fine species cannot well be confounded with any other *Actinometra*, the only form which at all approaches it being *Actinometra multiradiata*, in which, however, there are normally no post-palmars, while the cirri do not have more than twenty-six joints.

I have only seen three specimens of *Actinometra sentosa*, one which was brought from the Moluccas to the Paris Museum by Quoy and Gaimard, and the two dredged at Banda by the Challenger. The Paris specimen was referred by Müller[1] to the type of *Asterias multiradiata*, Linn., his final diagnosis of the species differing but little from his previous description of the Retzian type, except that he gave the number of cirrus-joints as twenty to thirty instead of simply twenty-four; while he described forty to fifty arms, instead of thirty to forty, the number assigned by Retzius. The latter change involved the presence of post-palmar axillaries, to which, however, Müller made no reference.

I was at first inclined to follow Müller's example, and to describe the two Challenger individuals under the name *Actinometra multiradiata*;[2] but I have since examined a greater variety of specimens, and have come to the conclusion that the larger number

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 261.
[2] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 521.

of cirrus-joints and the additional axillary together constitute a good specific character. Palmars occur on every ray of each of the two Challenger specimens, so that the number of arms reaches twelve or sixteen to each ray; while in *Actinometra multiradiata* there are not usually more than six. Some of the cirri in both individuals have thirty joints or more, though the number may fall to twenty-six in cirri that are apparently mature; and on the other hand there may be as many as forty joints. The Paris specimen has about thirty.

5. *Actinometra lineata*, n. sp. (Pl. V. figs. 2, *a–e*; Pl. LX. fig. 3).

1879. *Antedon* sp., Rathbun, Trans. Connect. Acad., 1879, vol. v. p. 157.
1880. *Actinometra lineata*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xv. p. 213, pl. xii. figs. 27, *a*, *b*.
1882. *Actinometra lineata*, P. H. Carpenter, Proc. Zool. Soc. Lond., 1882, p. 747.

Specific formula—$a.3.2.[(p).br.].\frac{b}{a}$.

Centro-dorsal discoidal, bearing twenty to thirty marginal cirri. These have eleven to seventeen joints, usually not more than fourteen, several of which are longer than wide, the later joints overlapping dorsally.

The first radials are usually concealed, together with more or less of the second, which may or may not be united laterally. Three distichals, the axillary with a syzygy, and sometimes two palmars, the axillary with a syzygy. The perisome between the rays is occasionally plated as far as the distichal axillary.

Eighteen to thirty-four arms, the lower joints triangular and overlapping, but little wider than long; the middle joints more quadrate, and the later ones elongated.

A syzygy in the second brachial, and the next between the ninth and twelfth; others at intervals of one to five, usually three or four, joints.

The distichal pinnule reaches nearly 15 mm. long, with a large terminal comb. The next pinnule is but little smaller; but the size decreases considerably after the pinnule on the second brachial, till the third or fourth on the same side. The following pinnules increase slowly in length, becoming very long and slender in the terminal third of the arm. The first five or six brachial pinnules are sometimes webbed by perisome for about one-third of their length and have a small comb, which does not usually extend further, though it may occur as far out as the eighteenth brachial. The basal joints of the lower pinnules are sometimes slightly carinate.

Mouth variable in position; a few of the hinder arms may be non-tentaculiferous.

Disk naked, or bearing a few scattered grains.

Colour in spirit,—reddish or yellowish-brown, with a dark purple medio-dorsal line.

Disk 15 mm.; spread 16 cm.

Locality.—Bahia; 7 to 20 fathoms. Eight specimens.

Other Localities.—Coast of Brazil; also the "Blake," 1878-79, Station 285, off Barbados; 13 to 40 fathoms; and possibly Station 155, off Montserrat, 88 fathoms.

Remarks.—This Atlantic species may be readily distinguished from its allies of the Eastern seas by the greater relative length and the more quadrate shape of the arm-joints, the edges of which are by no means so spiny as in *Actinometra fimbriata*, *Actinometra multiradiata*, and their allies. The relative shortness of the syzygial interval and the frequent plating of the interradial perisome are distinctive characters of minor value.

The position of the mouth in this type seems to be a somewhat variable one. So far as I have been able to make out, it is radial in the Caribbean variety, but interradial in the Brazilian form. Neither of the Caribbean individuals that I have seen has any palmar series and they are sometimes absent in those from Bahia.

The calyx of *Actinometra lineata* is not unlike that of *Actinometra maculata*. In both alike the radials fail to cover the centro-dorsal entirely; while their angles are everted so as to appear beyond its edge (Pl. V. figs. 1*a*, 1*b*, 2*a*, 2*b*); but the latter character is more marked in the Atlantic species (Pl. V. fig. 2*d*). Figs. 2*c* and 2*b* on Pl. V. show the upper and side views of a centro-dorsal, from which three radials have been removed, so as to expose the rosette and a portion of the basal star.

Closely allied to this species is a very remarkable *Actinometra*, which was dredged by the "Blake" in the Caribbean Sea. At first sight it greatly resembles a large example of *Actinometra lineata*; but the palmar series are represented by single axillary joints, and the post-palmars may be of the same character, or there may be two joints united by syzygy. The second brachial is generally a syzygy on the outer arms of each ray, and sometimes also on the adradial arm, which is on the inner side of each distichium. But the other arms generally have the first two joints united by syzygy, so that the specific formula comes to be—$a.3.1.1.\frac{2br}{\frac{br}{2}}.\frac{(o)}{(i)}$. I really cannot tell what to make of this remarkable form, and should much like to see some more examples of it. For the present at any rate it may remain in the neighbourhood of *Actinometra lineata*.

The *Comatula* with an excentric mouth which was described by Rathbun[1] as *Antedon*, sp., from some locality either on the the coast of Pernambuco or of Parahyba do Norte, is I think identical with *Actinometra lineata*. But the question is a little difficult to decide, as he makes no reference to the presence or absence of syzygies in the distichal and palmar axillaries; and the position of the first brachial pinnule is not described very clearly.

[1] *Trans. Connect. Acad.*, 1879, vol. v. p. 157.

8. The *Parvicirra*-group.

Tridistichate species, with a pinnule on the second brachial and a syzygy in the third.

Remarks.—The tridistichate species of *Actinometra* which have the first arm-syzygy in the third brachial, make up nearly half the whole number of the species of this genus which are considered in this Report; and so far as I can judge from the undescribed material which I have examined, this proportion is not likely to be greatly affected by future work. In the genus *Antedon*, on the other hand, the number of tridistichate forms is quite small, both the ten-armed and the bidistichate groups containing a large number of species.

The *Parvicirra*-group is more widely distributed than any other in the genus *Actinometra;* though it does not occur in the Caribbean Sea, as the *Fimbriata*- and *Echinoptera*-groups do. It is represented on the Peruvian coast and at Tahiti, is abundant at Samoa, Tonga, and Fiji, and extends throughout the Eastern Archipelago to Japan on the north and the Nicobar Islands on the west, being also represented by one species on the southern coast of Australia. *Actinometra parvicirra* itself occurs at Natal and Simon's Bay; but I do not know for certain of any Atlantic representative of the group, though there is possibly one on the Brazilian coast.

A striking feature in some members of this group is the tendency to the development of two-jointed palmar series, either generally, as in *Actinometra divaricata* (Pl. LXIII. fig. 6), or on the outer parts of each ray only, as in *Actinometra belli*, *Actinometra duplex*, and *Actinometra nobilis* (Pl. LXIV. figs. 1, 3; Pl. LXV. fig. 1). In *Actinometra multifida* and *Actinometra variabilis* the palmar and all subsequent divisions are two-jointed; but in *Actinometra alternans* and *Actinometra divaricata* there are three-jointed post-palmars, followed in the former case by two joints again, and in the latter by a three-jointed series (Pl. LXIII. fig. 6). On the other hand in *Actinometra regalis* (Pl. LXVIII. fig. 2), *Actinometra bennetti*, &c., there are three, or even four, three-jointed series above the radial axillary, which is a very rare condition in *Antedon*.

These large multibrachiate species are all confined to the littoral fauna; but an example of *Actinometra parvicirra* with about thirty arms was obtained, together with the multibrachiate *Actinometra typica*, from a depth of at least 210 fathoms at Station 174.

The species of the *Parvicirra*-group may be classified as follows:—

A. Three distichals, not succeeded by palmars.
  I. Ten to twenty cirri, generally with less than fifteen joints.
    (*a*) Arm-joints triangular till some distance from the disk, and considerably wider than long, ... 1. *parvicirra*, Müll., sp.
    (*b*) Arm-joints relatively long, becoming quadrate about the fifteenth, 2. *quadrata*, n. sp.
  II. Thirty or more cirri of fifteen to twenty joints.
    (*a*) Arm-joints short; lower joints of distichal pinnules not specially marked, ... 3. *trichoptera*, Müll., sp.
    (*b*) Arm-joints of moderate length: lower joints of distichal pinnules rather large and carinate, ... *japonica*, Müll., sp.
B. Palmar series developed above the distichals.
  I. Two palmars, the axillary not a syzygy.
    (*a*) Post-palmars like palmars.
      1. Ten cirri, ... *multifida*, Müll., sp.
      2. Twenty cirri; one or two further divisions, like palmars, . *variabilis*, Bell.
    (*b*) Post-palmar series of three joints, the axillary with a syzygy.
      1. Fifty cirri on a hemispherical centro-dorsal, . . *grandicalyx*, Carpenter.
      2. Centro-dorsal reduced, with few or no cirri.
        α. Further division like palmars; centro-dorsal stellate, *alternans*, Carpenter.
        β. Further division like post-palmars.
          (i.) Fifteen to twenty small cirri, . . . *briareus*, Bell, sp.
          (ii.) Centro-dorsal stellate, without cirri.
            Rays well separated; mouth radial, . . 4. *divaricata*, n. sp.
            Rays closely united, and the interradial perisome plated; mouth interradial, . . *magnifica*, Carpenter, MS.
  II. Palmar series at outside of ray two-jointed, without a syzygy; the inner series three-jointed, with a syzygy.
    (*a*) Post-palmars of two joints, the axillary not a syzygy; pinnule joints carinate, ... 5. *belli*, n. sp.
    (*b*) Post-palmars of three joints, the axillary with a syzygy.
      1. Fifteen cirri; rays quite free, ... 6. *duplex*, n. sp.
      2. No functional cirri; rays closely united, . . . 7. *nobilis*, n. sp.
  III. Three palmars, the axillary with a syzygy.
    a. No further division. Centro-dorsal bears functional cirri.
      1. Ten to twenty-five cirri, generally with less than fifteen joints, ... 1. *parvicirra*, Müll., sp.
      2. Thirty or more cirri, of fifteen to twenty joints.
        (*a*) Lower pinnules not specially large.
          Arm-joints short; lower joints of distichal pinnules not carinate, ... 3. *trichoptera*, Müll., sp.
          Arm-joints of moderate length; lower joints of distichal pinnules rather large and carinate, . *japonica*, Müll., sp.
        (*b*) Distichal and palmar pinnules very large and stout, *robustipinna*, Carpenter.
    b. Post-palmar series present.
      1. No functional cirri; post-palmars of two joints, the axillary not a syzygy, ... 8. *littoralis*, n. sp.
      2. Cirrus-sockets not entirely obliterated; post-palmars like palmars.
        (*a*) Ten to thirty cirri.
          (i.) Ten to twenty cirrus-joints.
            α. No further division, . . . 1. *parvicirra*, Müll., sp.

β. A fourth post-radial series of three joints, the axillary with a syzygy.	
First radials largely visible; arm-joints of moderate length; pinnules on fourth and fifth brachials short, .	9. *regalis*, n. sp.
First radials mostly concealed; short arm-joints; pinnules on fourth and fifth brachials not specially short, .	*schlegeli*, Carpenter.
(ii.) Thirty cirrus-joints; first radials mostly concealed, ...	*peroni*, Carpenter.
(*b*) Forty to fifty cirri of twenty-five joints, . .	*bennetti*, Müll., sp.

1. *Actinometra parvicirra*, Müll., sp. (Pl. LXI.; Pl. LXVII. figs. 3, 4).

Specific formula—$a.3.[3(3)].\frac{ab}{a}$.

Remarks.—The synonymy and diagnosis of this remarkable type will be given on a subsequent page, when the species with palmar series are considered. The simpler forms of it, with not more than twenty arms, are known from the following localities:—

H.M.S. Challenger:—Simon's Bay; Ternate; Banda; Admiralty Islands; Prince of Wales Channel; Samboangan.

Other Localities.—Cape of Good Hope; Nicobar Islands; Timor; North Borneo; Solor; Ceram; Bohol; Port Molle; Moreton Bay, Fiji; Peru.

2. *Actinometra quadrata*, n. sp. (Pl. LXII. fig. 1).

Specific formula—$a.3.\frac{a}{a}$.

Description of an Individual.—Centro-dorsal a small thin disk, bearing a single row of ten marginal cirri, with eleven joints, of which the fourth and fifth are slightly the longest.

The first radials are largely visible, and the second partly united laterally, the rays being quite free. Three distichals, the axillary with a syzygy.

Sixteen long and slender arms, consisting of about one hundred and twenty tolerably smooth joints; the lower joints triangular and relatively long, soon becoming distinctly quadrate, then more square, and finally elongated. Syzygies in the third, tenth, and fourteenth brachials, and then at intervals of two to four joints.

The second distichal bears a pinnule about 8 mm. long, and that on the second brachial is but little shorter; but the next pair are considerably so, and the size decreases to about the sixth brachial, and then increases again, the terminal pinnules becoming very slender and reaching 12 mm. A terminal comb on the pinnules of the first eight brachials, and then irregularly till the twentieth.

Mouth interradial, and disk naked; all the arms are grooved.

Colour in spirit—greyish-green.
Disk 8 mm.; spread 22 cm.
Locality.—Tongatabu Reefs.

Remarks.—This is a very elegant species which may be distinguished from *Actinometra parvicirra* by the characters of its arm-joints. The lower joints lose their triangular shape very soon and become unequally quadrate; the two sides gradually become more equal until the outline is nearly square, and finally the joints become almost cylindrical with slightly oblique ends. The relative length of the lower joints varies in some of the arms; that selected by the artist for representation having rather shorter joints than its fellows.

The small size of the cirri, and their fewness in numbers, will prevent this species from being confounded with *Actinometra trichoptera.* Some specimens from the Nicobar Islands in the museums at Copenhagen and Vienna should perhaps be referred to it on account of the length of their arm-joints.

3. *Actinometra trichoptera* (Valenciennes), Müll., sp. (Pl. LXIII. figs. 1–5).

Specific formula—a.3.(3)$\frac{bc}{a}$.

Remarks.—This species, like *Actinometra parvicirra*, may or may not have palmar series, and will therefore be considered later. It was obtained by the Challenger at Port Jackson.

4. *Actinometra divaricata*, n. sp. (Pl. LXIII. figs. 6–8).

Specific formula—a.3.2.3.3.$\frac{o}{o}$.

Description of an Individual.—Centro-dorsal stellate, without traces of cirri, and a little below the level of the radial pentagon, the inner sides of which are somewhat cut away. The second radials are relatively long and incompletely united laterally; the rays are quite free and may divide five times.

Three distichals, the axillary with a syzygy; two palmars without a syzygy; the first and second post-palmar divisions, when present, each of three joints, the axillary with a syzygy.

Arms very numerous, eighteen or twenty to the ray, and all grooved; but the hinder arms are only faintly so and are very narrow and short, with one hundred to one hundred and twenty slightly overlapping joints; the anterior arms have rather more. The lower joints are shortly triangular, becoming more oblong, and finally nearly square.

Syzygies in the third, twelfth, and sixteenth brachials, and then at intervals of three or four joints.

The pinnules on the second distichal and post-palmar joints are about equally long, reaching 12 mm.; but the following pinnules are considerably shorter, diminishing to that of the third brachial which is the smallest; after which the length increases slightly, but the pinnules are always comparatively short. The lower pinnules have a terminal comb as far the fourth or fifth brachial, and it is continued at intervals to the eleventh or twelfth.

Mouth radial; disk naked, except for a few granules near the anal tube.

Colour in spirit,—dark blackish-brown.

Disk 30 mm.; spread 18 cm.

Locality.—Banda; 17 fathoms.

Remarks.—This species is remarkable for the relatively small size of the arms and pinnules as compared with that of the disk. Its nearest allies are the *Antedon briareus* of Bell and the Philippine species to which I have referred in Part I. as *Actinometra magnifica.*[1] The latter has nearly twice the spread of *Actinometra divaricata*, with a relatively smaller disk; while the rays are in close lateral contact as far as the distichal axillary, above which the perisome is strongly plated.

Antedon briareus is really an *Actinometra*, as is shown by the absence of sacculi, and the presence of a terminal comb on the lower pinnules, two points which seem to have escaped Bell's notice. According to his description of the species,[2] the post-palmar series resemble the palmars in consisting of but two joints, the axillary without a syzygy. This would indicate an alliance with *Actinometra multifida.* Bell's figure shows, however, that about two-thirds of the post-palmars have three joints, the axillary with a syzygy, and also that there are four cases of a further division, which he does not mention at all. In one case these second post-palmars consist of two joints, the axillary without a syzygy; but the remainder consist of three joints, the axillary with a syzygy, just as in *Actinometra divaricata* and *Actinometra magnifica.* Pending the discovery of other examples of this species, therefore, its formula must be—a.3.2.3.3.$\frac{b}{a}$, and not—A.2.3.(2).$\frac{b}{a}$, as was assigned to it by Bell.[3] Its centro-dorsal is evidently undergoing reduction to the *Phanogenia*-condition, but some poorly developed cirri still remain attached to it; while in *Actinometra alternans*, *Actinometra divaricata* (Pl. LXIII. fig. 6), and *Actinometra magnifica* it is stellate, with few or no traces of any cirri at all.

We now come to a group of species, which in one respect stand altogether alone in the whole family of Comatulæ. In each case there are three distichals, the axillary with a syzygy; but the two secondary arms borne on each distichal axillary are not alike when they divide again. That on the outside of the ray has but two palmar joints, the

[1] Zool. Chall. Exp., part xxxii. p. 57, pl. lvi. fig. 7. [2] "Alert" Report, p. 163, pl. xiv. [3] *Ibid.*, p. 155.

axillary without a syzygy, while the inner palmar series resembles the distichal one in consisting of three joints, the axillary with a syzygy. This is shown very well in the single example of *Actinometra duplex*, which has no very great number of arms (Pl. LXIV. fig. 3); and the fact that this arrangement is not merely an accidental one is shown by its occurrence in three individuals of *Actinometra belli* (Pl. LXIV. fig. 1), and in six of *Actinometra nobilis* (Pl. LXV. fig. 1), both species having four post-radial axillaries, and therefore a large number of arms.

5. *Actinometra belli*, n. sp. (Pl. LXIV. figs. 1, 2).

Specific formula—a.3. $\frac{2}{3}\left(\frac{o}{i}\right)$.2.2.$\frac{ab}{b}$.

Centro-dorsal a moderately thick circular disk, hollowed in the centre, and bearing about fifteen marginal cirri. These are fairly stout, of fifteen to twenty joints, a few of which are rather longer than wide.

The first radials are partly visible, and the second incompletely united; the rays are quite separate from one another, but the intervening perisome is regularly plated as far as the palmar axillary. The rays may divide five times, giving sixty-five to seventy arms.

Three distichals, the axillary with a syzygy; palmar series two-jointed without a syzygy on the outside of the ray, but three-jointed with a syzygy on the inside.

The first and second post-palmar series, when present, are also two-jointed. The anterior arms are long and slowly tapering, with one hundred and twenty to one hundred and fifty overlapping joints, which are shortly triangular at the base, becoming quadrate about the middle, and slightly elongated near the tip. The posterior arms are shorter and taper more quickly, with only eighty to one hundred joints. A syzygy in the third brachial; the next about the tenth or twelfth, with others at intervals of three to six joints.

The distichal pinnule is moderately stout and reaches 20 mm. in length; the palmar pinnule on the inside of the ray, and that of the second brachial are nearly as long; but that of the third brachial is only half their length and much more slender, while the next pair are the smallest on the arm. The terminal pinnules are long and slender on the anterior arms but shorter on the posterior ones. The basal segments of the genital pinnules have sharp dorsal keels, which are less distinct in the first few pinnules than in those immediately following. In the anterior arms they are lost after about the fiftieth brachial, but are traceable to near the end of the posterior arms. The lowest pinnules have a well-marked comb, which becomes gradually smaller and is lost about the fifteenth brachial.

Mouth interradial; the disk bears a variable number of small granules, especially round the ambulacra; several of the hinder arms are ungrooved.

Colour in spirit,—darkish-brown, with a dark medio-dorsal line; the pinnules sometimes tipped with green.

Disk 30 mm.; spread 21 cm.

Locality.—Station 186, September 9, 1874; Prince of Wales Channel; lat. 10° 30′ N., long. 142° 18′ E.; 8 fathoms; coral mud. Three specimens.

Remarks.—This fine species, which I have dedicated to the energetic curator of the National Collection of Echinoderms, is readily distinguished from the two others which have a similar arrangement of the palmar series, by the fact that its first and second post-palmar series are only two-jointed; so that on the outside of the ray there is no pinnule between that of the second distichal and that on the second joint of the free arm.

The difference in the lengths of the anterior and posterior arms is very considerable; and in each of the three individuals all the arms of the D ray are unprovided with ambulacra, which may also be the case on the adjacent arms of the C and E rays as well. This is well shown in fig. 2 on Pl. LXIV. The C ambulacrum only supplies the anterior half of the corresponding ray,[1] so that all the C_2 arms are grooveless. The same is the case with all the arms of D and of E_2, and even with some of those on E_1, as the groove which supplies them suddenly ceases before reaching the level of the palmar axillary.

One rather striking character of this species is the strong carination of the third and following joints in the pinnules of the tenth brachial and its successors; and another peculiarity is the very definite nature of the perisomic plating between the rays. The two radial axillaries are separated by a well-marked polygonal piece which rests on the truncated angles of the second radials, and corresponds exactly with the first interradial piece of the Apiocrinidæ.

One of the three individuals of this species was presented by Sir Wyville Thomson to the Natural History Museum at Stockholm, where I found it in August, 1886. The other two have yielded seven examples of *Myzostoma*. I could, however, find none of these parasites when I first searched for them, and again when I examined the species for descriptive purposes. But they seem to have become detached at a later period after the type had been drawn, and they are therefore not yet described.

6. *Actinometra duplex*, n. sp. (Pl. LXIV. fig. 3).

Specific formula—$a.3.\frac{2}{3}\left(\frac{o}{i}\right)3.(3).\frac{ab}{a}$.

Description of an Individual.—Centro-dorsal a rounded and slightly convex disk, bearing some fifteen marginal cirri which have fourteen to seventeen tolerably uniform joints. Three radials visible, the second partly united laterally; the rays are quite free

[1] See woodcut, fig. 6 on page 274.

and may divide four, or rarely five, times. Three distichals, the axillary with a syzygy; palmars, when present, two-jointed without a syzygy on the outside of the ray, but three-jointed with a syzygy on the inside. The first and second post-palmars, when present, also three-jointed, the axillary with a syzygy.

Forty-five arms; the anterior ones of a hundred and twenty slightly overlapping, triangular joints which gradually become quadrate; the hinder arms shorter, with only half as many joints. Syzygies in the third, twelfth, and sixteenth brachials, and then at intervals of three joints.

The distichal pinnule is relatively long and stout, reaching 13 mm., and that on the second post-palmar, which is but little smaller, is nearly twice the length of that on the second brachial. Those of the next three joints are still smaller, after which the size again increases, but the terminal pinnules are not specially long. The first few pinnules have a well-marked comb, which becomes gradually weaker and is lost after the tenth brachial. Mouth interradial; disk naked; some of the hinder arms have very faint grooves and others none at all.

Colour in spirit,—light reddish-brown.

Disk 15 mm.; spread 21 cm.

Locality.—Banda, 17 fathoms. One specimen.

Remarks.—This is an elegant little species, which differs altogether from *Actinometra belli* in having its post-palmar series like the distichals instead of being only two-jointed (Pl. LXIV. figs. 1, 3). They occur on all the rays but one, and in the anterior half of the ray regeneration has taken place to such an extent that there is a fifth post-radial axillary. As this is probably not the normal condition I have put brackets round the figure which indicates it in the specific formula.

The great difference in length between the anterior and posterior arms of this type is very striking, the more so as most of the hinder arms have grooves, though only faint ones. The five hinder arms of the E ray are, however, altogether devoid of ambulacra, as the groove which should supply them suddenly stops quite short on the disk at the base of the distichium; and the right or western curve of the horse-shoe passes by them altogether, on its way to the posterior or D ray.

7. *Actinometra nobilis*, n. sp. (Pl. LXV.).

Specific formula—$a.3.\frac{2}{3}.\left(\frac{o}{i}\right).3.3.\frac{a}{?}$.

Centro-dorsal a thin disk, with about ten marginal cirri in immature individuals; more or less stellate and rather below the level of the radial pentagon in the adult. Second and third radials short and closely united laterally. The two first distichals of each ray are also closely united laterally; those of adjacent rays are sometimes united all round the calyx, and sometimes separated by a strong interradial plating which extends to about the level of the palmar axillaries.

The rays may divide five times; three distichals, the axillary with a syzygy; palmars two-jointed without a syzygy on the outside of the ray, but three-jointed with a syzygy on the inside. First and second post-palmars three-jointed, the axillary with a syzygy.

Eighty to one hundred arms; the anterior ones long and slowly tapering, of one hundred and fifty to two hundred slightly overlapping joints, which remain almost triangular till near the end; the posterior arms tapering rapidly, with eighty to one hundred more quadrate joints. A syzygy in the third brachial; the next from the tenth to the seventeenth, with others at intervals of three to five joints.

The distichal pinnule is moderately stout, reaching 30 mm. in length. Those on the second joints of the following arm-divisions gradually decrease in size, but that of the second brachial is only half as long as its predecessor, and the next two pairs of pinnules are not much smaller. The terminal pinnules are much longer in the anterior than in the posterior arms. The terminal comb of the lower pinnules is variable, being sometimes small and ceasing about the tenth brachial, and sometimes much larger, extending out to the fortieth joint.

Mouth interradial; the ventral surface of the disk is usually naked, except for a little plating round the peristome. The hinder arms are mostly without ambulacra, and in one case, at least, there are ungrooved arms on each ray.

Colour in spirit,—dull green, either alone or mottled with purple, brown, and white.

Disk 50 mm.; spread 30 cm.

Localities.—Station 208, January 17, 1875; Philippine Islands; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud. One specimen.

Samboangan; 10 fathoms. Five specimens.

Remarks.—This is a large and finely developed species, which differs from *Actinometra duplex* in the normal presence of a fifth post-radial axillary, and in the large amount of perisomic plating between the rays and their subdivisions. It is further distinguished by the characters of the centro-dorsal, which does not bear comparatively stout cirri, as in *Actinometra duplex* (Pl. LXIV. fig. 3), but almost reaches the condition seen in *Actinometra typica* (Pl. LVII. fig. 1). The details of the process, which are illustrated on Pl. LXV. figs. 2–7, were explained on p. 15.

The five specimens obtained at Samboangan are generally very similar in their characters; but that from Station 208 is more uniformly coloured and has a much larger terminal comb, which extends to the fortieth brachial instead of ceasing about the tenth as in the Samboangan form, to which I referred as *Actinometra dissimilis* on pp. 110, 111, of Part I.; for I did not then consider them as specifically identical with the type from Station 208. Both in the latter individual and in one of those from Samboangan the disk bears cysts of *Myzostoma platypus*, which open into the ambulacral grooves, as seen in Pl. LXV. fig. 8.

1. *Actinometra parvicirra*, Müll., sp. (Pl. LXI.; Pl. LXVII. figs. 3, 4).

Specific formula—a.3.$[3.(3)]^{ab}_{a}$.

1841. *Alecto parvicirra*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1841, p. 185.
1841. *Alecto timorensis*, Müller, *Ibid.*, p. 186.
1843. *Alecto Wahlbergii*, Müller, Archiv f. Naturgesch., 1843, Jahrg. ix. Bd. i. p. 131.
1849. *Comatula (Actinometra) Wahlbergii*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 256.
1849. *Comatula (Alecto) parvicirra*, Müller, *Ibid.*, p. 260.
1849. *Comatula timorensis*, Müller, *Ibid.*, p. 263.
1862. *Comatula parvicirra*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 206.
1862. *Comatula timorensis*, Dujardin and Hupé, *Ibid.*, p. 206.
1862. *Actinometra Wahlbergii*, Dujardin and Hupé, *Ibid.*, p. 211.
1875. *Comatula mertensi*, Grube, 53e Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult., 1875, p. 74.
1876. *Actinometra (Comatula) armata* (Semper, MS.), P. H. Carpenter, Journ. Anat. and Physiol., 1876, vol. x. p. 582.
1877. *Actinometra polymorpha*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1877, vol. xiii. p. 443.
1879. *Actinometra parvicirra*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1877 [1879], p. 27.
1879. *Actinometra Wahlberghii*, P. H. Carpenter, *Ibid.*, p. 27.
1879. *Comatula timorensis*, P. H. Carpenter, *Ibid.*, p. 29.
1879. *Actinometra polymorpha*, P. H. Carpenter, *Ibid.*, p. 51.
1881. *Actinometra parvicirra*, P. H. Carpenter, Notes from the Leyden Museum, 1881, vol. iii. p. 204.
1882. *Actinometra parvicirra*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1882, vol. xvi. p. 519.
1882. *Actinometra meyeri*, P. H. Carpenter, *Ibid.*, p. 525.
1882. *Antedon mertensi*, Bell, Proc. Zool. Soc. Lond., 1882, p. 533.
1882. *Actinometra parvicirra*, Bell, *Ibid.*, p. 535.
1882. *Actinometra wahlbergi*, Bell, *Ibid.*, p. 535.
1882. *Actinometra annulata*, Bell, *Ibid.*, p. 535.
1882. *Actinometra annulata*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra parvicirra*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra wahlbergi*, P. H. Carpenter, *Ibid.*, p. 747.
1882. *Actinometra meyeri*, P. H. Carpenter, *Ibid.*, p. 747.
1884. *Actinometra parvicirra*, Bell, Rep. Zool. Coll. H.M.S. "Alert," Lond., 1884, p. 168.
1887. *Actinometra parvicirra*, Bell, Trans. Dublin Soc., 1887, vol. iii. ser. ii. p. 645.
... *Actinometra mutabilis*, Lütken, MS., (*pars*), Godeffroy Museum.

Centro-dorsal discoidal and sometimes greatly reduced, but always with some traces of marginal cirrus-sockets. Sometimes only three cirri visible, generally ten or twelve, and occasionally twenty or twenty-five. They have ten to eighteen joints, a few of which are longer than wide, and the later ones may have small dorsal spines.

First radials generally visible, sometimes largely so; the second are partly united laterally, but the rays are free and may divide two, three, and occasionally four times; each division of three joints, the axillary with a syzygy. Thirteen to forty-four arms of generally overlapping triangular joints, which become gradually quadrate and elongated at the ends. The arms are often dimorphic, the tentaculiferous anterior ones tapering slowly with one hundred and twenty to one hundred and fifty joints, while the hinder arms are ungrooved and taper rapidly with only fifty to ninety joints. A syzygy in the third brachial, the next from the eighth to twelfth, usually in the tenth, and others at intervals of one to ten, usually three or four joints.

The distichal pinnule may reach 15 mm., and the palmar pinnule, when present, is usually about the same length; but that on the second brachial is shorter, and those of the fourth and fifth brachials are the smallest, their successors increasing in size. The lower joints of these genital pinnules often overlap considerably and are sometimes carinate. The terminal pinnules of the anterior arms are generally long and slender, but those of the posterior arms are shorter and stouter, often with brownish ovoid bodies on the dorsal aspect of several joints. The terminal comb varies much in size, being sometimes quite small and inconspicuous. It may not extend beyond the pinnule of the third brachial, or occur on all the pinnules to the twelfth, and at intervals to the twenty-fifth brachial, occasionally even to near the end of the arm.

Mouth interradial or nearly so. Disk naked or bearing a few scattered granules round the anal tube; occasionally covered by a continuous pavement of plates. The hinder arms and sometimes also the corresponding part of the disk are often ungrooved and non-tentaculiferous.

Colour in spirit,—greenish-grey, or brown in various shades and more or less mixed with white; sometimes there is a medio-dorsal line, either white or dark.

Disk 20 mm.; spread reaching 22 cm.

Localities.—Simon's Bay. One specimen.

Station 174 (B, C, or D), August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 255, 210, or 610 fathoms[1]; coral mud; bottom temperature at 610 fathoms, 39° F. One specimen.

Station 186, September 3, 1874; Prince of Wales Channel; lat. 10° 30′ S., long. 142° 18′ E.; 8 fathoms; coral mud. Five specimens.

Banda; 17 fathoms. Two specimens.

Ternate. One specimen.

Admiralty Islands; 16 to 20 fathoms. One specimen.

Samboangan; 10 fathoms. Seven specimens.

[1] The exact Station, and consequently the exact depth, is not recorded.

Other Localities.—Cape of Good Hope; Port Natal; Ceylon; Nicobar Islands (?); Australian Seas (Péron and Lesueur); Timor; Solor; North Borneo; Sooloo; China Sea; Yedo; Zebu; Bohol; Ubay; Cabulan; Batjan; Ceram; H.M.S. "Alert," Warrior Reef, Torres Strait, and Port Molle; Kingsmills Islands; Moreton Bay, Fiji; Vavao; Peru.

History.—This name was given by Müller to an individual from some unknown locality which was found by Troschel in the Paris Museum. It had twenty-seven arms, owing to the presence of both distichal and palmar series, and twenty cirri of twelve joints. Müller's description of it in his final memoir[1] does not differ essentially from that which was drawn up for him by Troschel in 1841;[2] but he added to it a more detailed diagnosis, based on his own observation, of a specimen from Vavao which he was inclined to refer to the same type.

Although on two occasions I have searched carefully through the large *Comatula*-collection in the Paris Museum, a privilege for which I am indebted to the kindness of Professor Perrier, I have been unable to identify the original type of Müller's species. The number of arms, twenty-seven, mentioned by him, is larger than that in some individuals from the voyage of Péron and Lesueur which certainly belong to this species, though I do not think that they can be the type of it as I formerly suggested. But I can find no reference to them in any of Müller's writings, though he must certainly have seen them when at Paris; while they must also have been known to Lamarck, who founded other species on Comatulæ obtained by Péron and Lesueur.

Although, however, Müller's first type specimen seems to have disappeared, the second one, that from Vavao, is in excellent condition. It was obtained by Hombron and Jacquinot in 1841, during the voyage of the "Astrolabe," and is fortunately not dry, but preserved in spirits. Had Müller been able to visit the Paris Museum himself in 1840, he would probably have recognised the identity of the form which he called *Alecto parvicirra* with that which he found in the Leyden Museum under the name of *Comatula timorensis*. The two species were described on successive pages of the Berlin Monatsbericht for 1841, but I cannot regard them as different; and though the diagnosis of *Comatula timorensis* is better than that of *Comatula parvicirra*, which precedes it, I have preferred to retain the latter name, not on account of its one-page claim to priority, but because it expresses a definite character of this widely distributed type, and does not connect it with any particular locality.

Two years after making his first communication on the subject of *Comatula*-species, Müller described a twenty-armed form from Natal in the Stockholm Museum under the name "*Alecto Wahlbergii.*"[3] It has no palmar series, and further differs in several minor

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 256.
[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1841, p. 185.
[3] *Archiv f. Naturgesch.*, 1843, Jahrg. ix. Bd. i. p. 131.

points from the types of *Comatula parvicirra* and *Comatula timorensis*, so that I was for a long time inclined to regard it as specifically distinct; but I have at last been obliged to abandon this view, and now consider the type as another variety of *Actinometra parvicirra*.

Grube's description of his *Comatula mertensi*[1] only differs from those of *Comatula parvicirra* and *Comatula timorensis* in one essential point. He states that there are but "2 Radialia, das Axillare mit Syzygium." Were this really the case, his type would be most closely allied to *Actinometra distincta* of the *Typica*-group. But, having been enabled by the kindness of Professor Schneider, Grube's successor at Breslau, to examine the types of this species for myself, I can state positively that there are three radials with a bifascial articulation between the second and third, as in most Comatulæ; while in all other respects the characters of the type are those of *Actinometra parvicirra*, and Grube's name is therefore reduced to the rank of a synonym.

During his residence in the Philippine Islands, Professor Semper collected several examples of an *Actinometra* with thirteen to thirty-nine arms, on which, believing it to be new to science, he bestowed the MS. name *armata*. This name was employed by myself in a couple of anatomical papers,[2] though I subsequently found reason to replace it by *polymorpha*,[3] when giving a detailed description of the type, which did not appear to me to be absolutely identical with the Vavao variety of *Actinometra parvicirra*. Further experience, however, has convinced me that the two forms cannot be separated specifically, and I must also refer to the same variable type the dry specimen in the Hamburg Museum which I have noticed as *Actinometra meyeri*.[4] The same may be said of the *Actinometra annulata* of Bell,[5] in whose diagnosis I can find no single point of specific value by which this type can be distinguished from the *Actinometra polymorpha* which I had described some years previously, and had subsequently referred to *Actinometra parvicirra*, Müll., sp.;[6] while as Bell gave no hint of his views respecting the relationship of his new species, his reasons for establishing it are somewhat obscure.

Some of the specimens which have been distributed by the Godeffroy Museum under the name *Actinometra mutabilis*, Lütken, MS., must also be referred to *Actinometra parvicirra*, *e.g.*, No. 6146, from Moreton Bay, Fiji. There is a tridistichate individual from the Nicobar Islands which I found under this name in the Copenhagen Museum, and I subsequently saw a similar form at Vienna. The arm-joints are rather long in both cases, and without making a renewed examination of the specimens I should not like to

[1] 53e *Jahresber. der Schlesisch. Gesellsch. f. Vaterl. Cult.*, 1875, p. 74.
[2] *Journ. of Anat. and Phys.*, 1876, vol. x. p. 582; vol. xi. p. 91.
[3] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1877 [1879], p. 50.
[4] *Journ. Linn. Soc. Lond.* (Zool.), 1882, vol. xvi. p. 525.
[5] *Proc. Zool. Soc. Lond.*, 1882, p. 535.
[6] *Notes from the Leyden Museum*, 1881, vol. iii. p. 204.

speak positively as to their nature. But they must certainly belong either to *Actinometra quadrata* or to *Actinometra parvicirra*.

Remarks.—This latter variable and much be-named species is a somewhat isolated one. It is separated from *Actinometra trichoptera* and *Actinometra japonica* by its smaller number of cirri; while *Actinometra regalis* and its allies have many more arms which are united more or less completely by interradial plating (Pl. LXVIII. fig. 2). The only type which approaches *Actinometra parvicirra* at all closely is *Actinometra quadrata*, which seems to be distinguished from it by the shape of its middle and later arm-joints (Pl. LXII. fig. 1). There are, however, one or two forms among those collected at Samboangan by the Challenger which appear to approach *Actinometra quadrata*, and it may be that the latter name will have to be abandoned.

When describing the series of specimens which I called *Actinometra polymorpha*, I put down the number of arms as ranging from thirteen to thirty-nine; and among all the many specimens of this type which I have examined during the last twelve years I have found but one in which those limits have been exceeded. Bell, indeed, described his single individual of *Actinometra annulata* as having forty arms, which would mean that it has the full complement of ten distichal and twenty palmar axillaries; but I have found on examination that this is not the case in reality. Post-palmar axillaries occur in but few individuals that I have examined; and even when they are present I have only once found the number of arms to exceed thirty-nine, owing to the absence of palmars and even of distichal axillaries in other parts of the rays, as is well shown in Pl. LXVII. fig. 3. In this individual three of the primary arms do not divide at all, *i.e.*, there are only seven instead of ten distichal axillaries, and the deficiency of arms arising from their absence is partly compensated by the presence of three post-palmar axillaries. The same is true, though in a less degree, of two more Challenger specimens from Samboangan (Pl. LXI. fig. 5), and also of one from Batjan which I have seen in the Berlin Museum; but in one example from Banda which I must provisionally refer to this type, all the distichal and palmar axillaries are present, together with four post-palmars in addition. There are five more individuals in the Challenger collection which have distichals and palmars but no post-palmars, and eight more in which palmars are not present at all, a condition which also occurs in three of Semper's eleven examples, one of which has only thirteen arms. So great a variation in the number of arms as this is certainly unusual, but I have found myself quite unable to draw any fixed line of separation, often as I have attempted it. It does seem, however, as if forty were the usual limit of the number of arms in this species, even though post-palmars may sometimes be present; and I am inclined to lay more stress upon this as a character of systematic value than upon the presence or absence of palmar or post-palmar axillaries.

The potential dimorphism in the characters of the arms of *Actinometra* is very well shown in this species. It presents itself in two large individuals dredged by the

Challenger at Station 186, and in at least six of the seven from Samboangan. The usual rule is that the tentaculiferous anterior arms have about twice as many joints as the ungrooved hinder arms, which terminate definitely in a miniature axillary joint, bearing a couple of pinnules; while the anterior arms always seem to end in a growing point as is the case with all the arms of *Antedon*.

The problematical ovoid bodies, which occasionally appear as brown spots in the centre of the dorsal surface of some of the segments of the pinnules on the ungrooved arms, occur in single individuals of this species from Station 186, Banda, and Samboangan, and also in five out of the eleven examples obtained by Semper in the Philippines. I am at present quite unable to throw any light upon their character, though I hope that the researches of Dr. O. Hamann, in whose skilled hands I have placed several of the pinnules containing them, may add considerably to our knowledge of their nature and structure. They are not peculiar to *Actinometra parvicirra*, as they also present themselves in *Actinometra elongata* from Banda, and in the Brazilian *Actinometra meridionalis*.

The number of cirri which occur in *Actinometra parvicirra* seems to vary considerably, though the number of joints remains fairly constant at ten to sixteen. In three of the Philippine specimens the centro-dorsal is reduced to a thin disk bearing three or four moderately developed cirri, with indications of other sockets which have been more or less completely obliterated (Pl. LXI. figs. 1, 5); while in the individual from Station 174 the centro-dorsal is very irregularly shaped, and bears quite rudimentary cirri with imperfect sockets for others (Pl. LXI. fig. 3). Another Samboangan specimen has a larger number of cirri, but they are all small and rudimentary on a very thin centro-dorsal (Pl. LXI. fig. 4). As a general rule there are ten or a dozen cirri which are not unfrequently disposed in pairs, two at each angle, with a few others in intermediate positions (Pl. LXI. figs. 2, 6; Pl. LXVII. fig. 3). But I have seen individuals, both from the Philippines and from the Cape of Good Hope, with as many as twenty-five sockets on the centro-dorsal, which almost entirely conceals the first radials, though of course they may not all have borne cirri simultaneously. There is also a good deal of variation in the development of the spines on the later cirrus-joints, and in the characters of the terminal comb on the lower pinnules. Three modifications of this comb in different individuals from Samboangan are shown in figs. 8–10 on Pl. LXI. In the original of fig. 8, the comb is so small that it might easily escape notice; but the other two pinnules are more normal in character. The number of pinnules which bear a comb is also very variable. I have seen specimens both from Africa and from the Philippines, in which there is no comb after the third brachial; while in others from both localities it may be found on the pinnule of the fifteenth brachial, and in some of the Philippine specimens the later pinnules of the arms may have small combs. In like manner I have seen individuals from the Cape and from the Philippines in which the basal joints of the genital pinnules are considerably produced towards the dorsal side; but in other individuals from these and from other localities this character is entirely absent. That obtained by the Challenger at Simon's Bay seems to have just liberated its ova, as a small group of them is collected on the distal side of each genital pinnule, in the angle between it and the arm (Pl. LXI. fig. 7).

In nearly all the examples of this species which I have seen the mouth is very distinctly interradial, as is well shown in Müller's diagram of *Comatula wahlbergii*,[1] and in my own figures of *Actinometra polymorpha*.[2] In one or two cases, however, the A ambulacrum is somewhat displaced forwards, though never so much so as to cause the mouth to become radial.

The disk is generally naked, but the neighbourhood of the anal tube sometimes bears scattered granules; while in one individual from Torres Strait there is a tolerably close pavement of minute scale-like plates over the whole disk. The perisome of the arms and pinnules in this individual is considerably reduced, and the genital glands are but poorly developed, though in another from the same station, which was presented by Sir Wyville Thomson to the Stockholm Museum, the perisome is much more substantial and the genital pinnules, especially in the posterior arms, are much swollen, so that the two forms differ greatly in their external appearance.

Actinometra parvicirra, as described above, is a somewhat comprehensive type, embracing as it does three of Müller's species, together with four others which have been regarded as distinct at various times; and its distribution therefore is considerably extensive. It occurs to a distance of about 35° on either side of the equator, and has a range in longitude of some 260° from the Cape of Good Hope to Peru. Long since known from Natal, Timor, and from the Friendly Islands, it has subsequently been discovered at numerous intermediate localities, such as Ceylon, the Moluccas, Philippines, Japan, Fiji, and East Australia; and I quite expect that it will be eventually found in the Atlantic, more especially as the species of *Actinometra* characteristic of that ocean seems also to occur in the Arafura Sea, while *Antedon carinata* of the Indian Ocean and East Pacific is a common species in the West Atlantic.

[1] *Abhandl. d. k. Akad. d. Wiss. Berlin*, Jahrg. 1847 [1849], p. 245.
[2] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, 1877 [1879], pl. i. figs. 6–10.

3. *Actinometra trichoptera* (Valenciennes), Müll., sp. (Pl. LXIII. figs. 1–5).

Specific formula—a.3.(3).$\frac{bc}{a}$.

... *Comatula trichoptera*, Valenciennes, MS.
1846. *Comatula trichoptera*, Müller, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, 1846, p. 178.
1849. *Comatula trichoptera*, Müller, Abhandl. d. k. Akad. d. Wiss. Berlin, Jahrg. 1847 [1849], p. 257.
1862. *Comatula trichoptera*, Dujardin and Hupé, Hist. Nat. des Zoophytes, Échinodermes, Paris, 1862, p. 205.
1879. *Actinometra trichoptera*, P. H. Carpenter, Trans. Linn. Soc. Lond. (Zool.), ser. 2, 1877 [1879], p. 27.
1882. *Actinometra trichoptera*, Bell, Proc. Zool. Soc. Lond., 1882, p. 535.
1882. *Actinometra trichoptera*, P. H. Carpenter, *Ibid.*, p. 747.

Centro-dorsal a relatively wide disk, bearing some thirty or more marginal cirri. These have about sixteen joints, a few of which are longer than wide, the penultimate with but little trace of an opposing spine.

First radials scarcely visible, and the second but partially united laterally; the rays quite free and the axillary angle rather sharp. Three distichals and sometimes three palmars, the axillary with a syzygy.

Fifteen to twenty-two arms, of slightly overlapping joints, the lower ones relatively short and triangular, gradually becoming longer and more quadrate. Syzygies in the third and in the tenth or twelfth brachials, and then at intervals of three or four joints.

The distichal pinnule is about 9 mm. long, and that on the second brachial but little shorter. The next two or three diminish rapidly in length, but become swollen for the genital glands and lose their terminal comb. The lower joints of the earlier pinnules sometimes overlap rather sharply and have spinose edges.

Mouth interradial; disk naked.

Colour in spirit,—light yellowish-brown, mottled with grey or darkish brown.

Disk 9 mm.; spread 12 cm.

Locality.—Port Jackson; 10 to 12 fathoms. One specimen.

Other Localities.—Port Philip; King George's Sound.

Remarks.—The types of this species were brought to Paris from King George's Sound by Quoy and Gaimard, and received from Valenciennes the MS. name *trichoptera*, which was adopted by Müller when he afterwards described them. Its range was extended to Port Jackson by the Challenger, and the British Museum has since obtained examples of it from Port Philip, so that it may be assumed to be common along the whole southern coast of Australia. But I have never met with any form like it from the tropical seas. *Actinometra robustipinna* from the Moluccas resembles it in the presence of a large number of cirri, but is readily distinguished by the great size of its first three pinnules. On the other hand there is a considerable resemblance between *Actinometra trichoptera* and Müller's other species, *Actinometra japonica*, to which I would now refer—possibly as a varietal form—the individual which I called *Actinometra morsei* when asked by von Graff to name the host of *Myzostoma nigrescens*.

This is a little specimen without palmars, which are also absent in most of the examples of *Actinometra trichoptera* that I have seen. It has rather shorter axillaries than the type of *Actinometra japonica*, and less developed spines on the terminal cirrus-joints, both of which are points of resemblance to *Actinometra trichoptera*. It seems, however, to have longer arm-joints than the Australian species, and shows the carination of the large basal joints of the distal pinnules, which in *Actinometra japonica* extends further out on the arm. This does not appear in *Actinometra trichoptera*, and for the present, therefore, I should be inclined to regard the two species as distinct, though it is by no means improbable that other intermediate forms may eventually be discovered.

8. *Actinometra littoralis*, n. sp. (Pl. LXVII. figs. 1, 2).

Specific formula—a.3.3.(2).$\frac{o}{o}$.

Description of an Individual.—Centro-dorsal a very thin pentagonal disk with slightly incurved sides, rather above the level of the radial circlet and separated from it by faint clefts. Cirri all lost. Three radials visible; the second almost completely united laterally, but the axillaries free. The rays may divide four times. Three distichals and three palmars, the axillary with a syzygy; post-palmars, when present, of two joints only, the axillary without a syzygy. Thirty-eight arms, which are all grooved, but dimorphic. The anterior of one hundred and fifty, and the posterior of one hundred segments, which are triangular at the base, gradually becoming more quadrate and slightly elongated towards the end. Syzygies in the third and tenth or eleventh brachials; others at intervals of three or four joints.

The palmar pinnule is nearly as long as the distichal one, which reaches 12·5 mm.; but that of the second brachial is much shorter. The next pair are the smallest, their successors increasing again. The terminal pinnules are much longer and more slender in the anterior than in the posterior arms. The lowest joints of the proximal pinnules are rather wide and overlap slightly with spinose margins. The proximal pinnules have a well-defined comb which disappears by the fourth or fifth brachial.

Mouth interradial; all the arms grooved; disk naked.

Colour in spirit,—deep blackish-brown.

Disk 20 mm.; spread 20 cm.

Locality.—Banda; 17 fathoms. One specimen.

Remarks.—But one individual of this species having been obtained, I am unable to state its characters as definitely as I could wish. In the normal arrangement of the arm-divisions there are three distichals and three palmars, just as in *Actinometra parvicirra;* but sometimes there are only two palmars; and in one case this arrangement is followed by a post-palmar series of the same character, which does not seem to be due to regeneration (Pl. LXVII. fig. 1); but as it may not occur in other individuals, I have enclosed the sign for it within brackets in the specific formula.

Apart, however, from the possible presence of the two-jointed post-palmar series, *Actinometra littoralis* differs from *Actinometra parvicirra* and *Actinometra trichoptera* in the more complete reduction of its centro-dorsal. This is not quite lowered to the level of the radial pentagon, from which it is separated by commencing clefts, a condition not reached by any specimen that I have seen which in other respects presents the general characters of *Actinometra parvicirra.* A minor point of distinction between the two species is afforded by the overlap and the very spiny margins of the lower pinnule-joints in *Actinometra littoralis;* while the terminal comb disappears earlier than is usually the case in *Actinometra parvicirra,* though it is well-developed on the proximal pinnules (Pl. LXVII. fig. 2).

9. *Actinometra regalis*, n. sp. (Pl. LXVIII.).

Specific formula—a.3.3.3.3.$\frac{b}{a}$.

Centro-dorsal a rudely circular disc, much hollowed in the centre, and bearing fifteen to twenty marginal cirri, of fifteen nearly equal segments; the penultimate without an opposing spine.

Three radials visible, the second closely united laterally; axillaries short, widely triangular, and in contact laterally. The rays may divide five times but do not spread much, as the first joints beyond each division are closely united laterally. The rays and their divisions are united by interradial plating to the level of the distichal axillaries or slightly beyond it. Each division of three joints, the third of which is axillary with a syzygy.

Arms very numerous, thirteen to twenty-four on a ray. They have moderately long, triangular, and much-overlapping joints, which soon become quadrate and are nearly square at the ends; the anterior arms have one hundred and sixty, and the posterior only sixty or seventy joints. Syzygies in the third and the tenth or twelfth brachials, and then at intervals of two to six, usually three or four joints.

The distichal and palmar pinnules are of about equal size, reaching 15 mm.; the length diminishes to that on the second brachial, which is considerably shorter, and those of the fourth and fifth brachials are much more so, after which the length increases again. Later pinnules of the anterior arms not specially long; terminal comb to the tenth brachial.

Mouth interradial or nearly so; disk naked or slightly plated.
Colour in spirit,—deep brown, the pinnules tipped with yellow-green.
Disk 27 mm.; spread 22 cm.
Locality.—Banda; 17 fathoms. Two specimens.

Remarks.—These two individuals seem to be different from that which I found in the Leyden Museum and described under the name *Actinometra schlegelii.*[1] They show much more of the first radials, which are almost entirely concealed in the Leyden species, and have relatively longer arm-joints. This character is best marked in the middle and outer parts of the arms, those of *Actinometra schlegelii* being much wider than long; while in *Actinometra regalis* the joints are more equally quadrate, and the overlap of the lower joints is more marked. In this species too the pinnules of the fourth to sixth brachials are quite small, which is not the case in *Actinometra schlegelii.* The number of cirrus-joints in the latter type is not known; but *Actinometra regalis* has less than twenty, being thus distinguished from *Actinometra peroni* with its very long cirri of thirty joints; while in *Actinometra bennetti* there are fifty cirri of twenty-five joints.

Genus 6. *Promachocrinus*, P. H. Carpenter, 1879.

1879. *Promachocrinus*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 385.
1880. *Promachocrinus*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1880, vol. xv. p. 214.

Definition.—Centro-dorsal hemispherical or conical, bearing numerous closely-set cirri. Ten radials with high distal faces which have large muscle-plates. Mouth central; ambulacra symmetrically distributed and not provided with any definite skeleton. Sacculi well developed.

Remarks.—The principal distinctive character of this remarkable genus, which is only known from the dredgings of the Challenger, is the presence of ten radials in the calyx instead of the usual five (Pl. I. figs. 1, *a*, *b*, *c*). In all other respects there are no essential differences between *Promachocrinus* and *Antedon.* The species of the latter genus to which *Promachocrinus* is most allied are those of the *Eschrichti*-group, in which the radials have high articular faces with large muscle-plates (Pl. I. figs. 1, 6, 8, *a*). The latter character also presents itself in *Antedon acœla*, *Antedon basicurva*, and their allies (Pl. II. figs. 1–5, *a*); but all these forms have a well-defined ambulacral skeleton which is altogether absent in *Promachocrinus.*

One of the three species of this genus was obtained at a depth of 500 fathoms off the Meangis Islands (Station 214). Unfortunately, however, it is only represented by one individual in a most mutilated condition (Pl. LXIX. figs. 9, 10). But each of the other two species occurred at two localities in the southern sea. The type-species, *Promacho-*

[1] *Notes from the Leyden Museum*, 1881, vol. iii. p. 210.

crinus kerguelensis, was obtained in various shallow-water dredgings round the coast of Kerguelen Island, and was also found at 75 fathoms near Heard Island. In its general facies it has a singular resemblance to *Antedon eschrichti* and its allies; while *Promachocrinus abyssorum*, from 1600 and 1800 fathoms (Stations 147, 158) is more like the circumpolar and abyssal members of the *Tenella*-group among the species of *Antedon*. Two of these were associated with it at Station 147, while at Station 158 there was also obtained the remarkable genus *Thaumatocrinus*.

Although there are ten radials in the calyx of *Promachocrinus*, the symmetry of the basals is only pentamerous. Five of the radials are essentially like those of *Antedon*, with a smooth dorsal surface and two openings on the inner face, between which is the shallow groove lodging the radial axial furrow. This seems to have been converted into a canal by the radial process of a rosette, just as in *Antedon* and *Actinometra* (Pl. I. fig. 8*c*; Pl. III. figs. 4*c*, 5*b*); but I was unfortunately unable to obtain this rosette entire, for the central portions of it broke away from the peripheral part which remained firmly attached to the radials (Pl. I. fig. 1*c*).

In many of the five-rayed Comatulæ the interradial angles of the rosette become connected with the five elements of the basal star, which are developed in the synostosis between the centro-dorsal and the radials as I have explained elsewhere;[1] and these basal rays lie beneath the sutures between the five primary radials (Pl. I. fig. 6*c*; Pl. II. figs. 1–5, *c*; Pl. III. figs. 1*c*, 3*a*, 3*b*, 4*c*; Pl. IV. fig. 3*c*; Pl. V. figs. 1*c*, 5*d*). In *Promachocrinus*, however, with its ten radials (or at any rate in *Promachocrinus kerguelensis*), there is a basal ray beneath the middle of every alternate radial (Pl. I. figs. 1, *a*, *c*). Its inner end is broad and flattened, and extended laterally into two processes which meet those of the adjacent basal rays beneath the dorsal surface of the intervening primary radials (Pl. I. fig. 1*c*). When these ten radials are separated from one another the basal rays come away with the "interradial radials" to which they are attached (Pl. I. figs. 2, *a*, *b*), and their impressions are left upon the inner ends of the dorsal surface of the true primary radials with which they were in contact (Pl. I. figs. 1, 3, *c*).

The isolated centro-dorsal of *Promachocrinus* is indistinguishable from that of *Antedon*. Its ventral surface is marked by five grooves lodging the basal rays (Pl. I. figs. 1*c*, 5). But there are only five large radial areas without any indication whatever that each of these lodges portions of two additional radials, as well as its true or primary one. In the large centro-dorsal of *Promachocrinus kerguelensis* the five interradial pillars within the central cavity are very distinct, as is also the case in *Antedon antarctica* (Pl. I. figs. 1, 6, *d*).

In one of the three species of *Promachocrinus* the rays divide so as to produce twenty arms; but they remain simple in the other two species, just as in *Eudiocrinus* and *Thaumatocrinus*. In both alike the first pinnule is on the second joint above the

[1] *Trans. Linn. Soc. Lond.* (Zool.), 1879, ser. 2, vol. ii. pp. 95–100.

primary radial; but there seems to be no constancy as to the side on which it appears, some arms having it on the right, and others on the left side.

The three species of the genus may be classified as follows :—

I. Twenty arms, ... 1. *kerguelensis*, n. sp.
II. Ten arms only.
   A. Centro-dorsal small, with but few cirri; elongated arm-joints, . . 2. *abyssorum*, n. sp.
   B. Centro-dorsal large, bearing numerous cirri; arm-joints not specially long, . 3. *naresi*, n. sp.

1. *Promachocrinus kerguelensis*, n. sp. (Pl. I. figs. 1, *a–d*; Pl. LXX.).

1879. *Promachocrinus kerguelensis*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 385.
1880. *Promachocrinus kerguelensis*, P. H. Carpenter, Journ. Linn. Soc. Lond. (Zool.), 1880, vol. xv. pl. xii. fig. 28.

Centro-dorsal conical and thickly covered almost to the apex with eighty or more cirri. These may reach to 40 mm. in length, and consist of thirty-five to forty tolerably uniform joints, which are mostly rather longer than wide. The later joints may overlap slightly, but the penultimate is small, with little or no trace of an opposing spine.

First radials barely visible; the second short, nearly oblong, and but slightly joined laterally; axillaries widely rhombic. The first brachial is scarcely incised by the second, which is irregularly quadrate. The next few joints are quadrate, and their successors triangular, wider than long, and slightly overlapping. A syzygy in the third brachial; the next in the seventh or eighth, with others at intervals of two to four joints. The first two pinnules on each side are tolerably equal, slender, and flagellate, and reach over 20 mm. in length.

The lowest pinnules have the most slender joints, those of their successors increasing in stoutness, but diminishing in number. The two lowest joints of the middle and later pinnules are somewhat flattened, with their apposed edges incurved.

Mouth central and anus marginal; disk naked; genital glands long and slender; sacculi abundant on the pinnules.

Colour in spirit,—light yellowish-brown, or greyish-white with dark red spots.

Disk 16 mm.; spread 18 cm.

Localities.—Kerguelen Island; 10 to 100 fathoms. One specimen.

Station 149c, January 19, 1874; Balfour Bay; 20 to 60 fathoms. Two specimens.

Station 149d, January 20, 1874; Royal Sound; lat. 49° 28′ S., long. 70° 13′ E.; 28 fathoms. One specimen.

Station 149e, January 21, 1874; off Greenland Harbour; 30 fathoms. One specimen.

Station 149h, January 29, 1874; off Cumberland Bay; 127 fathoms. Two young specimens.

The bottom deposit at all these stations is volcanic mud.

Station 151, February 7, 1874; off Heard Island; lat. 52° 59′ 30″ S., long. 73° 33′ 30″ E.; 75 fathoms; volcanic mud. One young specimen.

Remarks.—There is a most remarkable general resemblance between this species and the two allied forms *Antedon eschrichti* and *Antedon antarctica*, which last was found associated with it off Heard Island. The characters of the cirri, arm-joints, pinnules, and even of the genital glands are very closely similar in the two types; so that if nothing were known of *Promachocrinus kerguelensis* but some fragments of its arms, one would unhesitatingly refer them to an *Antedon* of the *Eschrichti*-group.

Three of the seven specimens obtained at Kerguelen appear to be fully developed, while two are premature, and two more, those from Christmas Harbour, are quite young (Pl. LXX. fig. 2). The cirri of these last exhibit a very striking dimorphism. Most of them belong to the "small mature" type, while there are others with a much larger number of immature joints. The latter type is the one which chiefly presents itself in the adult.

The first radials of these young individuals are much more distinctly visible than is the case in the adult; while the second radials and first brachials are more deeply incised, and the arm-joints relatively longer with a more distinct overlap. The Heard Island specimen is considerably older than those from Christmas Harbour, but also has a large number of the "small mature" cirri.

The anal tube of this species, in the five examples of which I have examined the disk, is near the margin and not close up to the central mouth, as is usually the case in *Antedon*.

2. *Promachocrinus abyssorum*, n. sp. (Pl. I. figs. 4, 5; Pl. LXIX. figs. 5–7).

1879. *Promachocrinus abyssorum*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 385.

Centro-dorsal small and rounded, nearly covered by the sockets of about twenty cirri, which seem to have had very long lower joints.

Radials partially visible; the first brachial of moderate length, and somewhat incised by the second, which bears a pinnule. The next few joints are nearly oblong, and their successors quadrate, gradually becoming much elongated. There is a syzygy in the fourth or fifth brachial, and others at intervals of one to five joints.

The first few pinnules on each side are tolerably equal, slender, and flagellate, reaching 8 mm. in length. The lowest pinnules have the smallest joints, those of their successors becoming both longer and stouter.

Mouth central; disk naked. Genital glands short and stout. Sacculi fairly abundant on the pinnules.

Colour in spirit,—white.

Disk 6 mm.; spread perhaps 10 cm.

Localities.—Station 147, December 30, 1873; lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze; bottom temperature, 34°·2 F. Three specimens.

Station 158, March 7, 1874; south-west of Melbourne; lat. 50° 1′ S., long. 123° 4′ E.; 1800 fathoms; Globigerina ooze; bottom temperature, 33°·5 F. One specimen.

Remarks.—The general characters of this little species are altogether those of an abyssal *Antedon* belonging to the *Tenella*-group. It is remarkable for the shape of its genital glands, which are short and thick (Pl. LXIX. figs. 7*a*, *b*), instead of being long and fusiform as in *Promachocrinus kerguelensis* and in *Antedon eschrichti*.

3. *Promachocrinus naresi*, n. sp. (Pl. LXIX. figs. 8–10).

1879. *Promachocrinus naresii*, P. H. Carpenter, Proc. Roy. Soc., 1879, vol. xxviii. p. 385.

Description of an Individual.—Centro-dorsal hemisphericál, 9 mm. in diameter, and covered except at the dorsal pole by the sockets of some forty cirri.

Radials just visible; the first brachial rather short and but little incised by the second, which bears a pinnule. The next few joints are nearly oblong or quadrate, with somewhat tubercular junctions and pinnules on their shorter sides; the later joints become more distinctly triangular and quadrate towards the ends. A syzygy in the fourth brachial, and others at intervals of four to twelve joints. Sacculi abundant on the pinnules.

Colour in spirit,—brownish-white.

Locality.—Station 214, February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F. One mutilated individual.

Remarks.—This specimen is unfortunately so mutilated that a complete description of it is impossible. But it is obviously not identical with the other ten-armed species just described, as it has a larger centro-dorsal with more numerous cirri, and the arm-joints relatively shorter and more triangular (Pl. LXIX. figs. 5, 8). The general characters of the arms and pinnules, so far as can be judged from the fragments of them which are preserved, are essentially those of *Promachocrinus kerguelensis*.

VII. BATHYMETRICAL DISTRIBUTION AND STATION LIST.

Station List of the Comatulæ which have been obtained by the various British Expeditions for Deep-Sea Exploration between the Years 1868 and 1882.

This list also contains the generic names of those Stalked Crinoids which were dredged at Stations where Comatulæ occurred. The specific details respecting them will be found in Chapter xiii. of Part I.

H.M.S. "Lightning," 1868.

Station 13. Lat. 59° 5′ N., long. 7° 29′ W.; 189 fathoms; bottom temperature, 49°·3 F.

Antedon phalangium. Also in the Minch; off Cape Mondego and Cape Sagres; the Seine Bank, and Mediterranean.

H.M.S. "Porcupine," 1869.

The Minch, 60 to 88 fathoms; and off Loch Scavaig, Skye.

Antedon phalangium. Also at Station 13 (1868); off Cape Mondego and Cape Sagres; the Seine Bank, and Mediterranean.

Station 51. Lat. 60° 6′ N., long. 8° 14′ W.; 440 fathoms; bottom temperature, 42° F.

Antedon tenella. Also at Stations 54, 55, 74; and 1870, Station 17a. Also the "Triton," 1882, Stations 2, 5.

Station 54. Lat. 59° 56′ N., long. 6° 27′ W.; 363 fathoms; bottom temperature, 31°·4 F.

Antedon tenella. Also at Stations 51, 55, 74; and 1870, Station 17a. Also the "Triton," 1882, Stations 2, 5.

Station 55. Lat. 60° 4′ N., long. 6° 19′ W.; 605 fathoms; bottom temperature, 29°·8 F.

Antedon tenella. Also at Stations 51, 54, 74; and 1870, Station 17a. Also the "Triton," 1882, Stations 2, 5.

STATION 57. Lat. 60° 14′ N., long. 6° 17′ W.; 632 fathoms; bottom temperature, 30°·5 F.

Antedon eschrichti. Also the "Valorous," 1875, Station 1; the "Alert," 1875, Franklin-Pierce Bay; the Challenger, Station 48; and the "Triton," 1882 Station 4.

STATION 74. Lat. 60° 39′ N., long. 3° 9′ W.; 203 fathoms; bottom temperature, 47°·6 F.

Antedon tenella. Also at Stations 51, 54, 55; and 1870, Station 17A; also the "Triton," 1882, Stations 2, 5.

STATIONS not recorded.

Antedon rosacea. Also off the coast of Tunis.
Antedon hystrix. Also the "Triton," 1882, Station 4.

H.M.S. "PORCUPINE," 1870.

STATION 13. Off Cape Mondego; lat. 40° 16′ N., long. 9° 37′ W.; 220 fathoms; bottom temperature, 52° F.

Antedon phalangium. Also in the Minch; off Cape Sagres; the Seine Bank, and the Mediterranean.

STATION 17A. Lat. 39° 39′ N., long. 9° 39′ W.; 740 fathoms; bottom temperature. 49°·3 F.

Antedon lusitanica.
Antedon tenella. Also 1869, Stations 51, 54, 55, 74; also the "Triton," 1882, Stations 2, 5.

STATION 25. July 27, 1870; near Cape St. Vincent; lat. 37° 11′ N., long. 9° 7′ W.; 374 fathoms; rock; bottom temperature, 53°·5 F.

Actinometra pulchella. Also at Station 31, and by the Challenger at St. Paul's Rocks; perhaps also at Station 192. Abundant in the Caribbean Sea.

STATION 31. Lat. 35° 56′ N., long. 7° 6′ W.; 477 fathoms; clay; bottom temperature, 50°·5 F.

Actinometra pulchella. Also at Station 25, and at St. Paul's Rocks.

Off Cape Sagres; 45 fathoms.

Antedon phalangium. Also in the Minch; off Cape Mondego; the Seine Bank, and Mediterranean.

Off Carthagena; 80 fathoms.

Antedon phalangium. Also in the Atlantic.

Bay of Benzert; 50 to 100 fathoms.

Antedon phalangium.
Antedon rosacea (young). Also in the Færoe Channel.

Skerki Bank; 30 to 120 fathoms.

Antedon phalangium.
Antedon rosacea (young).

H.M.S. "Valorous," 1875.

STATION 1. July 22, 1875; off Hare Island in Davis Strait; lat. 70° 30′ N., long. 54° 41′ W.; 175 fathoms; sand and mud.

Antedon eschrichti. Also the "Porcupine," 1869, Station 57; the "Alert," 1875, Franklin-Pierce Bay; the Challenger, Station 48; and the "Triton," 1882. Station 4.

STATION 6. August 10, 1875; lat. 64° 5′ N., long. 56° 47′ W.; 410 fathoms; sand and mud; bottom temperature, 34°·6 F.

Antedon quadrata. Also the "Alert," 1875, Discovery Bay and Franklin-Pierce Bay; the Challenger, Station 48; and the "Triton," 1882, Stations 4, 6.

H.M.S. "Alert," 1875.

Franklin-Pierce Bay; lat. 79° 25′ N.

Antedon eschrichti. Also the "Porcupine," 1869, Station 57; the "Valorous," 1875, Station 1; the Challenger, Station 48; and the "Triton," 1882, Station 4.

Antedon quadrata. Also at Discovery Bay; also the "Valorous," 1875, Station 6; the Challenger, Station 48; and the "Triton," 1882, Stations 4, 6.

Discovery Bay; lat. 81° 41′ N.; 25 fathoms; hard bottom.

Antedon prolixa.

Antedon quadrata. Also at Franklin-Pierce Bay; the "Valorous," 1875, Station 6; the Challenger, Station 48; and the "Triton," 1882, Stations 4, 6.

H.M.S. "Knight Errant," 1880.

On the plateau N.N.W. of North Rona; lat. 59° 12′ N., long. 5° 57′ W.; 53 fathoms; rough ground.

Antedon rosacea. Also in the Mediterranean.

H.M.S. "Triton," 1882.

Station 2. Lat. 59° 37′ 30″ N., long. 6° 19′ 0″ W.; 530 fathoms; mud; bottom temperature, 46°·2 F.

Antedon tenella. Also at Station 5. Also the "Porcupine," 1869, Stations 51, 54, 55, 74; and 1870, Station 17A.

Station 3. August 8, 1882; on the Færoe Banks; lat. 60° 39′ 30″ N., long. 9° 6′ 0″ W.; 87 fathoms; sand and shells; bottom temperature, 49° F.

Antedon petasus.

Station 4. Lat. 60° 22′ 40″ N. and 60° 31′ 15″ N., long. 8° 21′ 0″ W. and 8° 14′ 0″ W.; 327 to 430 fathoms; stones, mud; bottom temperature, 31°·5 to 30° F.

Antedon eschrichti. Also the "Porcupine," 1869, Station 57; the "Valorous," 1875, Station 1; the "Alert," 1875, Franklin-Pierce Bay; and the Challenger, Station 48.

Antedon hystrix. Also the "Porcupine," 1869.

Antedon quadrata. Also at Station 6. Also the "Valorous," 1875, Station 6; also the "Alert," 1875, Discovery Bay and Franklin-Pierce Bay; and the Challenger, Station 48.

STATION 5. Lat. 60° 11′ 25″ N. and 60° 20′ 15″ N., long. 8° 15′ 0″ W. and 8° 8′ 0″ W.; 433 to 285 fathoms; hard ground, stones; bottom temperature, 43°·5 to 40°·8 F.

Antedon tenella. Also at Station 2. Also the "Porcupine," 1869, Stations 51, 54, 55, 74; and 1870, Station 17A.

STATION 6. Lat. 60° 9′ 0″ N., long. 7° 26′ 30″ W.; 466 fathoms; stones; bottom temperature, 29°·5 F.

Antedon quadrata. Also at Station 4. Also the "Valorous," 1875, Station 6; also the "Alert," 1875, Discovery Bay and Franklin-Pierce Bay; and the Challenger, Station 48.

H.M.S. CHALLENGER, 1873–1876.

STATION 48. May 8, 1873; on the Le Have Bank; lat. 43° 4′ N., long. 64° 5′ W.; 51 fathoms; rock.

Antedon eschrichti. Also the "Porcupine," 1869, Station 57; the "Valorous," 1875, Station 1; the "Alert," 1875, Franklin-Pierce Bay; the "Triton," 1882, Station 4.

Antedon quadrata. Also the "Valorous," 1875, Station 6; the "Alert," 1875, Discovery Bay and Franklin-Pierce Bay; and the "Triton," 1882, Stations 4, 6.

St. Paul's Rocks. Lat. 0° 55′ 36″ N., long. 29° 22′ 32″ W.

Actinometra pulchella. Possibly at Station 192. Also the "Porcupine," 1870, Stations 25, 31. Abundant in the Caribbean Sea.

STATION 122. September 10, 1873; off Barra Grande; lat. 9° 5′ S., long. 34° 50′ W.; 350 fathoms; red mud.

Atelecrinus balanoides. Also at several Stations in the Caribbean Sea.

Pentacrinus maclearanus.

Bahia; 7 to 20 fathoms.

Antedon carinata. Also in the Pacific, Eastern Archipelago, and Indian Ocean.
Antedon dübeni.
Actinometra lineata.
Actinometra meridionalis. Abundant in the Caribbean Sea.

STATION 135E. October 18, 1873; near Tristan da Cunha; lat. 37° 21′ 0″ S., long. 12° 22′ 30″ W.; 1000 fathoms; hard ground, shells, gravel.

Three Pentacrinoid larvæ.

STATION 135G. October 18, 1873; off Tristan da Cunha; lat. 37° 10′ 50″ S., long. 12° 18′ 30″ W.; 550 fathoms; hard ground.

Antedon multispina. Also at Station 344.

Simon's Bay, Cape of Good Hope.

Actinometra parvicirra. Also at Stations 174, 186, Banda, Ternate, Admiralty Islands, and Samboangan.

Off Marion Island; 50 to 75 fathoms.

Antedon exigua. Also at Station 145.

STATION 145. December 27, 1873; off Marion Island; lat. 46° 43′ 0″ S., long. 38° 4′ 30″ E.; 140 fathoms; volcanic sand.

Antedon exigua. Also in 50 to 75 fathoms.
Antedon hirsuta.

STATION 147. December 30; between Marion Island and the Crozets, 1873; lat. 46° 16′ S., long. 48° 27′ E.; 1600 fathoms; Diatom ooze; bottom temperature, 34°·2 F.

Antedon abyssorum.
Antedon bispinosa.
Antedon remota.
Promachocrinus abyssorum. Also at Station 158.
Bathycrinus aldrichianus.
Hyocrinus bethellianus.

Kerguelen Island; 10 to 100 fathoms.

STATION 149C. January 19, 1874; Balfour Bay; 20 to 60 fathoms.

STATION 149D. January 20, 1874; Royal Sound; lat. 49° 28′ S., long. 70° 13′ E.; 28 fathoms.

STATION 149E. January 21, 1874; off Greenland Harbour; 30 fathoms.

STATION 149H. January 29, 1874; off Cumberland Bay; 127 fathoms.

The bottom deposit at all these Stations is volcanic mud.

Promachocrinus kerguelensis. Also at Station 151.

STATION 150. February 2, 1874; near Heard Island; lat. 52° 4′ S., long. 71° 22′ E.; 150 fathoms; coarse gravel; bottom temperature, 35°·2 F.

Antedon australis.

STATION 151. February 7, 1874; off Heard Island; lat. 52° 59′ 30″ S., long. 73° 33′ 30″ E.; 75 fathoms; volcanic mud.

Antedon antarctica.
Promachocrinus kerguelensis. Also at Stations 149C, D, E, H.

STATION 158. March 7, 1874; south-west of Melbourne; lat. 50° 1′ S., long. 123° 4′ E.; 1800 fathoms; Globigerina ooze; bottom temperature, 33°·5 F.

Promachocrinus abyssorum. Also at Station 147.
Thaumatocrinus renovatus.

STATION 160. March 13, 1874; south-west of Melbourne; lat. 42° 42′ S., long. 134° 10′ E.; 2600 fathoms; red clay; bottom temperature, 33°·9 F.

Antedon abyssicola. Also at Station 244.

Port Jackson; 8 to 10 fathoms.

Actinometra trichoptera.

Port Jackson; 30 to 35 fathoms.

Antedon macronema.

STATION 164. June 12, 1874; off Port Jackson; lat. 34° 8′ S., long. 152° 0′ E.; 950 fathoms; green mud; bottom temperature, 36°·5 F.

Antedon spinicirra.
Eudiocrinus semperi. Also at Station 169.

STATION 169. July 10, 1874; north-east of New Zealand; lat. 37° 34′ S., long. 177° 22′ W.; 700 fathoms; blue mud; bottom temperature, 40° F.

Antedon alternata. Also at Stations 170A, 218, and 236.
Eudiocrinus semperi. Also at Station 164.

STATION 170A. July 14, 1874; near the Kermadec Islands; lat. 29° 45′ S., long. 178° 11′ W.; 630 fathoms; volcanic mud; bottom temperature, 39°·5 F.

Antedon alternata. Also at Stations 169, 218, and 236.
Antedon basicurva.
Antedon breviradia. Also at Station 175.
Antedon echinata.
Antedon inæqualis. Also at Station 174 (B, C, or D).
Antedon incerta.
Antedon incisa. Also at Station 174 (B, C, or D).
Pentacrinus naresianus.
Metacrinus (two species).

Tongatabu Reefs.

Antedon regalis.
Actinometra quadrata.

STATION 174 (B, C, or D). August 3, 1874; near Kandavu, Fiji; lat. (about) 19° 6′ S., long. (about) 178° 18′ E.; 225, 610, or 210 fathoms; coral mud; bottom temperature (at 610 fathoms), 39° F.

Antedon inæqualis. Also at Station 170A.
Antedon incisa. Also at Station 170A.
Antedon occulta.
Antedon similis.
Antedon tuberculata.

Actinometra parvicirra. Also at Station 186, Simon's Bay, Banda, Ternate, Admiralty Islands, and Samboangan.

Actinometra stelligera.

Actinometra typica.

Atelecrinus wyvillii.

STATION 175. August 12, 1874; near Kandavu, Fiji; lat. 19° 2′ S., long. 177° 10′ E.; 1350 fathoms; Globigerina ooze; bottom temperature, 36° F.

Antedon acutiradia.

Antedon breviradia. Also at Station 170A.

DOUBTFUL.

Antedon basicurva. Also at Station 170A.

Antedon inæqualis. Also at Stations 170A, 174 (B, C, or D).

Pentacrinus naresianus.

Cape York. September 7, 1874; Channel between Albany Island and Somerset.

Actinometra paucicirra. Also at Station 187, and the Arrou Islands.

Actinometra pectinata. Also at Samboangan.

Actinometra solaris. Also at Station 187.

STATION 186. September 8, 1874; Prince of Wales Channel; lat. 10° 30′ S., long. 142° 18′ E.; 8 fathoms; coral mud.

Antedon microdiscus.

Antedon variipinna. Also at the Arrou Islands.

Actinometra belli.

Actinometra maculata.

Actinometra multiradiata.

Actinometra parvicirra. Also at Simon's Bay, Banda, Ternate, Admiralty Islands, Samboangan, and Station 174.

Actinometra valida.

STATION 187. September 9, 1874; off Booby Island; lat. 10° 36′ S., long. 141° 55′ E.; 6 fathoms; coral mud.

Antedon multiradiata.

Actinometra paucicirra. Also at Cape York, and at the Arrou Islands.

Actinometra solaris. Also at Station 186.

STATION 190. September 12, 1874; in the Arafura Sea; lat. 8° 56′ S., long. 136° 5′ E.; 49 fathoms; green mud.

Antedon denticulata.
Antedon elegans.

STATION 192. September 26, 1874; near the Ki Islands; lat. 5° 49′ 15″ S., long. 132° 14′ 15″ E.; 140 fathoms; blue mud.

Antedon angustiradia.
Antedon compressa. Also at Station 201.
Antedon discoidea.
Antedon flexilis.
Antedon longicirra.
Antedon manca.
Antedon parvipinna.
Antedon patula.
Antedon pusilla.
Antedon quinquecostata.
Antedon robusta.
Actinometra pulchella?
Metacrinus (five species).

Arrou Islands.

Antedon variipinna. Also at Station 186.
Actinometra paucicirra. Also at Station 187 and Cape York.

Banda; 17 fathoms.

Actinometra coppingeri. Also at Samboangan.
Actinometra divaricata.
Actinometra duplex.
Actinometra elongata.
Actinometra fimbriata. Also at Station 208.
Actinometra littoralis.
Actinometra multibrachiata.
Actinometra parvicirra. Also at Simon's Bay, Ternate, Admiralty Islands, Samboangan, and Stations 174, 186.
Actinometra regalis.
Actinometra sentosa.

Ternate, Shore.

Actinometra parvicirra. Also at Simon's Bay, Banda, Admiralty Islands, Samboangan, and Stations 174, 186.

STATION 201. October 26, 1874; off Mindanao, Philippine Islands; lat. 7° 3′ N., long. 121° 48′ E.; 82 fathoms; stones, gravel.

Antedon balanoides.
Antedon compressa. Also at Station 192.

STATION 203. October 31, 1874; off Panay; lat 11° 6′ N., long. 123° 9′ E.; 20 fathoms; mud.

Antedon milberti. Also at Station 212.

STATION 205. November 13, 1874; off Luzon; lat. 16° 42′ N., long. 119° 22′ E.; 1050 fathoms; blue mud; bottom temperature, 37° F.

Eudiocrinus varians.

STATION 208. January 17, 1875; Philippine Islands; lat. 11° 37′ N., long. 123° 31′ E.; 18 fathoms; blue mud.

Antedon informis.
Antedon marginata.
Antedon parvicirra.
Actinometra fimbriata. Also at Banda.
Actinometra nobilis. Also at Samboangan.

Zebu Reef, Philippines.

Antedon conjungens.
Antedon disciformis.

STATION 210. January 25, 1875; off the Panglao and Siquijor Islands; lat. 9° 26′ N., long. 123° 45′ E.; 375 fathoms; blue mud; bottom temperature, 54°·1 F.

Antedon distincta.
Antedon tuberosa.
Pentacrinus (two species ?).
Metacrinus (one species ?).

STATION 212. January 30, 1875; off Samboangan; lat. 6° 54′ N., long. 122° 18′ E.; 10 fathoms; sand.

Antedon anceps.
Antedon clemens.
Antedon milberti. Also at Station 208.
Antedon quinduplicava.

Samboangan, Philippines.

Actinometra coppingeri. Also at Banda.
Actinometra distincta.
Actinometra nobilis. Also at Station 208.
Actinometra parvicirra. Also at Simon's Bay, Banda, Ternate, Admiralty Islands, and Stations 174, 186.
Actinometra pectinata. Also at Cape York.
Actinometra rotalaria.

STATION 214. February 10, 1875; off the Meangis Islands; lat. 4° 33′ N., long. 127° 6′ E.; 500 fathoms; blue mud; bottom temperature, 41°·8 F.

Antedon acœla.
Antedon aculeata.
Antedon angusticalyx.
Antedon gracilis.
Antedon lævis.
Antedon valida.
Promachocrinus naresi.
Pentacrinus (two species).
Metacrinus (four species).

STATION 218. March 1, 1875; north of Papua; lat. 2° 33′ S., long. 144° 4′ E.; 1070 fathoms; blue mud; bottom temperature, 36°·4 F.

Antedon alternata. Also Stations 169, 170A, and 236.

STATION 219. March 10, 1875; north of the Admiralty Islands; lat. 1° 54′ 0″ S., long. 136° 49′ 40″ E.; 150 fathoms; coral mud.

Antedon tenuicirra.

Admiralty Islands; 16 to 20 fathoms.

Actinometra parvicirra. Also at Simon's Bay, Banda, Ternate, Samboangan, and Stations 184, 186.
Actinometra simplex.

STATION 232. May 12, 1875; off Japan; lat. 35° 11′ N., long. 139° 28′ E.; 345 fathoms; green mud; bottom temperature, 41°·1 F.

Antedon latipinna.

STATION 235. June 4, 1875; south of Japan; lat. 34° 7′ N., long. 138° 0′ E.; 565 fathoms; green mud; bottom temperature, 38°·1 F.

Eudiocrinus japonicus.
Pentacrinus (?) *mollis.*

STATION 236. June 5, 1875; south of Japan; lat. 34° 58′ N., long. 139° 29′ E.; 775 fathoms; green mud; bottom temperature, 37°·6 F.

Antedon alternata. Also at Stations 169, 170A, and 218.

STATION 244. June 28, 1875; east of Japan; lat. 35° 22′ N., long. 169° 53′ E.; 2900 fathoms; red clay; bottom temperature, 35°·3 F.

Antedon abyssicola. Also at Station 160.

STATION 308. January 5, 1876; off Tom Bay, Patagonia; lat. 50° 8′ 30″ S., long. 74° 41′ 0″ W.; 175 fathoms; blue mud.

Antedon rhomboidea.

STATION 320. February 14, 1876; off Monte Video; lat. 37° 17′ S., long. 53° 52′ W.; 600 fathoms; green sand; bottom temperature, 37°·2 F.

Antedon angustipinna.
Antedon lineata.
Antedon longipinna.

STATION 344. April 3, 1876; Ascension Island; lat. 7° 54′ 20″ S., long. 14° 28′ 20″ W.; 420 fathoms; volcanic sand.

Antedon multispina. Also at Station 135c.
Antedon porrecta.

BATHYMETRICAL TABLES.

A Roman numeral opposite the name of a species shows that it also occurs in one of the other Tables.

TABLE I.—Species found at depths down to 20 fathoms.

Antedon acuticirra.
adeonæ.
anceps.
articulata.
bidens.
bimaculata.
bipartipinna.
brevicuneata.
carinata, II.–V.
carpenteri.
clemens.
conjungens.
disciformis.
dübeni.
elegans, II.
elongata.
eschrichti, II.–VII.
flagellata.
gyges.
imparipinna.
impinnata.
indica.
informis.
lævicirra.
lævipinna.
lævissima.
lovéni.
ludovici.
macronema, II.
marginata.
microdiscus.
Antedon milberti.
milleri.
multiradiata.
palmata.
parvicirra.
perspinosa.
petasus, II., III.
philiberti.
pinniformis.
protecta.
pumila.
quinduplicava.
regalis.
reginæ.
reynaudi.
rosacea, II., III.
savignyi.
serripinna.
spicata.
tessellata.
variipinna, II.
Actinometra alternans.
belli.
bennetti.
borneensis.
brachiolata.
briareus.
coppingeri.
cumingi.
distincta.
divaricata.

Actinometra duplex.
echinoptera.
elongata.
fimbriata.
grandicalyx.
japonica.
lineata, II.
littoralis.
maculata.
magnifica.
meridionalis, II.–V.
multibrachiata.
multifida.
multiradiata.
nigra.
nobilis.
novæ-guineæ.
parvicirra, V.
Actinometra paucicirra.
pectinata.
peroni.
quadrata.
regalis.
robustipinna.
rotalaria.
rubiginosa.
schlegeli.
sentosa.
simplex.
solaris.
stelligera, V.
trichoptera.
typica, V.
variabilis.
valida.

Totals.—*Antedon*, 52 species ; *Actinometra*, 45 species.

TABLE II.—Species found at depths between 20 and 50 fathoms.

Antedon armata.
carinata, I.–V.
denticulata.
elegans, I.
eschrichti, I.–VII.
macronema, I.
magellanica.
petasus, I.–III.
phalangium, III.–V.
Antedon prolixa, III.–VII.
quadrata, III.–VI.
rosacea, I.–III.
variipinna, I.
Actinometra lineata, I.
meridionalis, I.–V.
Eudiocrinus indivisus.
Promachocrinus kerguelensis, III., IV.

Totals.—*Antedon*, 13 species ; *Actinometra*, 2 species.

TABLE III.—Species found at depths between 50 and 100 fathoms.

Antedon antarctica.
balanoides.
carinata, I.–V.
compressa, IV.
defecta, IV., V.
Antedon duplex, IV., V.
eschrichti, I.–VII.
hageni, IV., V.
petasus, I., II.
phalangium, II.–V.

Antedon prolixa, II.–VII.
quadrata, II.–VI.
rosacea, I., II.
spinifera, IV., V.
tenella, IV.–VII.
Actinometra blakei, IV., V.
discoidea, IV.
meridionalis, I.–V.
pulchella, IV.–VII.
Promachocrinus kerguelensis, II.–IV.

Totals.—*Antedon*, 15 species; *Actinometra*, 4 species.

TABLE IV.—Species found at depths between 100 and 200 fathoms.

Antedon angustiradia.
australis.
barentsi.
carinata, I.–V.
compressa, III.
defecta, III.–V.
discoidea.
duplex, III.–V.
eschrichti, I.–VII.
exigua.
flexilis.
granulifera.
hageni, III.–V.
hirsuta.
longicirra.
manca.
parvipinna.
Antedon patula.
phalangium, II.–V.
pourtalèsi, V.
prolixa, II.–VII.
pusilla.
quadrata, II.–VI.
quinquecostata.
robusta.
rhomboidea.
spinifera, III.–V.
tenella, III.–VII.
tenuicirra.
Actinometra blakei, III.–V.
discoidea, III.
meridionalis, I.–V.
pulchella, III.–VII.
Promachocrinus kerguelensis, II., III.

Totals.—*Antedon*, 29 species; *Actinometra*, 4 species.

TABLE V.—Species found at depths between 200 and 350 fathoms.

Antedon brevipinna.
carinata, I.–IV.
defecta, III., IV.
duplex, III., IV.
eschrichti, I.–VII.
hageni, III., IV.
inæqualis[1]?
incisa[1]?
Antedon latipinna.
occulta.[2]
phalangium, II.–IV.
pourtalèsi, IV.
quadrata, II.–VI.
similis.[2]
spinifera, III., IV.
tenella, III.–VII.

[1] Most probably obtained from 610 fathoms at Station 174.
[2] Most probably obtained from 210 or 255 fathoms at Station 174.

Antedon tuberculata.[1]
Actinometra blakei, III., IV.
meridionalis, I.–IV.
parvicirra,[1] I.
Actinometra pulchella, III.–VII.
stelligera,[1] I.
typica,[1] I.
Atelecrinus balanoides, VI.

Totals.—*Antedon*, 15 species; *Actinometra*, 6 species.

TABLE VI.—Species found at depths between 350 and 500 fathoms.

Antedon acœla.
aculeata.
angusticalyx.
columnaris.
cubensis.
distincta.
eschrichti, I.–VII.
gracilis.
hystrix.
lævis.
multispina, VII.
Antedon porrecta.
prolixa, II.–VII.
quadrata, II.–IV.
tenella, III.–VII.
tuberosa.
valida.
Actinometra pulchella, III.–VII.
Atelecrinus balanoides, V.
cubensis.
Eudiocrinus atlanticus.
Promachocrinus naresi.

Totals.—*Antedon*, 17 species; *Actinometra*, 1 species.

TABLE VII.—Species found at depths between 500 and 800 fathoms.

Antedon alternata, VIII.
angustipinna.
basicurva.
breviradia, IX.
echinata.
eschrichti, I.–VI.
inæqualis.
incerta.
incisa.
lineata.
longipinna.
lusitanica.
multispina, VI.
Antedon occulta[2] ?
prolixa, II.–VI.
similis[2] ?
tenella, III.–VI.
tuberculata[2] ?
Actinometra pulchella, III.–VI.
parvicirra[2] ?
stelligera[2] ?
typica[2] ?
Atelecrinus wyvillii.
Eudiocrinus japonicus.
semperi, VIII.

Totals.—*Antedon*, 15 species; *Actinometra*, 1 species.

[1] Most probably obtained from 210 or 255 fathoms at Station 174.
[2] Only if obtained from 630 fathoms at Station 174, which is improbable.

Table VIII.—Species found at depths between 800 and 1100 fathoms.

Antedon alternata, VII.	*Eudiocrinus varians.*
spinicirra.	*semperi*, VII.
Pentacrinoid larvæ of *Antedon*, sp.	

Table IX.—Species found at depths between 1100 and 1500 fathoms.

Antedon acutiradia.	*Antedon breviradia*, VII.
basicurva[1]?	*inæqualis?*

Table X.—Species found at depths between 1500 and 1800 fathoms.

Antedon abyssorum.	*Promachocrinus abyssorum.*
bispinosa.	*Thaumatocrinus renovatus.*
remota.	

Table XI.—Species found at 2600 and 2900 fathoms.

Antedon abyssicola.

Summary.

A.

I.	97	species found at depths down to 20 fathoms.		
II.	17	species found between	20 and 50	fathoms.
III.	20	,, ,,	50 and 100	,,
IV.	34	,, ,,	100 and 200	,,
V.	22	,, ,,	200 and 350	,,
VI.	22	,, ,,	350 and 500	,,
VII.	19	,, ,,	500 and 800	,,
VIII.	5	,, ,,	800 and 1100	,,
IX.	2	,, ,,	1100 and 1500	,,
X.	5	,, ,,	1500 and 1800	,,
XI.	1	,, ,,	2600 and 2900	,,

B.

I. 97 species found at depths down to 20 fathoms.
I.–II. 9 of these descend to 50 fathoms.
I.–III. 5 of which reach 100 fathoms.
I., V. 3 also occur at 210 or 255 fathoms.

[1] Only if obtained from 1350 fathoms at Station 175.

I.–V.	3 of these 5 descend to 350 fathoms.					
I.–VII.	1 of which descends to 632 fathoms.					
II.–IV.	4 species descend from 20 to 200 fathoms.					
II.–V.	2 of these descend to 220 fathoms.					
II.–VII.	1 of which descends to 743 fathoms.					
III.–IV.	9 species descend from 50 to 200 fathoms.					
III.–V.	5 of these descend to 350 fathoms.					
III.–VII.	2 of which descend to 800 fathoms.					
IV.–V.	1 species descends from			124 to	262	fathoms.
V.–VI.	1	,,	,,	291 to	422	,,
VI.–VII.	1	,,	,,	420 to	550	,,
VII.–VIII.	2	,,	,,	550 to	1100	,,
VII.–IX.	1	,,	,,	630 to	1350	,,
XI.	1	,,	,,	2600 to	2900	,,

C.

I.	86 species only found at depths down to 20 fathoms.					
II.	4 species only found at depths of			20 to	50	fathoms.
III.	2	,,	,,	50 to	100	,,
IV.	17	,,	,,	100 to	200	,,
V.	5	,,	,,	200 to	350	,,
VI.	15	,,	,,	350 to	500	,,
VII.	11	,,	,,	500 to	800	,,
VIII.	2	,,	,,	800 to	1100	,,
IX.	1	,,	,,	1100 to	1500	,,
X.	5	,,	,,	1500 to	1800	,,
XI.	1	,,	,,	2600 to	2900	,,

An analysis of Summaries **B** and **C** shows that of twenty-eight *Comatula*-species which occur in the abyssal zone, twenty-two are peculiar to it. Seventeen of these twenty-two belong to the genus *Antedon*, seven of them to the *Tenella*-group, and the remainder to the *Basicurva*-, *Spinifera*-, and *Granulifera*-groups, all of which have flattened rays and plated ambulacra. Furthermore, the only continental species of *Antedon* which extends downwards into the abyssal zone also has plated ambulacra; while two of the three littoral species found in the abyssal zone belong to the *Tenella*-group, the third being *Antedon eschrichti*, which is so widely distributed in the northern circumpolar region.

Table showing the Species of Comatulæ which occur in the Abyssal Zone.

Genus.	Species confined to the Abyssal Zone.		Continental Species occurring in the Abyssal Zone.	Littoral Species occurring in the Abyssal Zone.
Thaumatocrinus,	*renovatus.*	...	... ...	... ...
Atelecrinus, .	*wyvillii.*	...	... ...	... ...
Eudiocrinus, .	*semperi.*	...	*japonicus?*	... ...
	varians.	...	... ...	... ...
Promachocrinus,	*abyssorum.*	...	.. ..	... ...
Actinometra, .	...	...	.. ...	*pulchella.*
	A. Species with Plated Ambulacra.	B. Species of the *Tenella*-group.		
Antedon, .	*acutiradia.*	*abyssicola.*	A. *multispina.*	*eschrichti.*
	basicurra.	*abyssorum.*	... ...	B. *prolixa.*
	bispinosa.	*alternata.*	... ...	B. *tenella.*
	breviradia.	*angustipinna.*	... ...	... ...
	echinata.	*lineata.*	... ...	... ...
	inæqualis.	*longipinna.*	.. ...	... ...
	incerta.	*remota.*	... ...	... ...
	incisa.	... ...	... ...	... ...
	lusitanica.	... ...	... ...	... ...
	spinicirra.	... ...	... ...	... ...

The characteristic abyssal species of *Antedon* thus belong to two very distinct types.—(1) That with the bases of the rays flattened laterally and plated ambulacra. It is rarely represented above 100 fathoms and ranges downward to 1600 fathoms. Eight of the ten abyssal species are simple forms with but ten arms. This type is represented in the fossil state by *Antedon costata* (the *Solanocrinus costatus* of Goldfuss) from the White Jura (ε) of Southern Germany, as has been already indicated on p. 101. (2) Delicate ten-armed species allied to *Antedon tenella* of the Subarctic region, which has a range in depth of 50 to 740 fathoms. The only *Antedon* found below 1600 fathoms belongs to this group; and it was obtained at two localities, one in the Southern Ocean (2600 fathoms), and one in the North Pacific (2900 fathoms).

The only species of *Actinometra* which extends downwards into the abyssal zone is common among the Caribbean Islands, and also occurs in the continental region of the East Atlantic.

Eudiocrinus atlanticus may possibly extend into the abyssal zone, but we have no definite information on this subject as yet (see p. 79); while *Eudiocrinus japonicus* from 563 fathoms in the North Pacific may possibly also occur as a continental species in Japanese seas, for Dr. Hilgendorf thinks that his specimen was dredged from 300 or 400 fathoms.

The following list, containing the names of one hundred and twenty species of *Antedon* and forty-eight species of *Actinometra*, embodies the result of our present knowledge of the Comatulidæ. But many species are still awaiting description, and the geographical range of others will be greatly extended when the large collections in many European museums have undergone a critical revision.

On the other hand it is more than probable that some of the names in the following list will eventually be reduced to the rank of synonyms. Thus, for example, I strongly suspect that *Actinometra meridionalis* is identical with the *Comatula echinoptera* of Müller, while I have no doubt whatever that some of the following are not good species, *Antedon dübeni*, *Antedon hageni*, *Antedon milleri*, *Antedon petasus*, and *Antedon rosacea*. But the time has not yet come for a discussion of their mutual relations.

A List of the known Living Species of Comatulæ, showing their Bathymetrical and Geographical Distribution.

Explanation of the Letters used.

A. Species discovered by the "Blake," and other U. S. ships.
B. Previously known species collected by the "Blake," &c.
C. Species discovered by the Challenger.
D. Previously known species collected by the Challenger.
E. Species discovered by the Arctic Expedition, 1875–76.
F. Previously known species collected by the Arctic Expedition.
G. Species discovered by H.M.S. "Alert," 1878–82.
H. Previously known species collected by the "Alert."
K. Species discovered in the Philippine Islands by Professor Semper.
L. Previously known species collected by Professor Semper.
N. Previously known species collected by the "Vöringen" (Norwegian).

P. Species discovered by the "Porcupine."

Q. Previously known species collected by the "Lightning," "Porcupine," "Knight Errant," and "Triton."

S. Species discovered by the "Talisman" and "Travailleur" (French).

T. Previously known species collected by the "Talisman" and "Travailleur."

V. Species discovered by the "Varna" (Dutch).

W. Previously known species collected by the "Willem Barents" and "Varna."

X. Previously known species collected by the "Vettor Pisani" (Italian).

Y. Species discovered by the "Tegetthoff" (Austro-Hungarian).

	How obtained.	Range in Depth.	Principal Localities.
		Fathoms.	
Thaumatocrinus, Carp.,	...	...	... ...
renovatus, Carp.,	C.	1800	Southern Ocean, Station 158.
Atelecrinus, Carp.,		...	... ...
balanoides, Carp.,	B. C.	291–422	South-West Atlantic, Station 122; Caribbean Islands.
cubensis, Pourt., sp.,	A.	450	Near Havana.
wyvillii, Carp.,	C.	610	Pacific—near Fiji, Station 174c.
Eudiocrinus, Carp.,	...	...	... ...
atlanticus, Perr.,	S.	486	East Atlantic—Bay of Biscay.
indivisus, Semp., sp.,	K.	30	Pandanon, Philippine Islands.
japonicus, Carp.,	C.	300–565	Pacific—South of Japan, Station 235.
semperi, Carp.,	C.	700–950	South Pacific—off Port Jackson, and north-east of New Zealand, Stations 164, 169.
varians, Carp.,	C.	1050	Pacific—off Luzon, Station 205.
Promachocrinus, Carp.,	...	...	... ...
abyssorum, Carp.,	C.	1600–1800	Southern Ocean, Stations 147, 158.
kerguelensis, Carp.,	C.	28–120	Near Kerguelen; and off Heard Island, Station 151.
naresi, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém.		Fathoms.	
Series I.			
Elegans-group.			
elegans, Bell,	D. H. K.	12–49	Torres Strait; Port Molle; Arafura Sea, Station 190; Mergui; Philippines.
microdiscus, Bell,	D. H.	6–12	Port Molle and Nicol Bay, Australia; Torres Strait, Station 186.
multiradiata, Carp.,	C.	6	Torres Strait, Station 187.
Series II.			
1. **Basicurva**-group.			
aculeata, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.
acutiradia, Carp.,	C.	1350	Pacific—near Fiji, Station 175.
basicurva, Carp.,	C.	630	Pacific—near the Kermadecs, Station 170A.
bispinosa, Carp.,	C.	1600	Southern Ocean, Station 147.
brevipinna, Pourt.,	A.	270	Straits of Florida.
breviradia, Carp.,	C.	630–1350	Pacific—near the Kermadecs, Station 170A; near Fiji, Station 175.
denticulata, Carp.,	C.	49	Arafura Sea, Station 190.
duplex, Carp., MS.,	A.	88–262	Caribbean Islands; Straits of Florida.
echinata, Carp.,	C.	630	Pacific—near the Kermadecs, Station 170A.
flexilis, Carp.,	C.	140	Ki Islands, Station 192.
gracilis, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.
incerta, Carp.,	C.	630	Pacific—near the Kermadecs, Station 170A.
incisa, Carp.,	C.	610–630	Pacific—near the Kermadecs, Station 170A; near Fiji; Station 174.
latipinna, Carp.,	C.	345	Pacific—off Japan, Station 232.
longicirra, Carp.,	C.	140	Ki Islands, Station 192.
lusitanica, Carp.,	P.	740	East Atlantic—off Portugal.
multispina, Carp.,	C.	420–550	South Atlantic—off Tristan da Cunha, Station 135G; near Ascension, Station 344.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém., *contd.*		Fathoms.	
parvipinna, Carp.,	C.	140	Ki Islands, Station 192.
pusilla, Carp.,	C.	140	Ki Islands, Station 192.
spinicirra, Carp.,	C.	950	South Pacific—near Port Jackson, Station 164.
tuberosa, Carp.,	C.	375	Pacific—off the Panglao and Siquijor Islands, Station 210.
valida, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.
2. Accela-group.			
accela, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.
discoidea, Carp.,	C.	140	Ki Islands, Station 192.
3. Eschrichti-group.			
antarctica, Carp.,	C.	75	Southern Ocean—near Heard Island, Station 151.
australis, Carp.,	C.	150	Southern Ocean—near Heard Island, Station 150.
barentsi, Carp.,	V.	132	Kara Sea.
eschrichti, Müll., sp.,	D. F. Q. W.	20–632	Circumpolar and North Atlantic, Station 48.
magellanica, Bell,	G. X.	30	Straits of Magellan.
quadrata, Carp.,	D.F.Q.W.Y.	25–410	Smith's Sound, Davis Strait, Barents Sea, Kara Sea; and North Atlantic, Station 48.
rhomboidea, Carp.,	C.	175	Straits of Magellan, Station 308.
4. Tenella-group.			
abyssicola, Carp.,	C.	2600–2900	Southern Ocean—South-West of Melbourne, Station 160; Pacific—East of Japan, Station 244.
abyssorum, Carp.,	C.	1600	Southern Ocean, Station 147.
alternata, Carp.,	C.	630–1070	Pacific—North-East of New Zealand, Station 169; near the Kermadecs, Station 170A; North of Papua, Station 218; South of Japan, Station 236.
angustipinna, Carp.,	C.	600	West Atlantic—off Monte Video, Station 320.
armata, Pourt.,	A.	35	Florida Straits.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém., *contd.*		Fathoms.	
columnaris, Carp.,	A.	122	Off St. Lucia.
cubensis, Pourt.,	A.	450	Florida Straits.
dübeni, Böhlsche,	D.	20	Bahia; Rio Janeiro.
exigua, Carp.,	C.	50–175	Southern Ocean—off Marion Island, and Station 145.
hageni, Pourt.,	A.	82–242	Caribbean Islands and Straits of Florida.
hirsuta, Carp.,	C.	140	Southern Ocean—near Marion Island, Station 145.
hystrix, Carp.,	P.	320–430	Færoe Channel.
lævis, Carp.,	C.	500	Pacific—near the Meangis Islands, Station 214.
lineata, Carp.,	C.	600	West Atlantic—off Monte Video, Station 320.
longipinna, Carp.,	C.	600	West Atlantic—off Monte Video, Station 320.
milleri, Müll., sp.,	...	...	Milford Haven.
petasus, Düb. and Kor., sp.,	Q.	20–100	North-East Atlantic.
phalangium, Müll., sp.,	Q. T.	30–220	East Atlantic—Hebrides to Gibraltar and Mediterranean.
prolixa, Sladen,	N. W. Y.	25–743	Smith's Sound; Kara Sea; North-East Atlantic.
remota, Carp.,	C.	1600	Southern Ocean, Station 147.
rosacea, Linck, sp.,	Q. X.	100	East Atlantic—Hebrides to Madeira and Mediterranean.
tenella, Retz., sp.,	B. Q. W.	50–740	Barents Sea; Kara Sea; Scandinavia; Færoe Channel; North Atlantic—off Coasts of Portugal and New England.
tenuicirra, Carp.,	C.	150	Pacific—North of Admiralty Islands, Station 219.
5. Milberti-group.			
anceps, Carp.,	C.	10	Pacific—off Samboangan, Station 212.
carinata, Carp.,	B. D. X.	7–278	Brazil; Venezuela; St Lucia; Chile; Java (?); Ceylon; Seychelles; Red Sea; Zanzibar; Mauritius; Madagascar; St. Helena.
carpenteri, Bell,	G.	7	Queensland.
informis, Carp.,	C.	18	Philippine Islands, Station 208.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém., *contd.*		Fathoms.	
laevissima, Grube, sp.,	...	...	Borneo.
loveni, Bell,	G.	3–4	Queensland.
milberti, Müll., sp.,	D. H.	3–20	Pacific—off Panay, Station 203; off Samboangan, Station 212. Queensland; Torres Strait; Ceram; Borneo; Mergui.
parvicirra, Carp.,	C.	18	Philippine Islands, Station 208.
perspinosa, Carp.,	...	...	Jobie.
pinniformis, Carp.,	H.	...	New Guinea; North-West Australia.
pumila, Bell,	G.	5	Port Jackson; Port Stephens; Nelson's Bay.
serripinna, Carp.,	...	...	New Guinea.
tessellata, Müll., sp.,	...	...	"Indien."
variipinna, Carp.,	C. H.	8–36	Torres Strait, Station 186, and Arrou Islands. Arafura Sea; Borneo; Canton.
Unclassified species.			
adeonae, Lam., sp.,	H.	...	Queensland.
balanoides, Carp.,	C.	82	Pacific—off Mindanao, Station 201.
bidens, Bell,	G.	10	Torres Strait.
defecta, Carp., MS.,	A.	77–242	Caribbean Islands.
impinnata, Carp., MS.,	...	15	Mauritius.
laevipinna, Carp.,	...	...	Canton.
Series III.			
6. Spinifera-group.			
brevipinna, Pourt.,	A.	270	Straits of Florida.
compressa, Carp.,	C.	82–140	Ki Islands, Station 192; off Mindanao, Station 201.
duplex, Carp., MS.,	A.	88–262	Caribbean Islands; Straits of Florida.
flexilis, Carp.,	C.	140	Ki Islands, Station 192.
lusitanica, Carp.,	P.	740	East Atlantic—off Portugal.
macronema, Müll., sp.,	D.	35	King George's Sound; Port Jackson; Port Stephens.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém., *contd.*		Fathoms.	
patula, Carp., . . .	C.	140	Ki Islands, Station 192.
pourtalèsi, Carp., MS., . .	A.	124–262	Caribbean Islands.
quinquecostata, Carp., . .	C.	140	Ki Islands, Station 192.
robusta, Carp., . . .	C.	140	Ki Islands, Station 192.
spinifera, Carp., . . .	B.	80–297	Caribbean Islands.
7. **Palmata**-group.			
æquipinna, Carp.	...	...	?
articulata, Müll., sp., . .	H.	...	Moluccas; Queensland.
bimaculata, Carp., . .	...	...	Amboina.
brevicuneata, Carp., . .	...	...	Amboina.
clemens, Carp., . . .	C.	10	Pacific—off Samboangan, Station 212.
conjungens, Carp., . . .	C.	...	Zebu Reefs.
disciformis, Carp., . .	C.	...	Zebu Reefs.
elongata, Müll., sp., . .	...	...	New Guinea.
flagellata, Müll., sp., . .	...	...	?
gyges, Bell, ...	G.	...	Torres Strait.
imparipinna, Carp., . .	...	...	?
indica, Smith, sp., . . .	...	...	Rodriguez.
lævicirra, Carp., . . .	...	...	Arrou Islands.
manca, Carp., . . .	C.	140	Ki Islands, Station 192.
marginata, Carp., . . .	C.	18	Philippine Islands, Station 208.
occulta, Carp., . . .	C.	210 or 255	Pacific—near Fiji, Station 174.
palmata, Müll., sp., . .	X.	...	Red Sea; Ceylon.
protecta, Lütk., MS., . .	...	...	Fiji; Tonga.
regalis, Carp., . . .	C.	...	Tongatabu Reefs.
reginæ, Bell, ...	G.	...	Queensland.
similis, Carp., . . .	C.	210 or 255	Pacific—near Fiji, Station 174.

	How obtained.	Range in Depth.	Principal Localities.
Antedon, de Frém., *contd.*		Fathoms.	
spicata, Carp., . . .	...	...	Banda Sea; Ugi.
tuberculata, Carp., . . .	C.	210 or 255	Pacific—near Fiji, Station 174.
SERIES IV.			
8. **Granulifera**-group.			
angusticalyx, Carp., . .	C.	500	Pacific—off the Meangis Islands, Station 214.
distincta, Carp., . . .	C.	375	Pacific—off the Panglao and Siquijor Islands, Station 210.
granulifera, Pourt., . .	A.	101–120	Caribbean Islands.
inæqualis, Carp., . . .	C.	610–630	Pacific—near the Kermadecs, Station 170A; near Fiji, Station 174.
multispina, Carp., . . .	C.	420–550	South Atlantic—off Tristan da Cunha, Station 135G; near Ascension, Station 344.
porrecta, Carp., . . .	C.	420	South Atlantic—near Ascension, Station 344.
9. **Savignyi**-group.			
acuticirra, Carp., . . .	...	...	?
anceps, Carp., . . .	C.	10	Pacific—off Samboangan, Station 212.
angustiradia, Carp., . .	C.	140	Ki Islands, Station 192.
bipartipinna, Carp., . .	...	...	Hong Kong.
ludovici, Carp., . . .	...	...	Hong Kong.
philiberti, Müll., sp., . .	...	...	Java.
quinduplicava, Carp., . .	C.	10	Pacific—off Samboangan, Station 212.
reynaudi, Müll., sp., . .	...	...	Ceylon.
savignyi, Müll., sp., . .	...	...	Red Sea; Kurrachee.
variipinna, Carp., . . .	C. H.	8–36	Torres Strait, Station 186, and Arrou Islands. Arafura Sea; Borneo; Canton.
Actinometra, Müll.			
SERIES I.			
1. **Solaris**-group.			
brachiolata, Lam., sp., . .	...	...	Australia.

	How obtained	Range in Depth.	Principal Localities.
Actinometra, Müll., *contd.*		Fathoms.	
pectinata, Retz., sp.,	D. H. L.	8–12	Java; Singapore; Moluccas; Celebes; Arafura Sea; Torres Strait; Queensland; Bohol; Samboangan.
solaris, Lam., sp.,	D. H.	6–12	Singapore; Hong Kong; Torres Strait, Station 187; Queensland.
2. Paucicirra-group.			
paucicirra, Bell,	D. H.	3–12	Arrou Islands; Torres Strait, Station 187; Queensland.
3. Typica-group.			
distincta, Carp.,	C.	10	Samboangan.
multibrachiata, Carp.,	C.	17	Banda.
novæ-guineæ, Müll., sp.,	...	...	Eidouma, New Guinea.
typica, Lovèn, sp.,	D.	210 or 255	Pacific—near Fiji Station 174. Malacca; Jobie; Zebu; Kingsmills Islands.
Series II.			
4. Echinoptera-group.			
blakei, Carp., MS.,	A.	62–262	Caribbean Islands.
cumingi, Müll., sp.,	H.	...	Malacca; Queensland.
echinoptera, Müll., sp.,	...	...	?
meridionalis, Pourt., sp.,	A. D.	7–262	Florida Straits; Caribbean Islands; Brazil.
pulchella, Pourt., sp.,	B. D. P. T.	73–830	Caribbean Islands; St. Paul's Rocks; East Atlantic—near Gibraltar, and off Rochefort. Ki Islands, Station 192 (?).
rubiginosa, Pourt., sp.,	A.	9–17	Bahamas; Florida Straits.
Series III.			
5. Stelligera-group.			
maculata, Carp.,	C.	8	Torres Strait, Station 186.
nigra, Carp., MS.,	K.	...	Philippines.
pulchella, Pourt., sp.,	B. D. P. T.	73–830	Caribbean Islands; St. Paul's Rocks; East Atlantic—near Gibraltar, and off Rochefort. Ki Islands, Station 192 (?).
stelligera, Carp.,	D.	210 or 255	Pacific—near Fiji, Station 174. Tonga; Samoa; Reef of Atagor.

	How obtained.	Range in Depth.	Principal Localities.
Actinometra, Müll., *contd.*		Fathoms.	
6. Valida-group.			
elongata, Carp.,	C.	17	Banda.
rotalaria, Lam., sp.,	D.	10	Samboangan; Australia.
simplex, Carp.,	C.	16–25	Admiralty Islands.
valida, Carp.,	C.	8	Torres Strait, Station 186.
Series IV.			
7. Fimbriata-group.			
borneensis, Grube,	...	...	North Borneo.
coppingeri, Bell,	C. H.	10–17	Banda and Samboangan. Singapore; Amboina; China Sea; Queensland.
discoidea, Carp.,	A.	88–118	Caribbean Islands.
fimbriata, Lam., sp.,	D.	17–18	Banda and Philippine Islands. Sunda Strait; Java; Nicobar Islands; Madagascar (?).
lineata, Carp.,	B. C.	7–40	Brazil; Barbados.
multiradiata, Linn., sp.,	D. L.	8	Torres Strait, Station 186. Philippines; China Sea; Japan.
sentosa, Carp.,	D.	17	Moluccas.
8. Parvicirra-group.			
alternans, Carp.,	H.	12–20	Queensland.
belli, Carp.,	C.	8	Torres Strait, Station 186.
bennetti, Böhlsche,	...	...	Loyalty Islands; Pelew Islands; Sooloo Sea; Singapore.
briareus, Bell, sp.,	G.	...	Queensland.
divaricata, Carp.,	C.	17	Banda.
duplex, Carp.,	C.	17	Banda.
grandicalyx, Carp.,	...	...	Canton.
japonica, Müll., sp.,	...	...	Japan.
littoralis, Carp.,	C.	17	Banda.
magnifica, Carp., MS.,	K.	...	Philippines.

	How obtained.	Range in Depth.	Principal Localities.
Actinometra*, Müll., *contd.		Fathoms.	
multifida, Müll., sp., . .	H.	...	Queensland; Torres Strait.
nobilis, Carp., . . .	C.	10–18	Philippine Islands—Samboangan, and Station 208.
parvicirra, Müll., sp., . .	D. H. L.	8–210 or 255	Pacific—near Fiji; Station 174. Torres Strait, Station 186. Borneo; Moluccas; Admiralty Islands; Philippines; Ceylon; Nicobar Islands; Natal; Cape of Good Hope; China Sea; Japan; Kingsmills Islands; Fiji; Friendly Islands; Peru.
peroni, Carp., . . .	...	...	Ceram.
quadrata, Carp., . . .	C.	...	Tongatabu.
regalis, Carp., . . .	C.	17	Banda.
robustipinna, Carp., . .	...	...	Moluccas.
schlegeli, Carp., . . .	...	...	East Indies (?).
trichoptera, Müll., sp., . .	D.	10–12	Port Jackson; Port Philip; King George's Sound.
variabilis, Bell, . . .	G.	...	Torres Strait.

Analysis of the above List.

Genus.	Number of Living Species.	"Porcupine."		"Challenger."		"Alert."	
		New Species.	Species previously known.	New Species.	Species previously known.	New Species.	Species previously known.
Thaumatocrinus, .	1	...	...	1	...	...	...
Atelecrinus, . .	3	...		2	...	...	...
Eudiocrinus, . .	5	...	...	3	...	...	...
Promachocrinus, .	3	...	...	3	...	...	...
Antedon, . .	120	2	6	64	8	7	7
Actinometra, . .	48	1	...	15	14	2	8
	180	3	6	88	22	9	15

Two facts shown in the above Table are worth notice :—

1. Representatives of each of the six living genera of Comatulæ were obtained by the Challenger, two of them being new to science.

2. Five-ninths of the recognised living species of Comatulæ have been discovered by British ships. This proportion will be largely modified, however, when the "Blake" collection and those of the Continental Museums have been properly worked up.

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INDEX TO AUTHORS QUOTED.

GENERAL INDEX.

The figures in dark type indicate the page on which the genus or species is first described.
Synonyms are distinguished by an asterisk *.

EXPLANATION OF THE PLATES.

A reference is given after each figure to a certain page of the text. In the case of figures which illustrate entire specimens, the reference given is usually to the page in the systematic part of the Report on which the species is first described. But with those figures which represent structural details, reference is given to the page containing the explanation which the figure was designed to illustrate. This is sometimes in the morphological and sometimes in the systematic part of the Report. In a few cases there is no special reference to a figure in the text; and the number of the page following its explanation is either that of the specific diagnosis, or that of a page containing a description of structural peculiarities which is more or less illustrated by the figure in question.

ERRATA.

Plate I.—The figure of the centro-dorsal of *Antedon antarctica should be* lettered "6*d*" *instead of* "6*a*."

Plate III.—Instead of "Fig. 4, *Antedon radiospina*," and "Fig. 5, *Antedon eversa*," read "Figs. 4, 5, *Antedon breviradia*."

Instead of "Fig. 7, *Antedon* (*Ophiocrinus*) *semperi*," read "Fig. 7, *Eudiocrinus semperi*."

Plate IV.—Fig. 3, Instead of "*Antedon macrocnema*," read *Antedon macronema*."

Fig. 4, Instead of "*Actinometra brasiliensis*," read "*Actinometra meridionalis*."

Fig. 6, Instead of "*Actinometra arcuensis*," read "*Actinometra paucicirra*."

Plate V.—Fig. 3, Instead of "*Actinometra jukesii*," read "*Actinometra paucicirra*."

Fig. 3*b* is wrongly lettered "5*b*."

Fig. 4, Instead of "*Actinometra strata*," read "*Actinometra solaris*."

Plate VIII.—Instead of "*Antedon fluctuans*, sp. n.," read "*Antedon elegans*, Bell."

Plate XXXIII.—Figs. 4, 5, Instead of "*Antedon notata*, sp. n." read "*Antedon tenuicirra*, sp. n."

Plate XXXVI.—Figs. 1–6, Instead of "*Antedon dubia*, sp. n.," read "*Antedon variipinna*, Carpenter."

PLATE I.

PLATE I.

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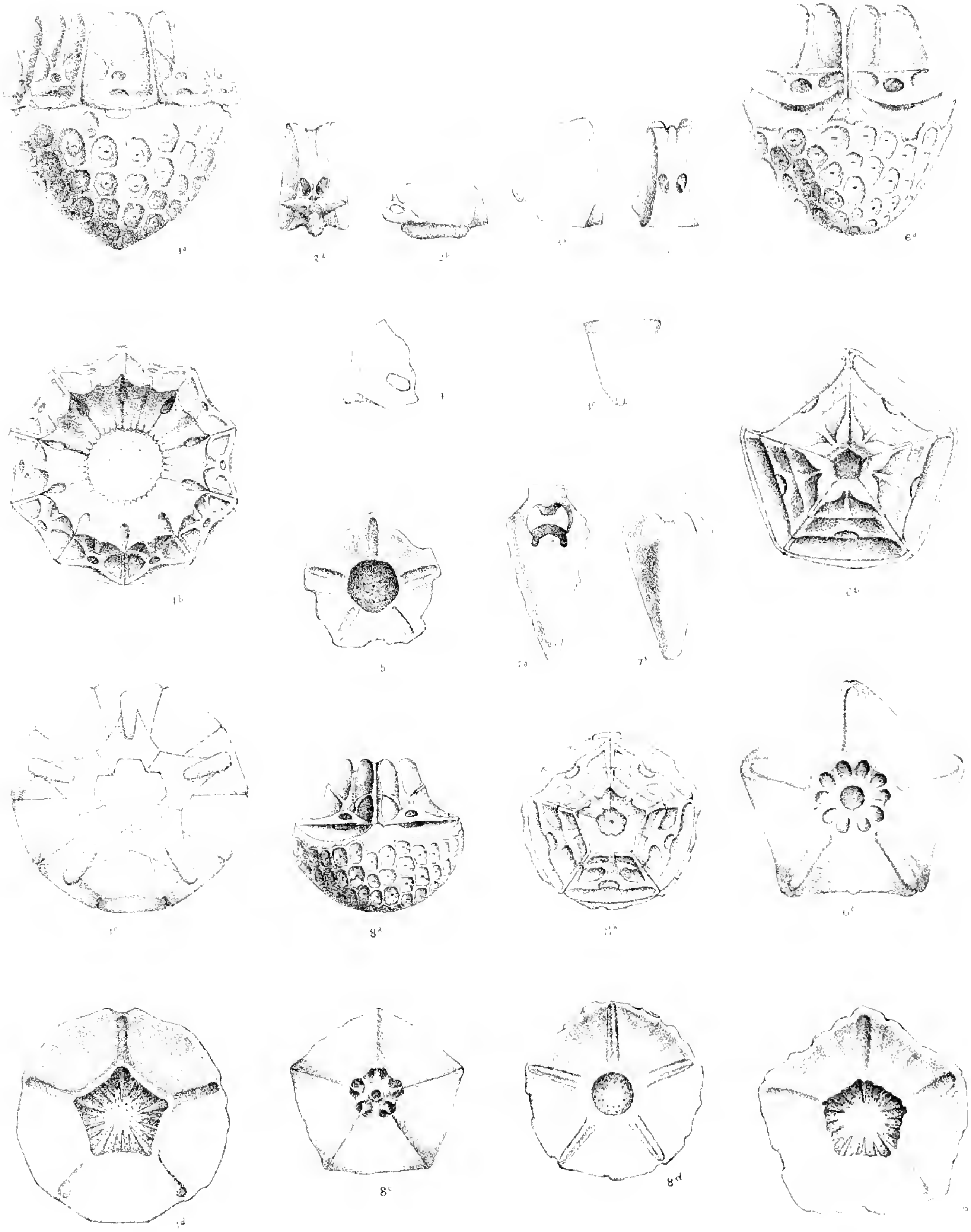
	d. Ventral aspect of the centro-dorsal,	× 3	10

[1] Wrongly lettered 6*a*.



C. Berjeau del. et lith.

1–3 PROMACHOCRINUS KERGUELENSIS
4–5 " ABYSSORUM
6–7 ANTEDON ANTARCTICA
8 " ESCHRICHTII

PLATE II.

PLATE II.

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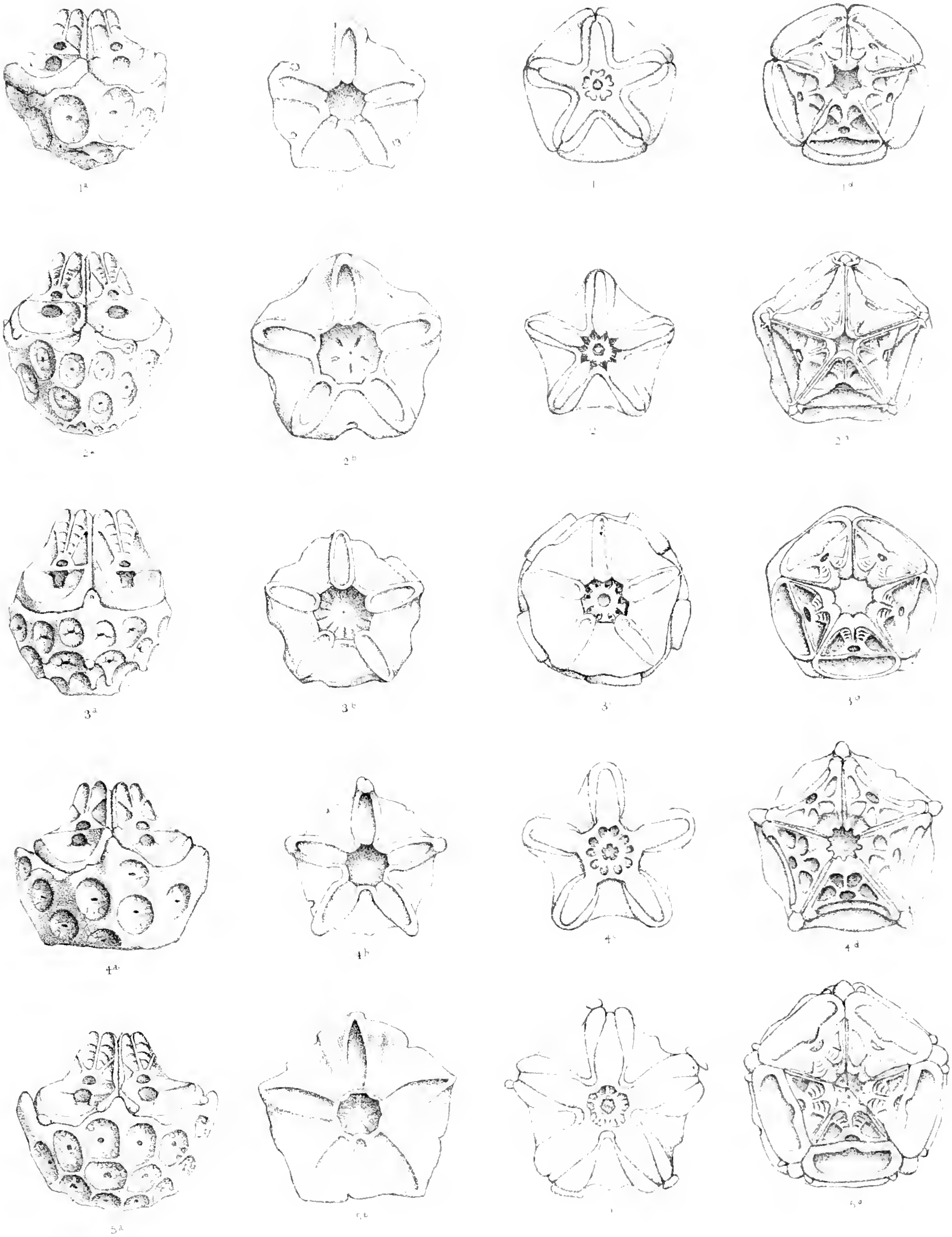

C. Berjeau del. et lith.

1 ANTEDON INCISA
2 " BASICURVA
3 ANTEDON ACŒLA
4 " ANGUSTICALYX
5 ANT. INAEQUALIS

PLATE III.

PLATE III.

Figs. 1–3. ANTEDON CARINATA, Lam., sp.

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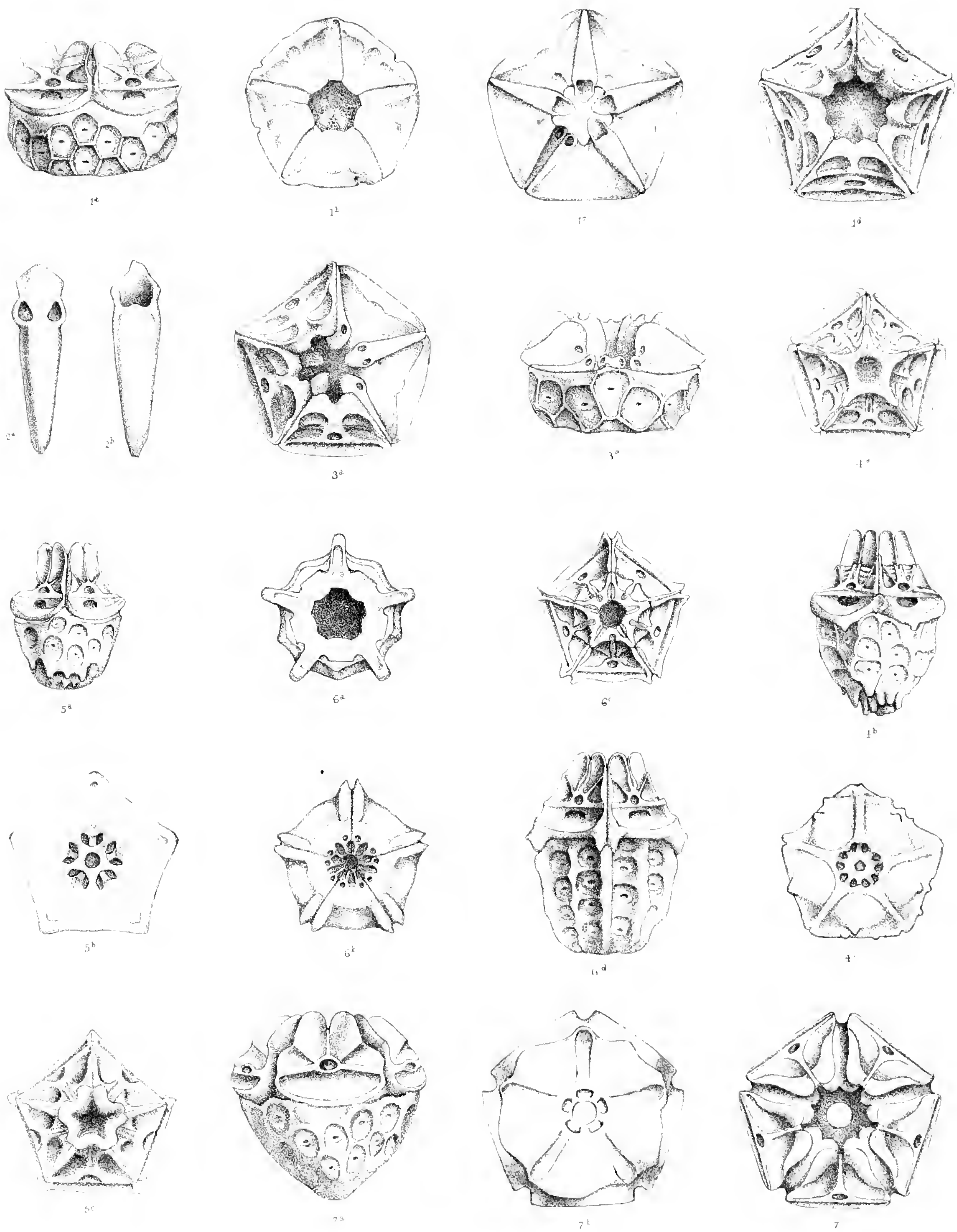
	b. Dorsal aspect of the radial pentagon,	75
	c. Ventral aspect of the same,	75



G. Berjeau del. et lith.

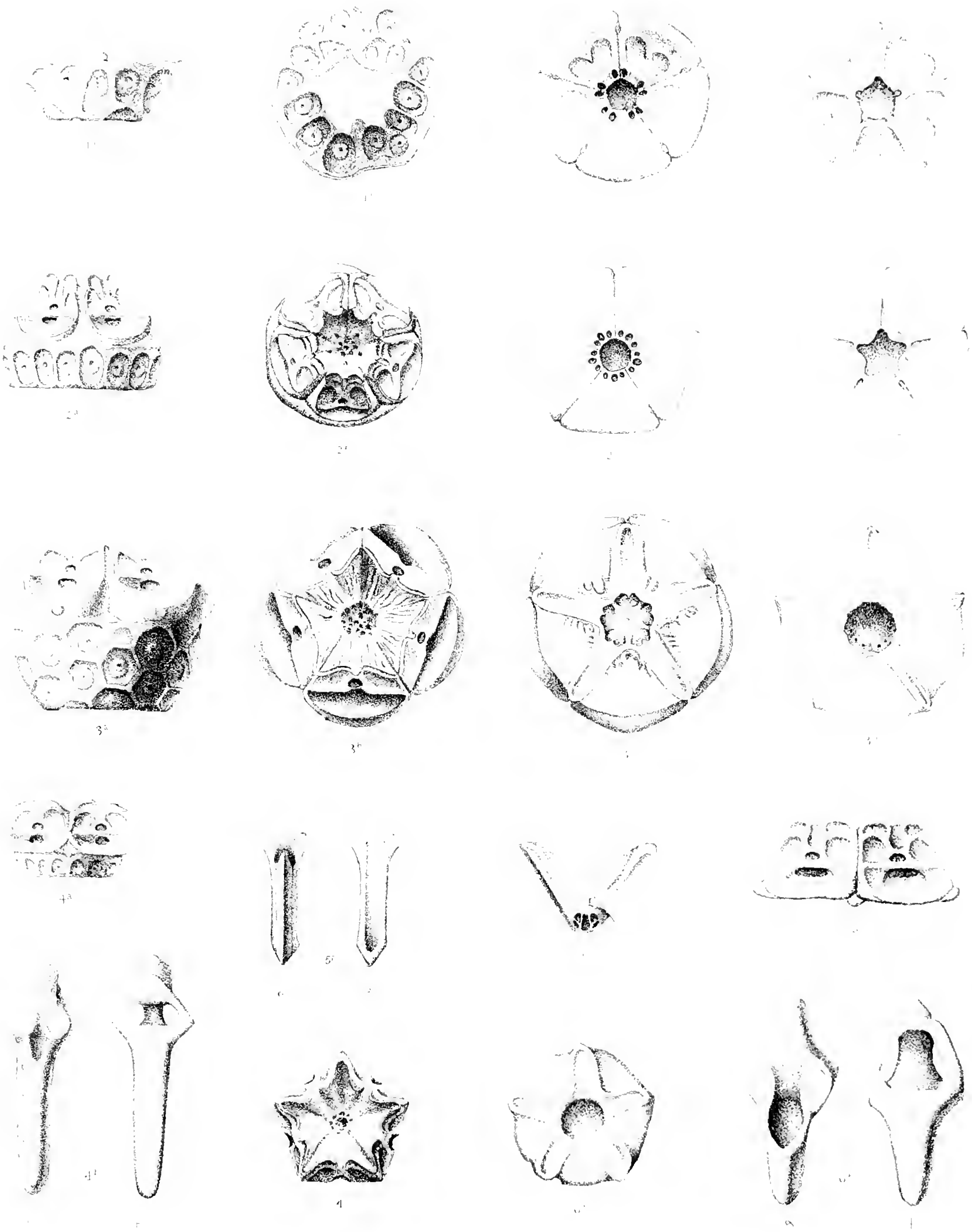
Hanhart imp.

1_3 ANTEDON CARINATA 5 ANTEDON EVERSA
4 " RADIOSPINA. 6 " QUINQUECOSTATA
7 ANTEDON (Ophiocrinus) SEMPERI

PLATE IV.

PLATE IV.

		Diam.	Page
Fig. 1. ANTEDON QUINDUPLICAVA, n. sp.,	×	8	
Fig. 1. *a.* The isolated centro-dorsal, side view,			263
b. Dorsal aspect of the same,			262
c. Dorsal aspect of the radial pentagon, after removal of the rosette,			9
d. Ventral aspect of the centro-dorsal,			9
Fig. 2. ANTEDON DISCIFORMIS, n. sp.,	×	8	
Fig. 2. *a.* The calyx from the side,			13
b. The calyx from above,			229
c. Dorsal aspect of the radial pentagon,			9
d. Ventral aspect of the centro-dorsal,			9
Fig. 3. ANTEDON MACRONEMA, Müll., sp.,	×	6	
Fig. 3. *a.* The calyx from the side,			25
b. The calyx from above,			24
c. Dorsal aspect of the radial pentagon and basal star,			6
d. Ventral aspect of the centro-dorsal,			10
Fig. 4. ACTINOMETRA MERIDIONALIS, Pourt., sp.,			
Fig. 4. *a.* The calyx from the side,	×	6	26
b. (α) Ventral and (β) dorsal aspects of an isolated basal,	×	15	22
c. The calyx from above,	×	6	26
Fig. 5. ACTINOMETRA PULCHELLA, Pourt., sp.			
Fig. 5. *a.* (α) Ventral and (β) dorsal aspects of an isolated basal,	×	8	22
b. Dorsal aspect of an isolated radial with one basal attached,	×	6	22
c. Side view of the radial pentagon with the basals attached,	×	6	22
Fig. 6. ACTINOMETRA PAUCICIRRA, Bell.			
Fig. 6. *a.* Ventral aspect of the young centro-dorsal,	×	6	10
b. (α) Ventral and (β) dorsal aspects of an isolated basal,	×	15	22



P. Bergeau del. et lith. Hanhart imp.

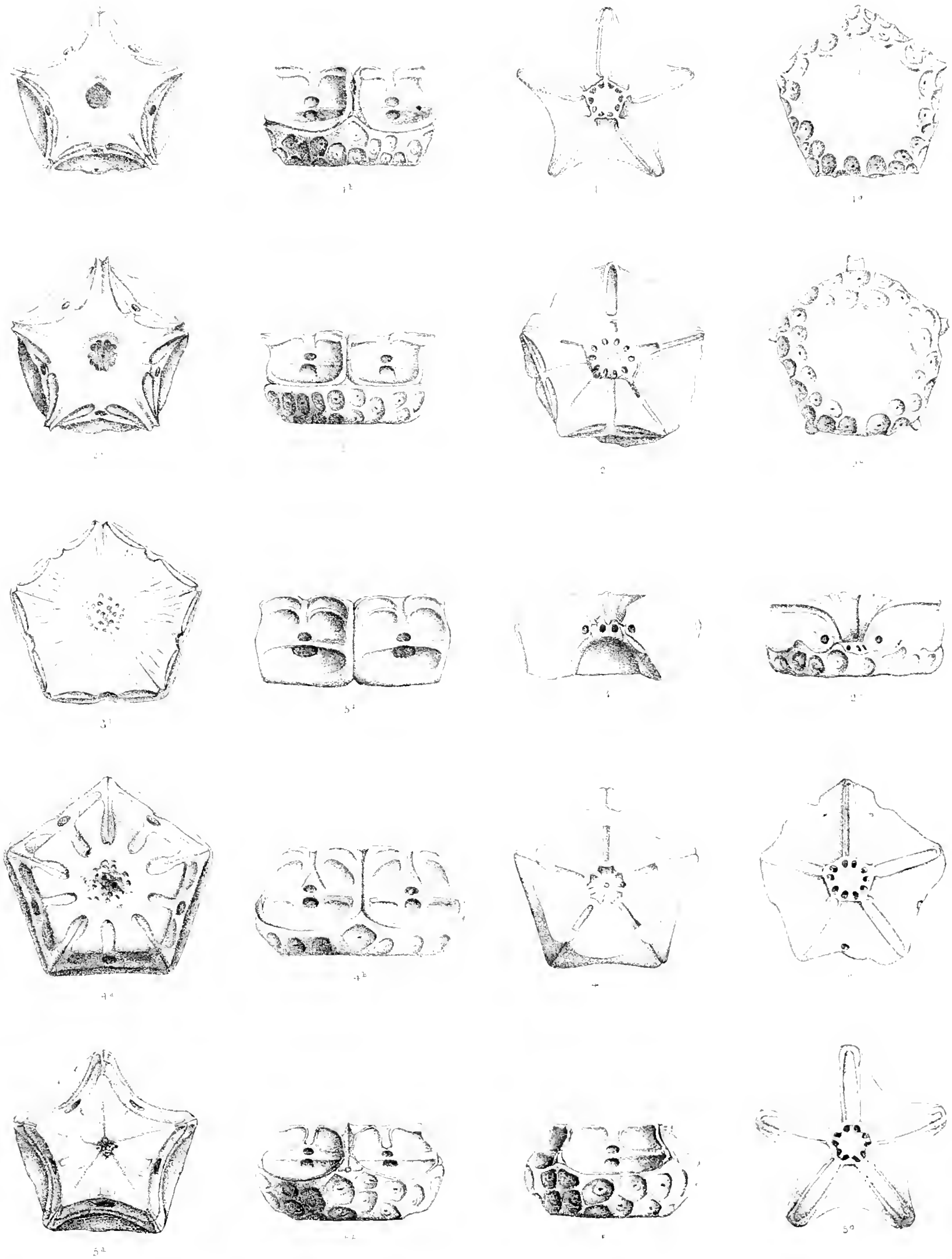
1 ANTEDON QUINDUPLICAVA
2 " DISCIFORMIS
3 " MACRONEMA
4. ACTINOMETRA BRASILIENSIS
5 " PULCHELLA
6 " ARUENSIS

PLATE V.

PLATE V.

	Diam.	Page
Fig. 1. Actinometra maculata, n. sp.,	× 6	
Fig. 1. *a*. The calyx from above,		307
b. The calyx from the side,		26
c. Dorsal aspect of the radial pentagon and basal star,		21
d. Dorsal aspect of the centro-dorsal,		307
Fig. 2. Actinometra lineata, n. sp.,	× 6	
Fig. 2. *a*. The calyx from above,		328
b. The calyx from the side,		26
c. Ventral aspect of the centro-dorsal with the rosette and two radials *in situ*,		8
d. Dorsal aspect of the centro-dorsal,		328
e. Side view of the centro-dorsal, with the rosette and two radials *in situ*,		26
Fig. 3. Actinometra paucicirra, Bell,	× 6	
Fig. 3. *a*. The calyx from above,		26
b.[1] The calyx from the side,		14
c. Internal aspect of three united radials, after removal of the centro-dorsal,		14
Fig. 4. Actinometra solaris, Lam., sp.,	× 6	
Fig. 4. *a*. The calyx from above,		26
b. The calyx from the side,		7
c. Dorsal aspect of the radial pentagon and imperfect basal star,		290
Fig. 5. Actinometra stelligera, n. sp.,	× 6	
Fig. 5. *a*. The calyx from above,		309
b. The calyx from the side, interradial view,		22
c. The calyx from the side, radial view,		26
d. Dorsal aspect of the radial pentagon and basal star,		21
e. Ventral aspect of the centro-dorsal, with the rosette and basal star *in situ*,		8

[1] Wrongly lettered 5*b*.



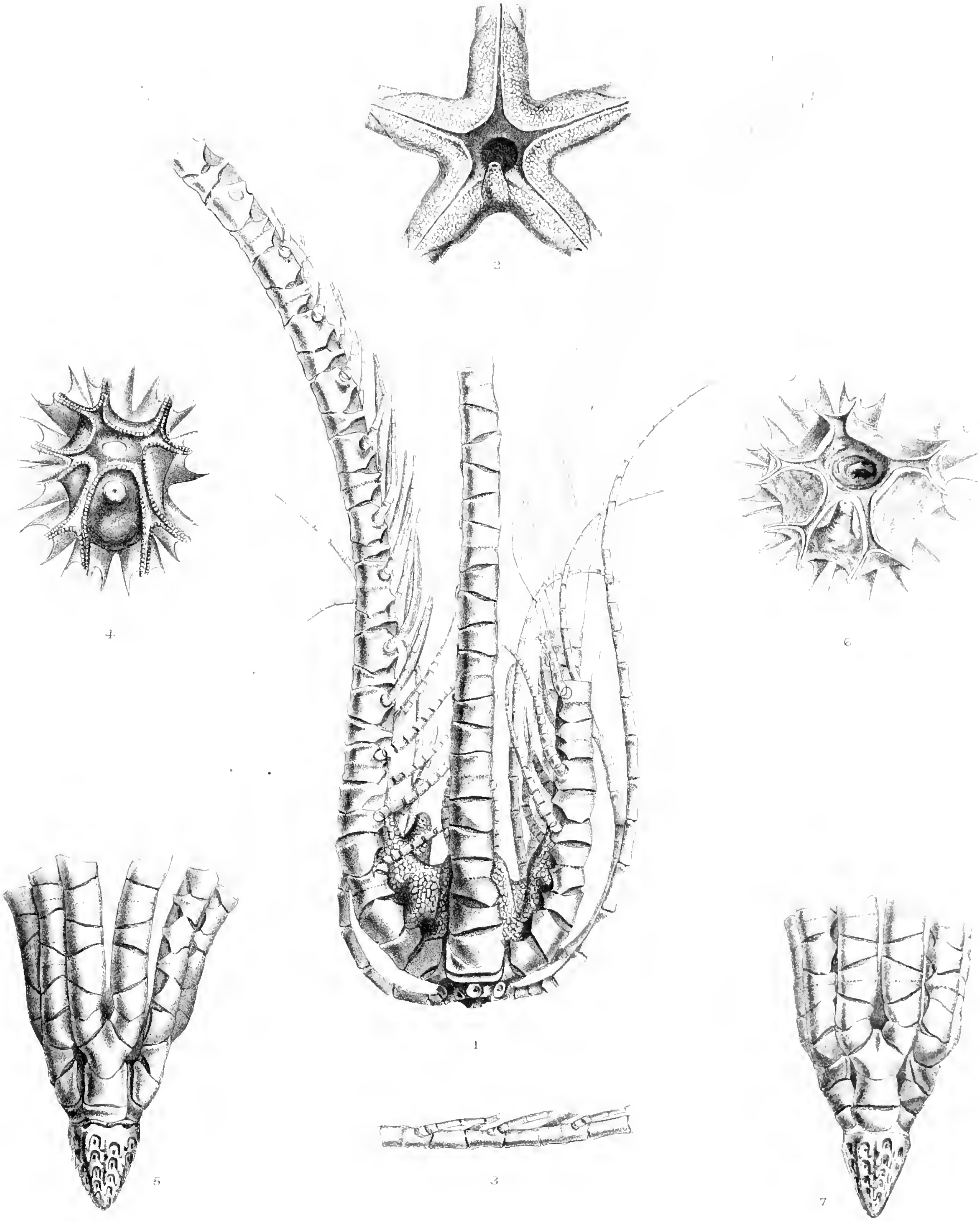
Berjeau del et lith

I ACTINOMETRA MACULATA 3 ACTINOMETRA JUKESII
2 " LINEATA 4 " STRATA
5. ACT STELLIGERA

PLATE VI.

PLATE VI.

	Diam.	Page
Figs. 1–3. EUDIOCRINUS SEMPERI, n. sp.,	× 4	
Fig. 1. Side view,		82
Fig. 2. The disk, from above,		74
Fig. 3. Distal portion of an arm,		82
Figs. 4, 5. ATELECRINUS WYVILLII, n. sp.		
Fig. 4. The disk, from above,	× 6	70
Fig. 5. Side view,	× 4	72
Figs. 6, 7. ATELECRINUS BALANOIDES, n. sp.		
Fig. 6. The disk, from above,	× 6	70
Fig. 7. Side view,	× 4	70



Gerneau & Highley del.

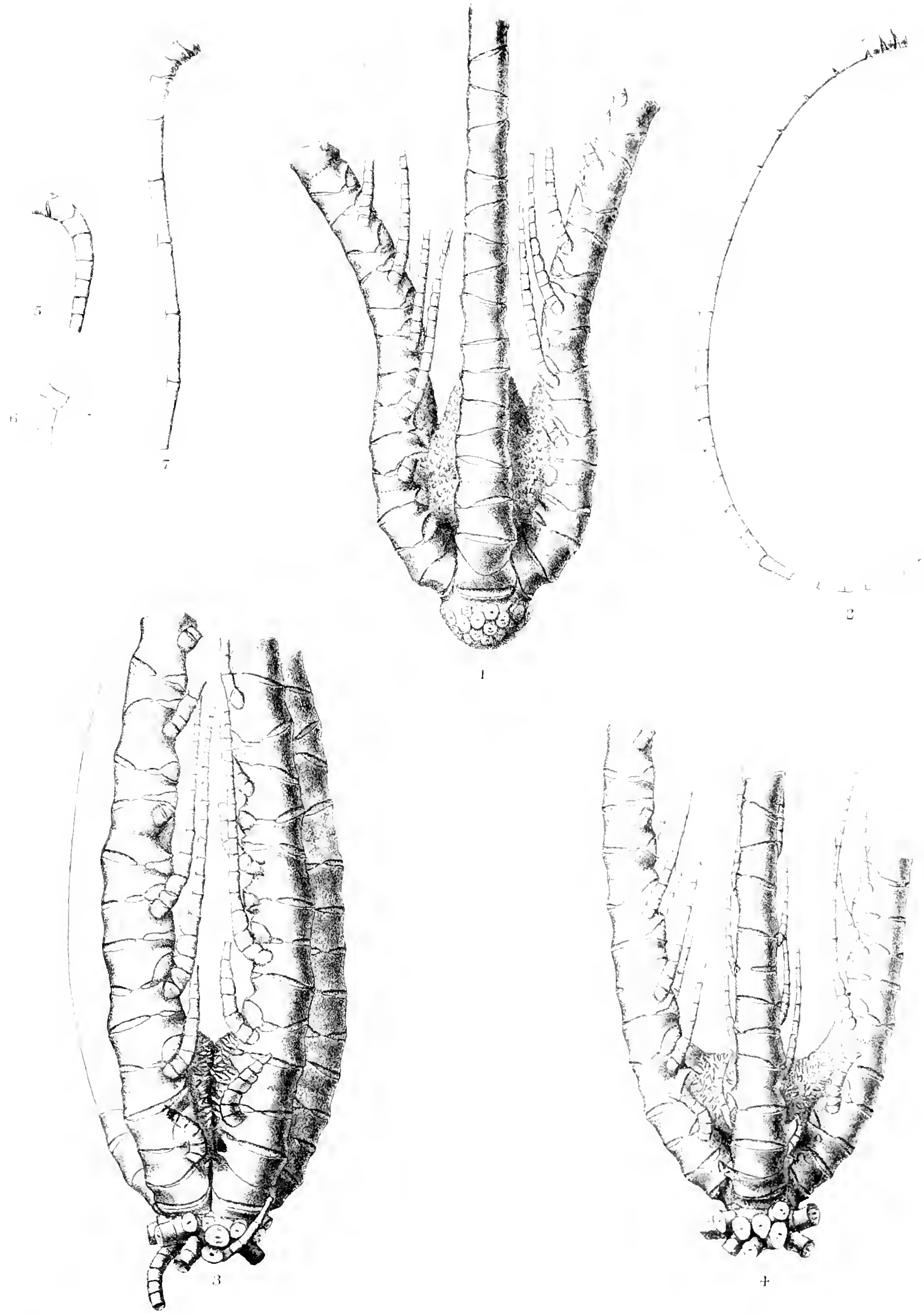
West Newman & Co. lith.

1–3 EUDIOCRINUS SEMPERI, sp. n.
4, 5. ATELECRINUS WYVILLII, sp. n. 6, 7 ATELECRINUS BALANOIDES, sp. n.

PLATE VII.

PLATE VII.

	Diam.	Page
Figs. 1, 2. EUDIOCRINUS JAPONICUS, n. sp.,	× 4	
Fig. 1. Side view,		84
Fig. 2. A cirrus,		84
Figs. 3–7. EUDIOCRINUS VARIANS, n. sp.,	× 4	
Fig. 3. Side view, interradial,		81
Fig. 4. Side view, radial,		81
Figs. 5, 6. The base of a short-jointed cirrus, from opposite sides,		82
Fig. 7. The base of a long-jointed cirrus,		82

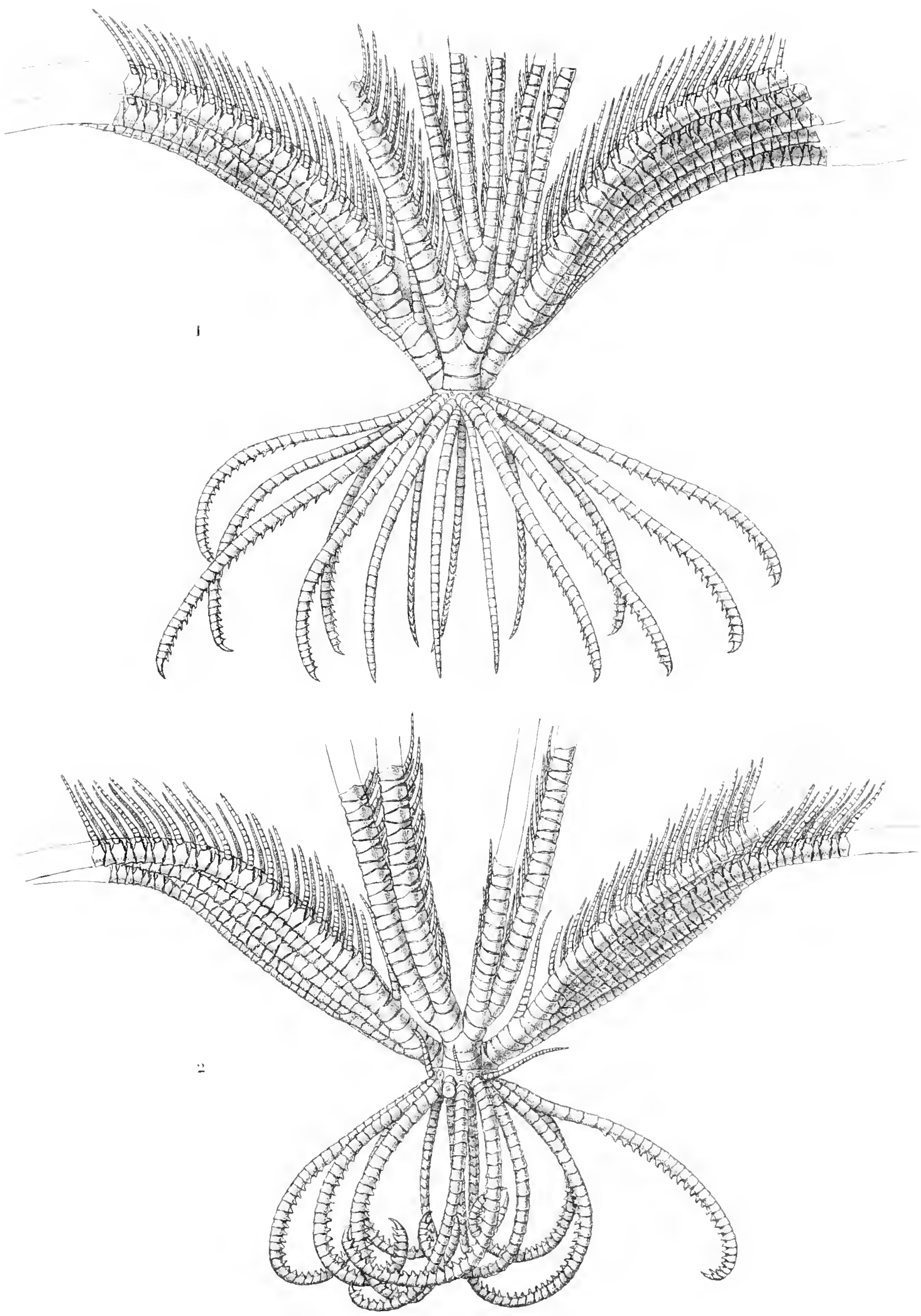


I. 2 EUDIOCRINUS JAPONICUS.
3_6 EUDIOCRINUS VARIANS.

PLATE VIII.

PLATE VIII.

		Diam.	Page
ANTEDON ELEGANS, Bell, ...	×	3	94



Berjeau & Highley del et lith. Mintern Bros imp.

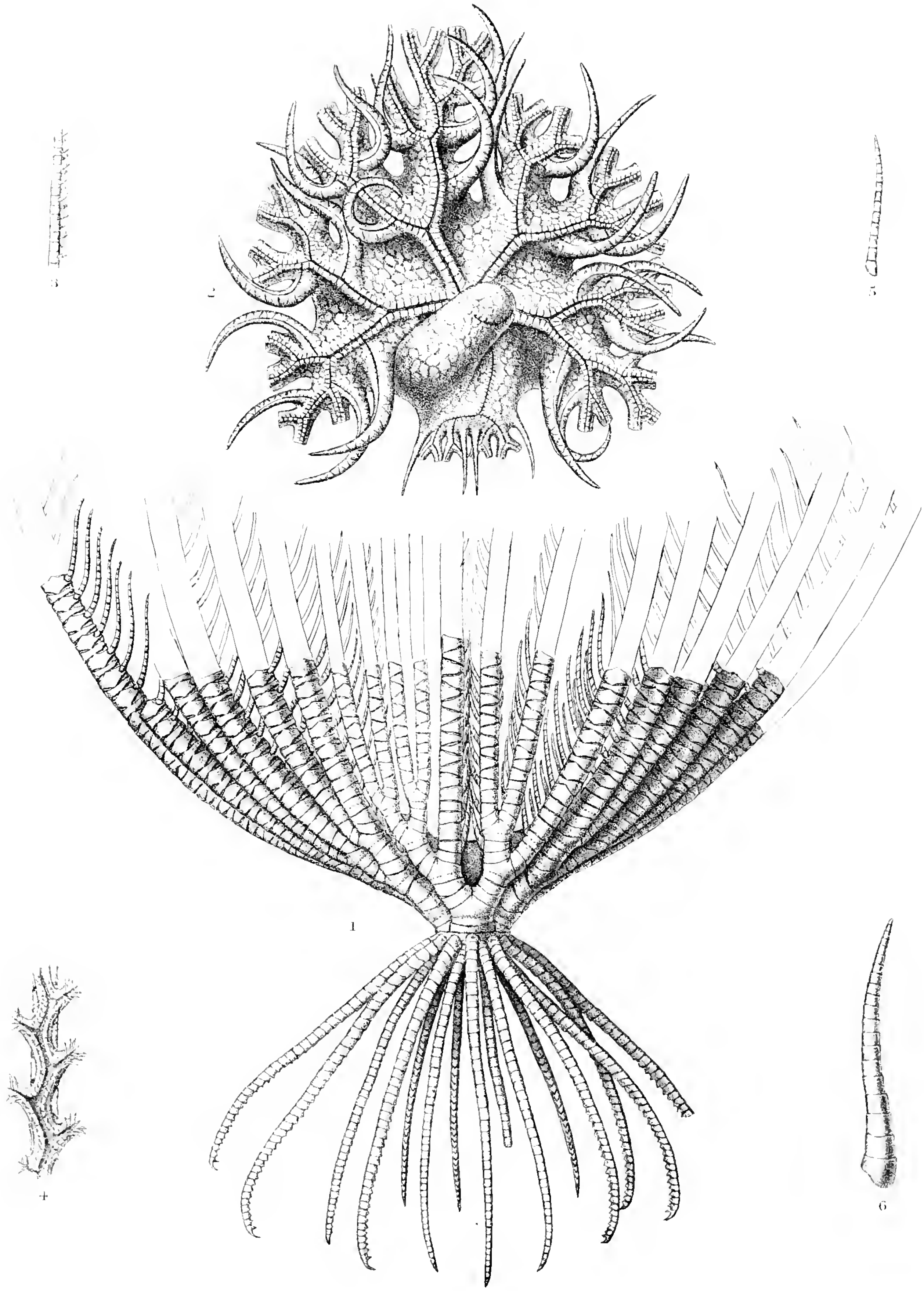
ANTEDON FLUCTUANS Sp. n.

PLATE IX.

PLATE IX.

ANTEDON MULTIRADIATA, n. sp.

		Diam.	Page
Fig. 1.	Side view	× 3	96
Fig. 2.	The disk, from above,	× 4	266
Fig. 3.	Distal portion of an arm,		96
Fig. 4.	Ambulacral groove of an arm,		96
Fig. 5.	A pinnule from the middle of an arm,		96
Fig. 6.	One of the proximal pinnules, its end broken,		96



Berjeau & ... del. et lith. Hanhart imp.

ANTEDON MULTIRADIATA, sp. n.

PLATE X.

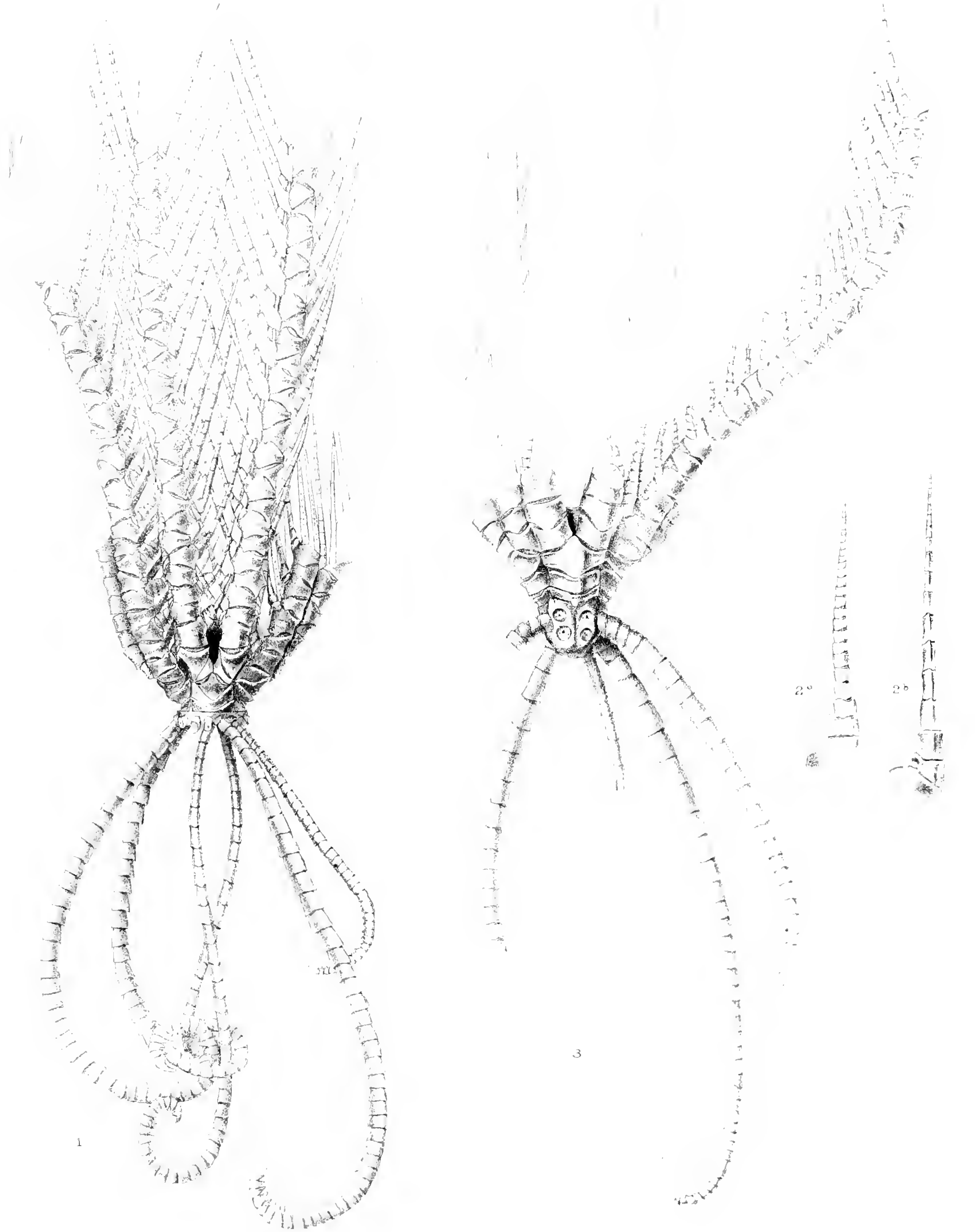
PLATE X.

Figs. 1, 2. Antedon discoidea, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	3	134
Fig. 2. *a*. The pinnule of the fourth brachial,	×	5	135
b. The pinnule of the eighth brachial,	×	6	135

Fig. 3. Antedon latipinna, n. sp.

Fig. 3. Side view,	×	4	116



Berjeau & Highley del.

1, 2 ANTEDON DISCOIDEA, sp. n 3 ANTEDON LATIPINNA, sp. n

PLATE XI.

PLATE XI.

Figs. 1, 2. ANTEDON SPINICIRRA, n. sp.

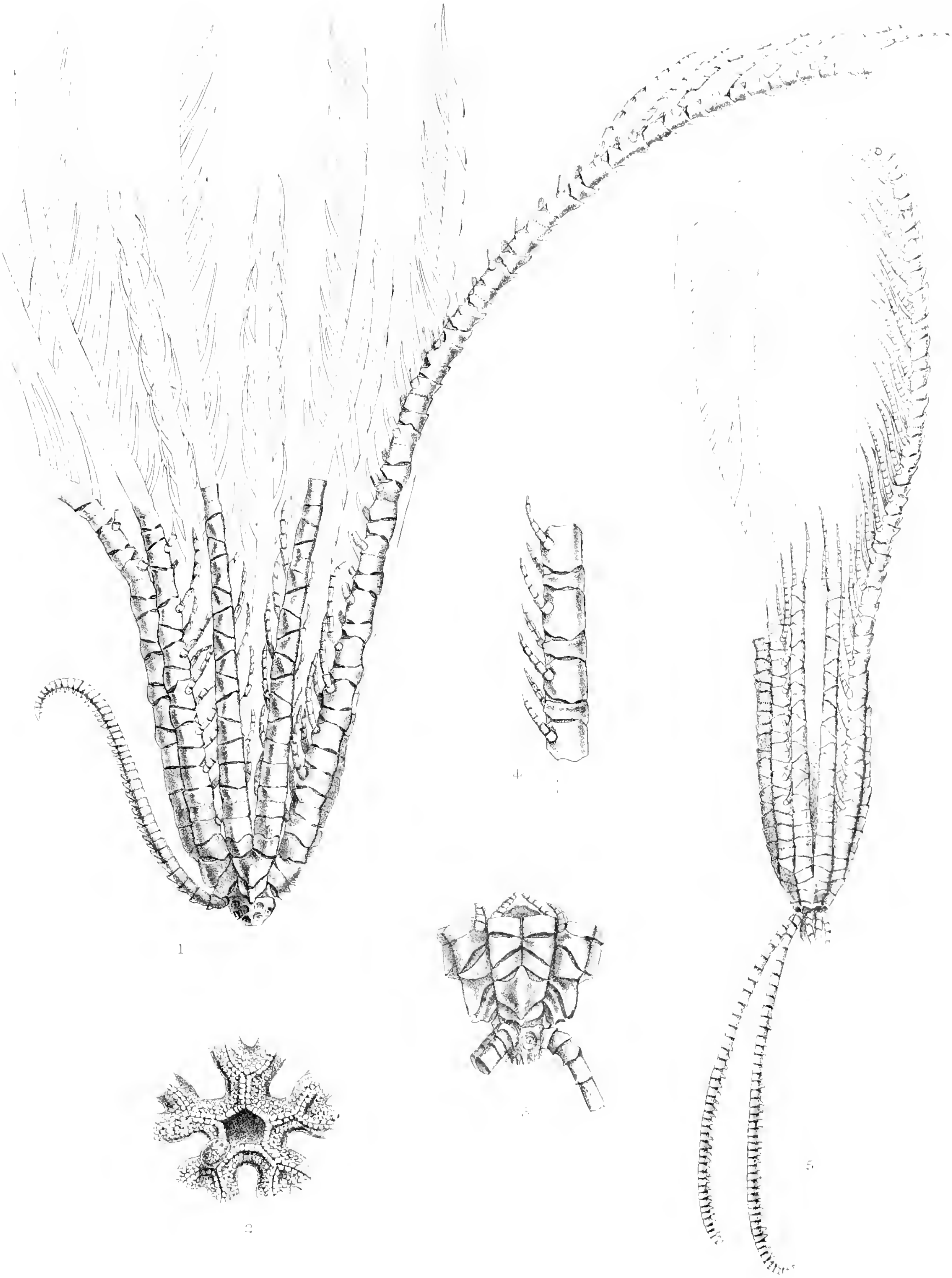
		Diam.	Page
Fig. 1. Side view,	×	4	112
Fig. 2. The disk, from above,	×	6	112

Figs. 3, 4. ANTEDON ACUTIRADIA, n. sp.

		Diam.	Page
Fig. 3. Side view,	×	4	113
Fig. 4. Middle portion of an arm,	×	4	113

Fig. 5. ANTEDON BREVIRADIA, n. sp.

		Diam.	Page
Fig. 5. Side view,	×	2	110



1, 2. ANTEDON SPINICIRRA, sp. n.
3, 4. ANTEDON ACUTIRADIA, sp. n.
5. ANTEDON BREVIRADIA, sp. n.

PLATE XII.

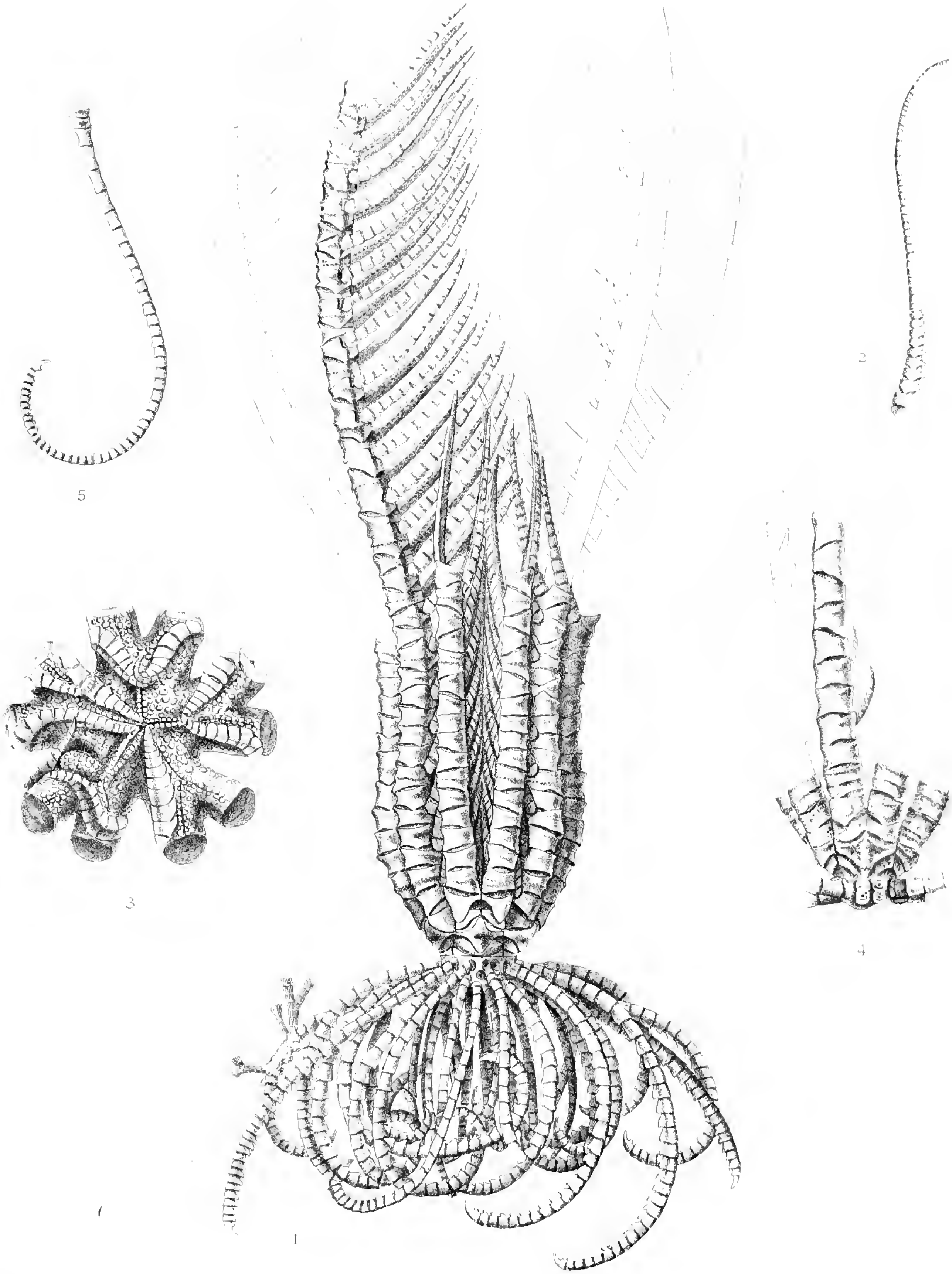
PLATE XII.

Figs. 1, 2. Antedon rhomboidea, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	2	148
Fig. 2. A lower pinnule,	×	3	148

Figs. 3–5. Antedon gracilis, n. sp.

Fig. 3. The disk, from above,	×	6	107
Fig. 4. Side view of a mutilated individual,	×	4	107
Fig. 5. A cirrus,	×	3	107



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West Newman & Co. lith.

1, 2. ANTEDON RHOMBOIDEA, sp. n. 3–5. ANTEDON GRACILIS, sp. n.

PLATE XIII.

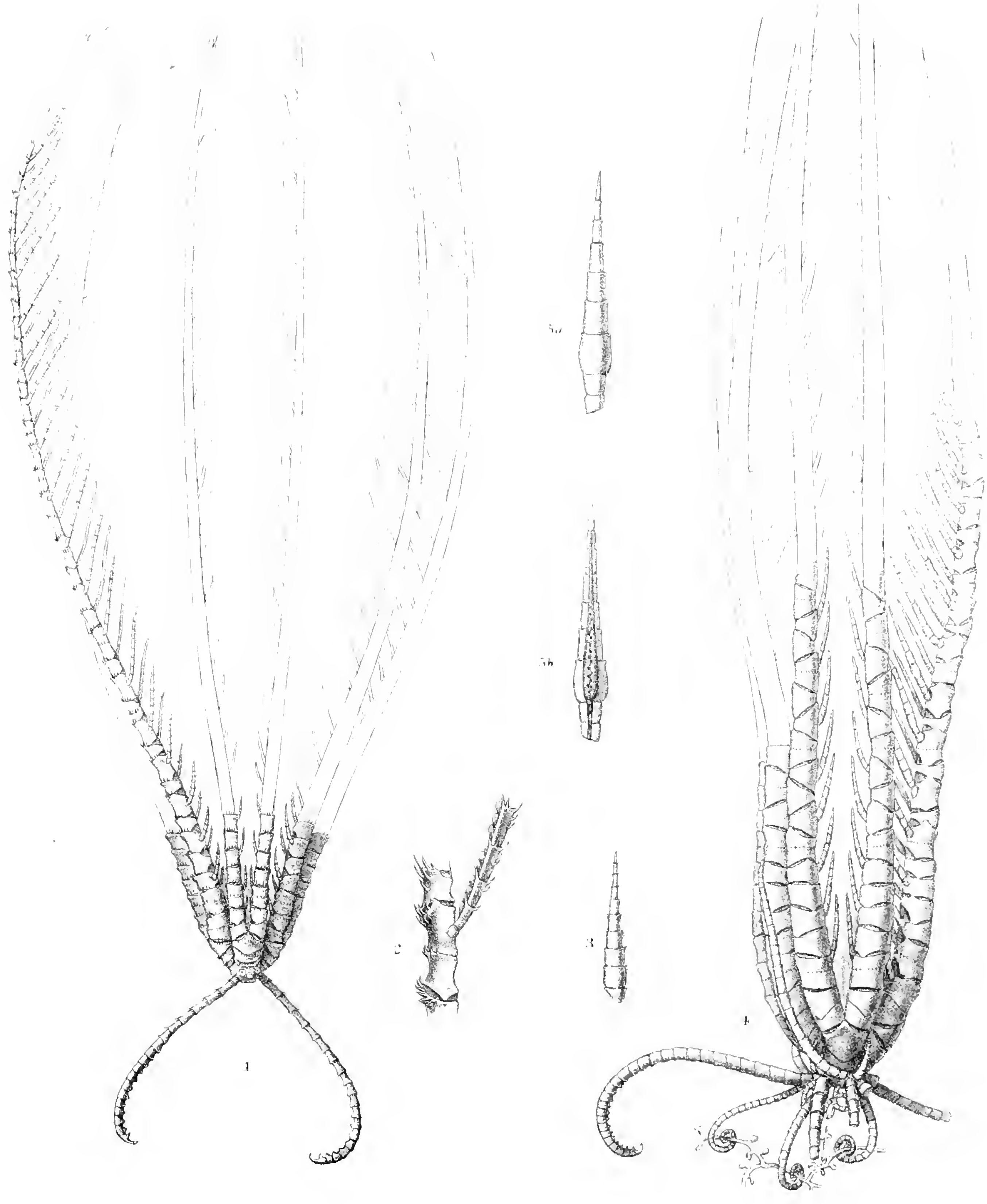
PLATE XIII.

Figs. 1–3. ANTEDON MULTISPINA, n. sp.

		Diam.	Page
Fig. 1. Side view of a young specimen,	×	4	117
Fig. 2. Middle portion of an arm of the same,	×	8	117
Fig. 3. The pinnule on the third brachial,	×	12	118

Figs. 4, 5. ANTEDON LINEATA, n. sp.

Fig. 4. Side view,	×	4	183
Fig. 5. (*a*) Dorsal and (*b*) ventral aspects of the pinnule on the twelfth brachial,	×	8	184

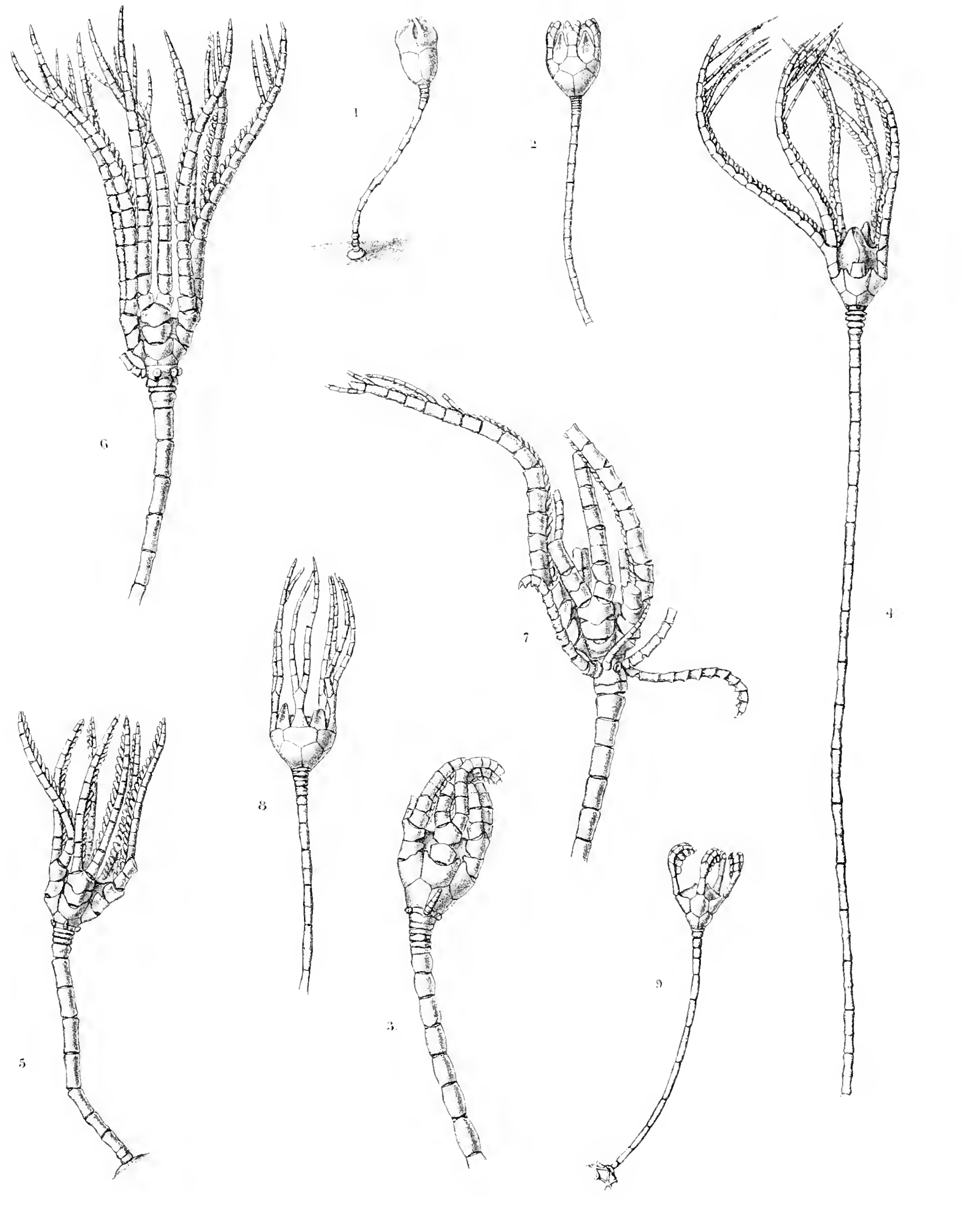


Berjeau & Highley del et lith.

1-3. ANTEDON MULTISPINA, Sp.n.
4-5. ANTEDON LINEATA, Sp.n.

PLATE XIV.

PLATE XIV.



Berjeau & Highley del et lith.

Mintern Bros. imp.

PENTACRINOID LARVÆ OF ANTEDON

PLATE XV.

PLATE XV.

Figs. 1–4. Antedon gracilis, n. sp.

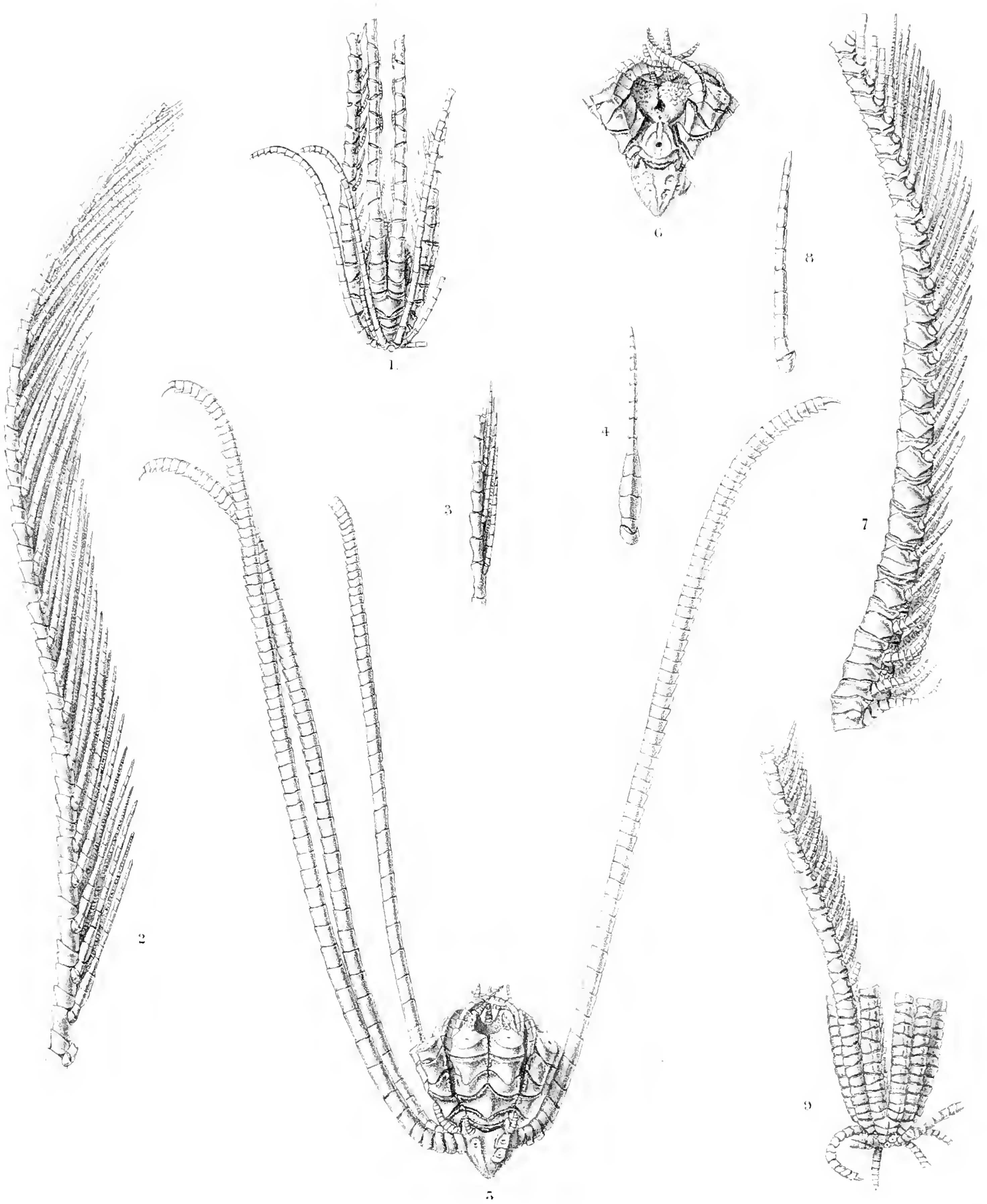
		Diam.	Page
Fig. 1. Side view of a young individual,	×	6	109
Fig. 2. Middle portion of an arm.	×	4	108
Fig. 3. Terminal portion of a young arm.	×	6	108
Fig. 4. Dorsal aspect of a lower pinnule.	×	6	108

Figs. 5–8. Antedon valida, n. sp.

Fig. 5. Side view of a mutilated individual.	×	2	104
Fig. 6. Side view of a calyx and arm bases with one ray removed,	×	2	101
Fig. 7. Lower portion of an arm from the third brachial onwards,	×	2	105
Fig. 8. A middle pinnule of a young individual,	×	6	105

Fig. 9. Antedon parvipinna, n. sp.

Fig. 9. Side view.	×	2	127



Berjeau & Highley del. et lith.

[illegible]

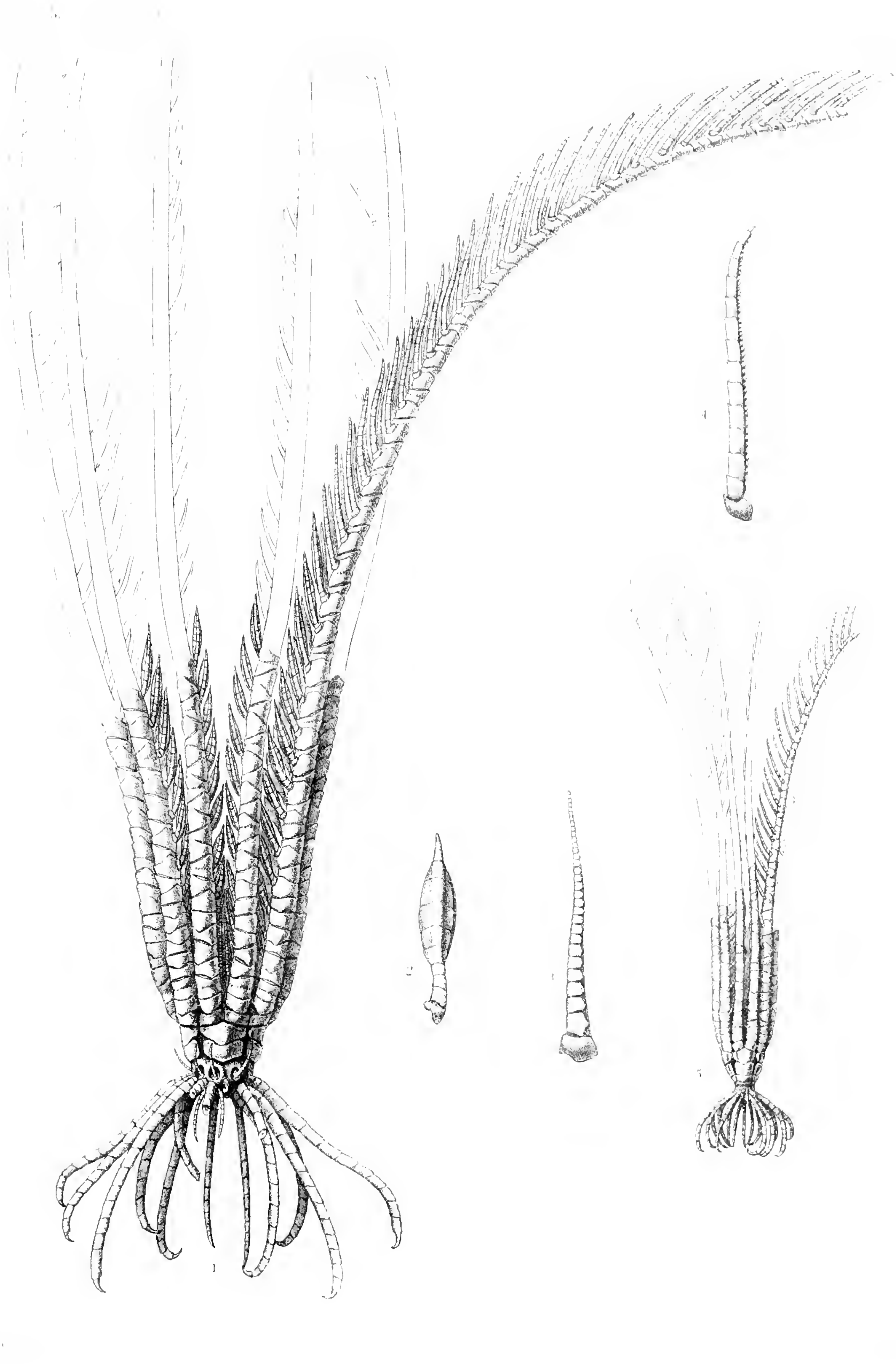
1-4. ANTEDON GRACILIS, Sp. n. 5-8. ANTEDON VALIDA, Sp. n.
9. ANTEDON PARVIPINNA, Sp. n.

PLATE XVI.

PLATE XVI.

ANTEDON ACŒLA, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	2	132
Fig. 2. Dorsal aspect of a genital pinnule,	×	6	133
Fig. 3. The pinnule of the second brachial,	×	6	132
Fig. 4. A pinnule from the middle of the arm,	×	6	134
Fig. 5. A young individual,	×	2	133



ANTEDON ACOELA

PLATE XVII.

PLATE XVII.

		Diam.	Page
Antedon longicirra, n. sp., ...	×	2	103

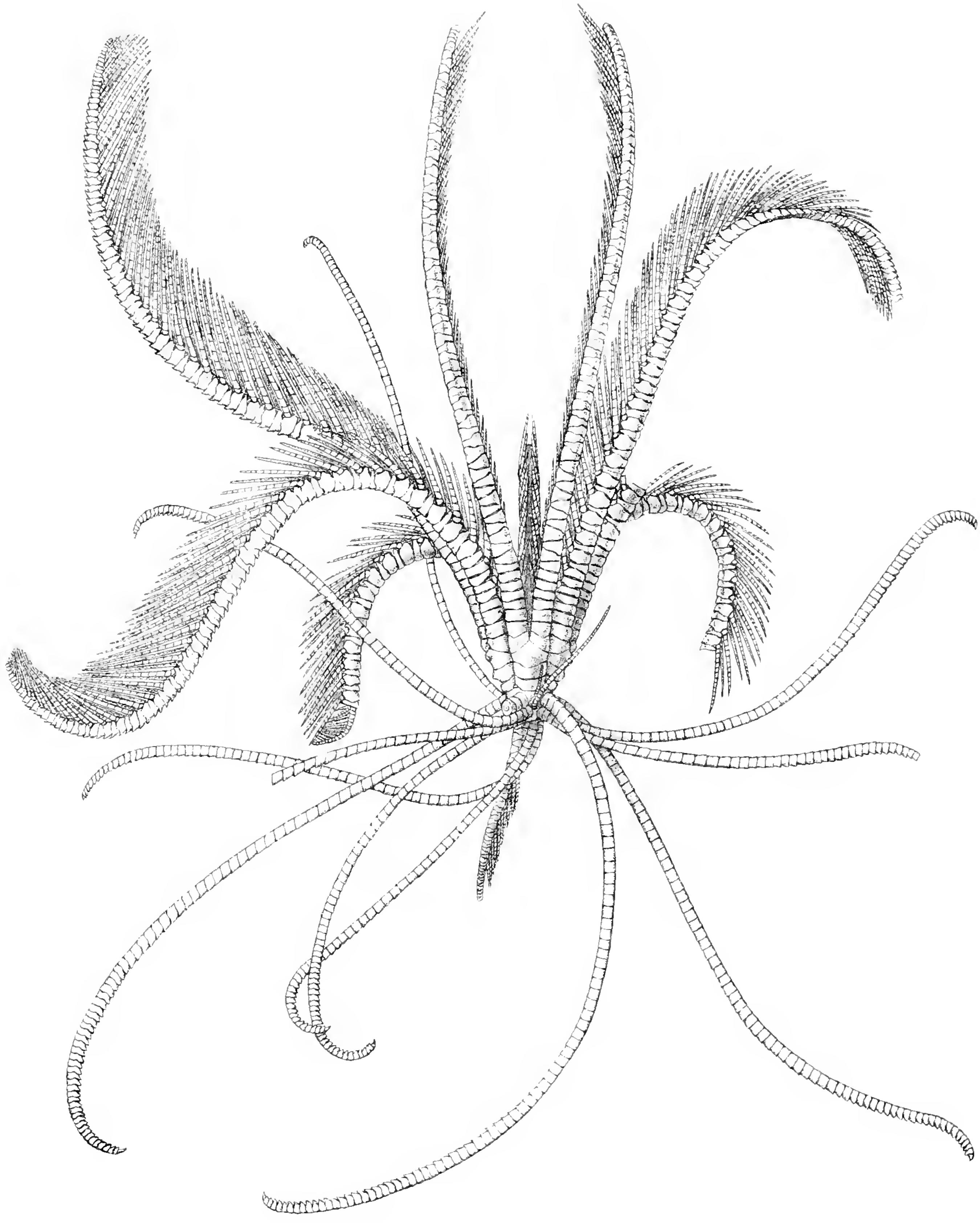


PLATE XVIII.

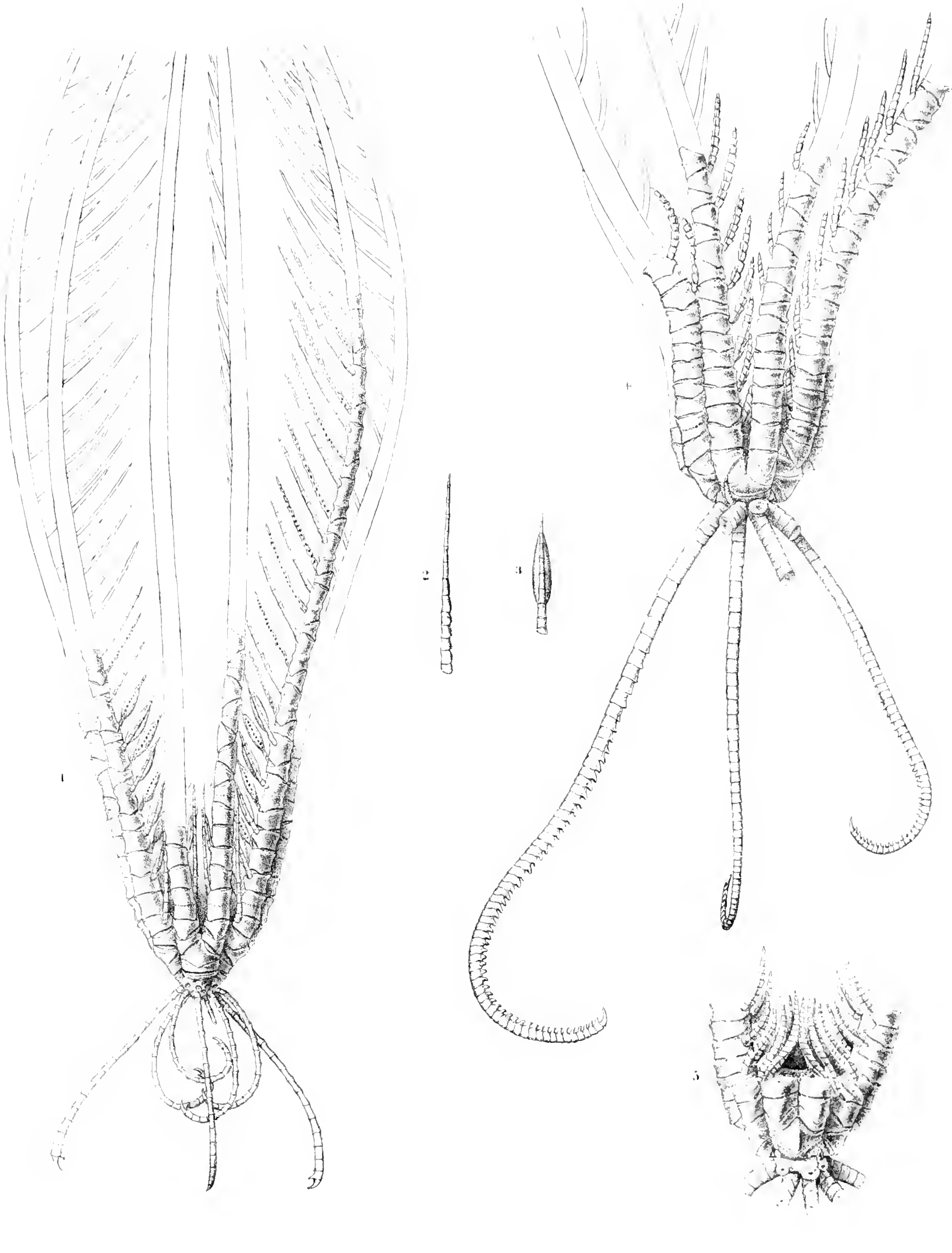
PLATE XVIII.

Figs. 1–3. ANTEDON ALTERNATA, n. sp.

		Diam.	Page
Fig. 1. Side view.	×	6	179
Fig. 2. A distal pinnule.	×	10	179
Fig. 3. A lower pinnule.	×	10	179

Figs. 4, 5. ANTEDON INCERTA, n. sp. . . . × 2

Fig. 4. Side view, showing the absence of the second radial in one ray. . .	106
Fig. 5. Another aspect of the same individual.	101



Berjeau & Highley del. et lith.

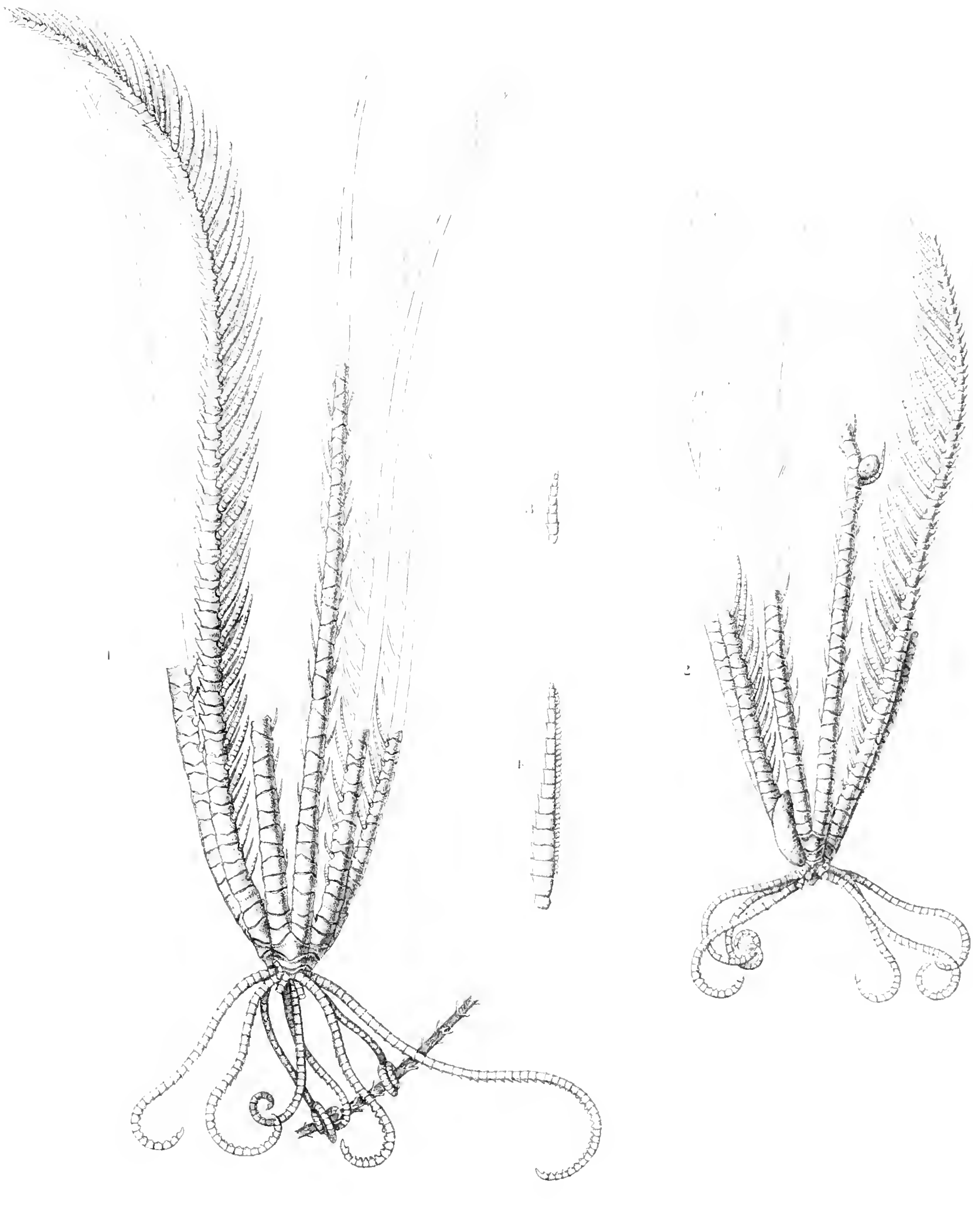
1-3 ANTEDON ALTERNATA.
4, 5. ANTEDON INCERTA

PLATE XIX.

PLATE XIX.

ANTEDON BREVIRADIA, n. sp.

		Diam.	Page
Fig. 1. Side view,	.	× $2\frac{1}{2}$	110
Fig. 2. A smaller specimen with cysts of *Myzostoma murrayi*,	.	× $2\frac{1}{2}$	111
Fig. 3. The pinnule of the sixth brachial,	.	× 6	110
Fig. 4. A later pinnule,	.	× 6	110



ANTEDON BREVIRADIA

PLATE XX.

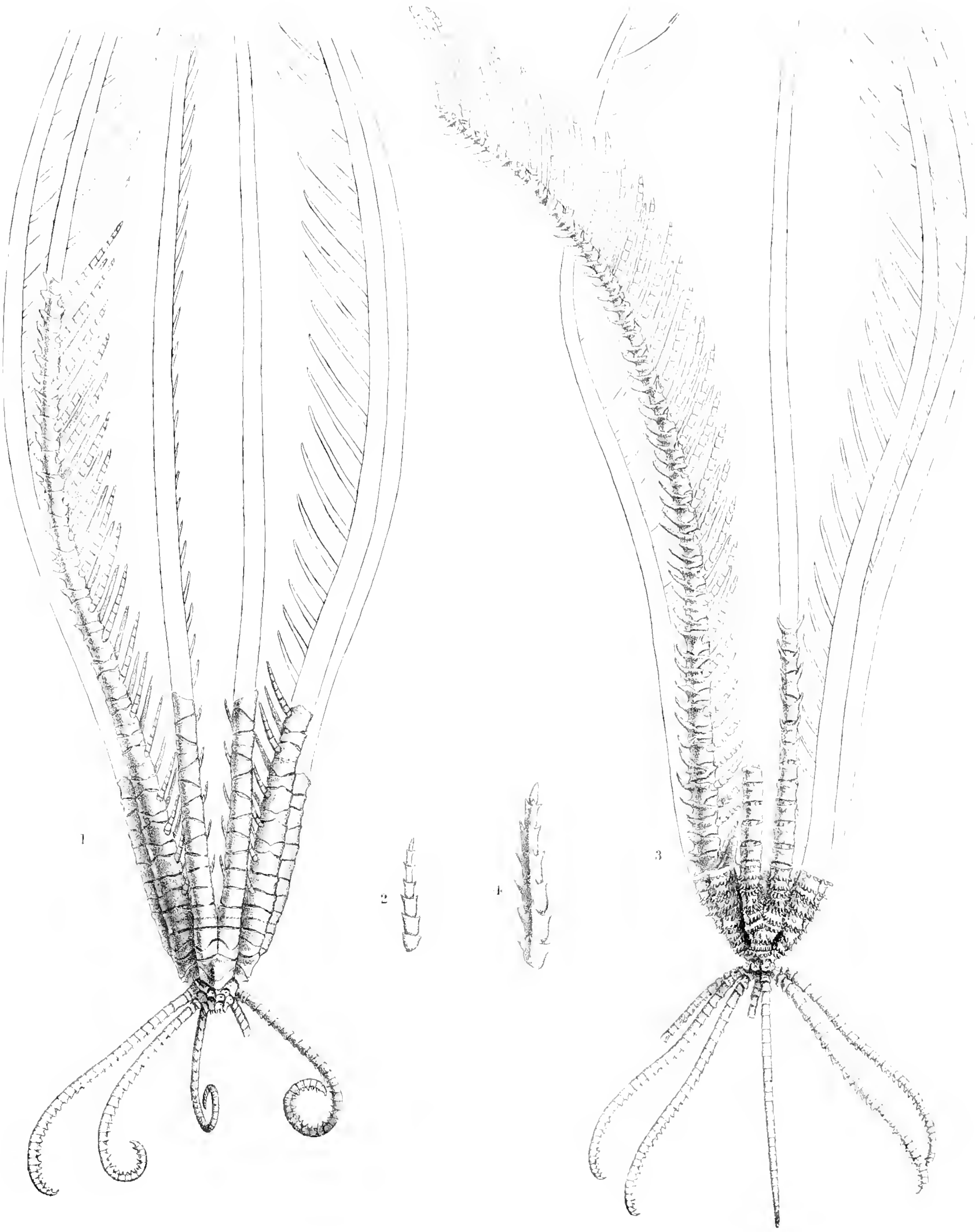
PLATE XX.

Figs. 1, 2. ANTEDON BREVIRADIA, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	4	110
Fig. 2. A distal pinnule,	×	12	110

Figs. 3, 4. ANTEDON BISPINOSA, n. sp.

		Diam.	Page
Fig. 3. Side view,	×	3	115
Fig. 4. The pinnule of the fourth brachial,	×	12	115



Berjeau & Highley, del et lith.

1,2 ANTEDON BREVIRADIA, n. sp.
3,4 ANTEDON BISPINOSA, n. sp.

Hanhart imp.

PLATE XXI.

PLATE XXI.

Figs. 1, 2. ANTEDON INCISA, n. sp.

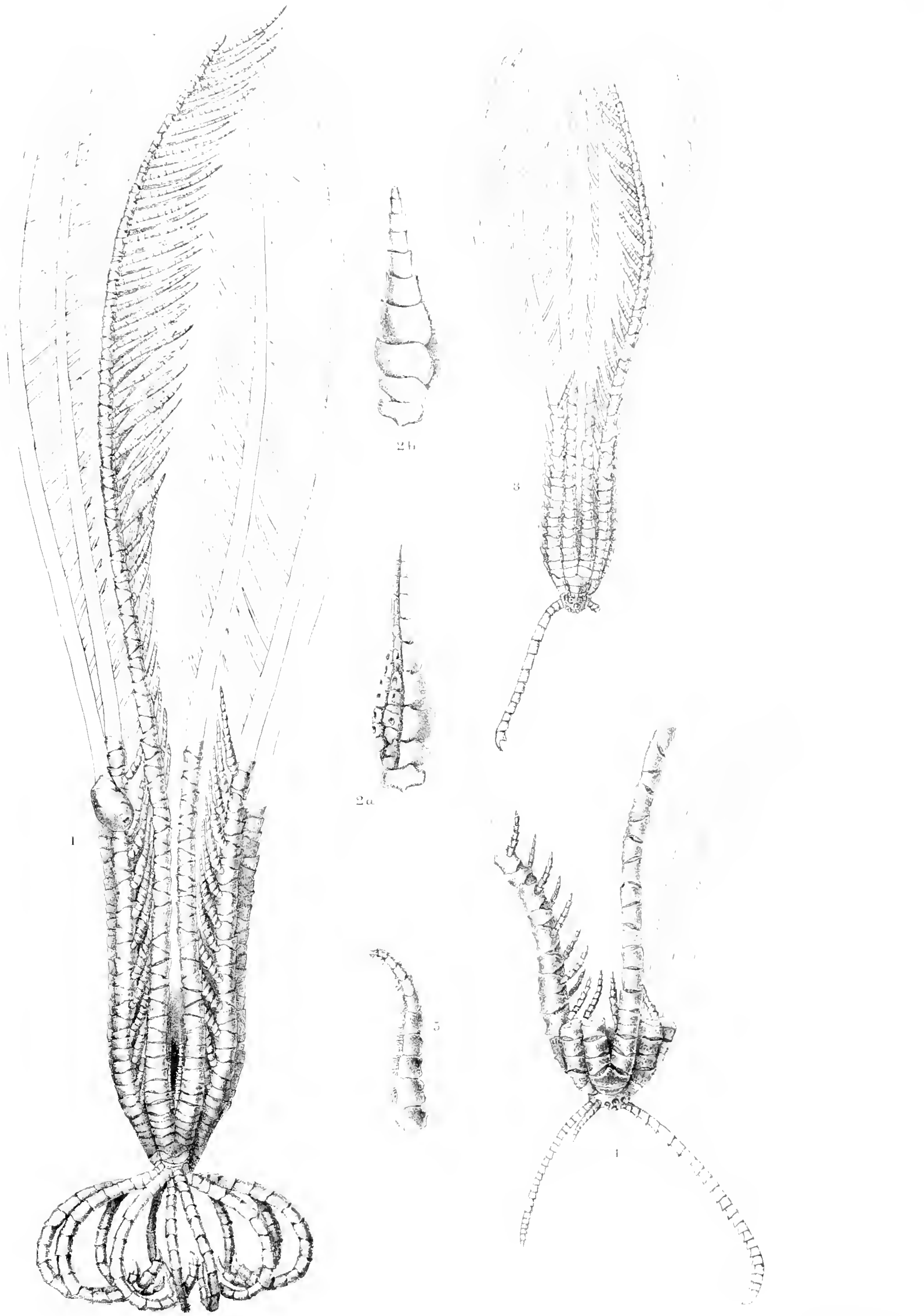
		Diam.	Page
Fig. 1. Side view, . . .	×	2	124
Fig. 2. (*a*) Inner and (*b*) outer views of the pinnule on the eighth brachial, ...	×	10	123

Fig. 3. ANTEDON BASICURVA, n. sp.

Fig. 3. A young specimen, . . .	×	2	123

Figs. 4, 5. ANTEDON ECHINATA, n. sp.

Fig. 4. Side view, ...	×	4	119
Fig. 5. The pinnule on the second brachial, ...	×	10	120



Berjeau & Highley del.

1, 2 ANTEDON INCISA, n. sp.
3 ANTEDON BASICURVA, n. sp. 4 ANTEDON ECHINATA n. sp.

PLATE XXII.

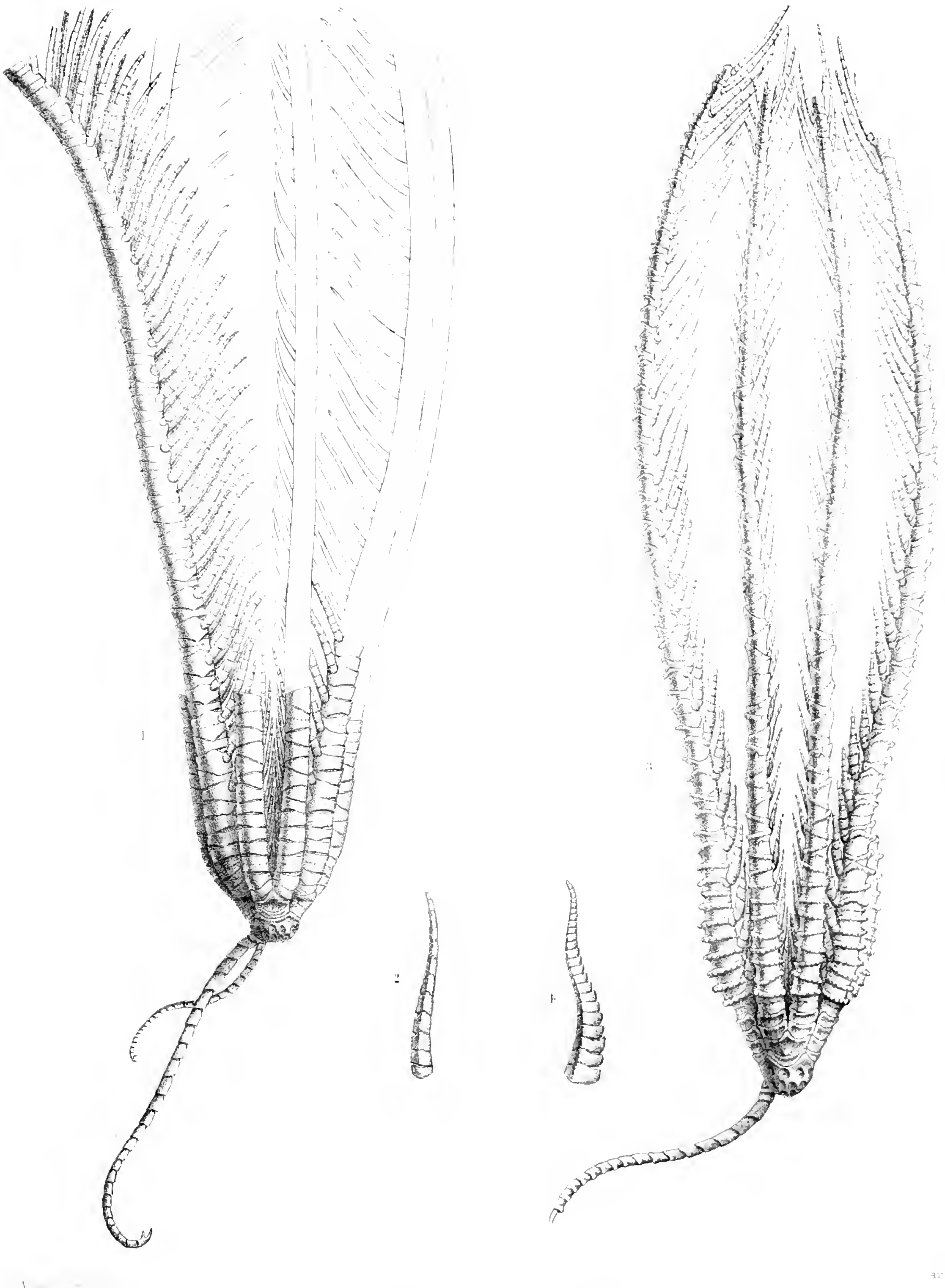
PLATE XXII.

Figs. 1, 2. ANTEDON DENTICULATA, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	4	130
Fig. 2. The pinnule on the sixth brachial,	×	6	130

Figs. 3, 4. ANTEDON BASICURVA, n. sp.

		Diam.	Page
Fig. 3. Side view,	×	2	120
Fig. 4. The pinnule on the second brachial,	×	8	123



1, 2. ANTEDON DENTICULATA

3, 4. ANTEDON BASICURVA

PLATE XXIII.

PLATE XXIII.

		Diam.	Page
Fig. 1	Antedon pusilla, n. sp.,	× 5	131
Fig. 2.	Antedon tuberosa, n. sp.,	× 3	126
Fig. 3.	Antedon aculeata, n. sp	× 3	128

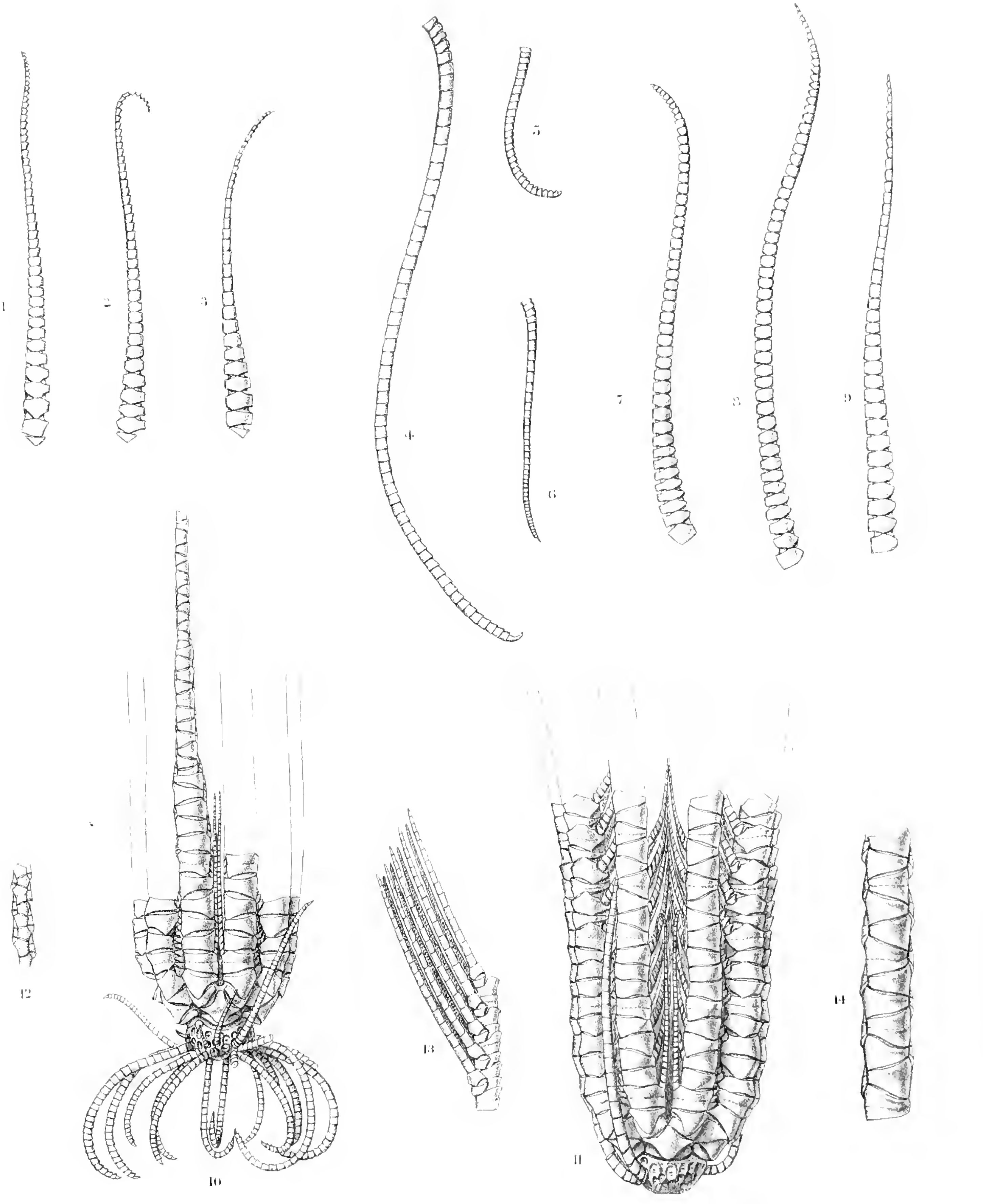
Bergeau & Highley del. et lith. Mintern Bros. imp.

1. ANTEDON PU[illegible]LLA, Sp. n. 2. ANTEDON TUBER[illegible]A, Sp. n.
3. ANTEDON ACULEATA, Sp. n.

PLATE XXIV.

PLATE XXIV.

	Diam.	Page
Figs. 1–3. ANTEDON RHOMBOIDEA, n. sp.		
Figs. 1–3. The pinnules on the second, fourth, and sixth brachials,	× 4	141
Figs. 4–14. ANTEDON ESCHRICHTI, Müll., sp.		
Fig. 4. A mature cirrus,	× 2	143
Fig. 5. "Small mature" cirrus,	× 2	143
Fig. 6. Normal young cirrus,	× 2	143
Figs. 7–9. The pinnules on the second, fourth, and sixth brachials,	× 2	141
Fig. 10. A "Porcupine" specimen with regenerated arm,	× 2	141
Fig. 11. A Challenger specimen,	× 2	139
Fig. 12. Terminal portion of an arm, dorsal aspect,	× 4	140
Fig. 13. Distal portion of an arm in side view,	× 4	141
Fig. 14. Middle portion of an arm, dorsal aspect,	× 4	153



Berjeau & Highley del. et lith.

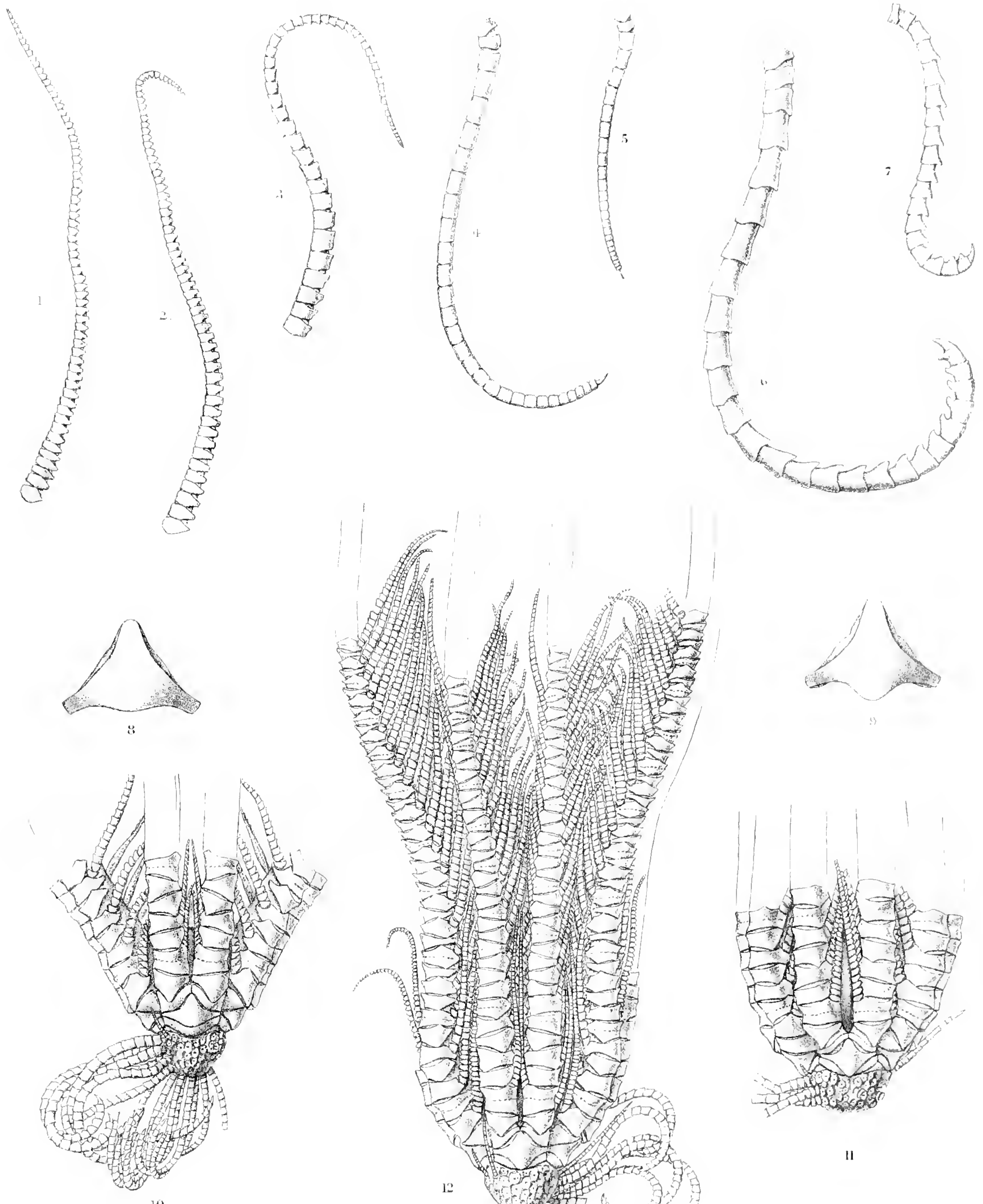
1–3. ANTEDON RHOMBOIDEA, sp. n. 4–14. ANTEDON [illegible]

PLATE XXV.

PLATE XXV.

Antedon antarctica, n. sp.

		Diam.	Page
Figs. 1–3. The pinnules on the second, fourth, and sixth brachials,	×	4	145
Fig. 4. Normal young cirrus,	×	5	145
Fig. 5. Another, still younger,	×	5	145
Fig. 6. A mature cirrus,	×	5	145
Fig. 7. "Small mature" cirrus,	×	5	145
Figs. 8, 9. Two radial axillaries,	×	5	145
Figs. 10–12. Side views of three individuals,	×	2	144



Berjeau & Highley del et lith

Mintern Bros imp.

ANTEDON ANTARCTICA, Sp.n.

PLATE XXVI.

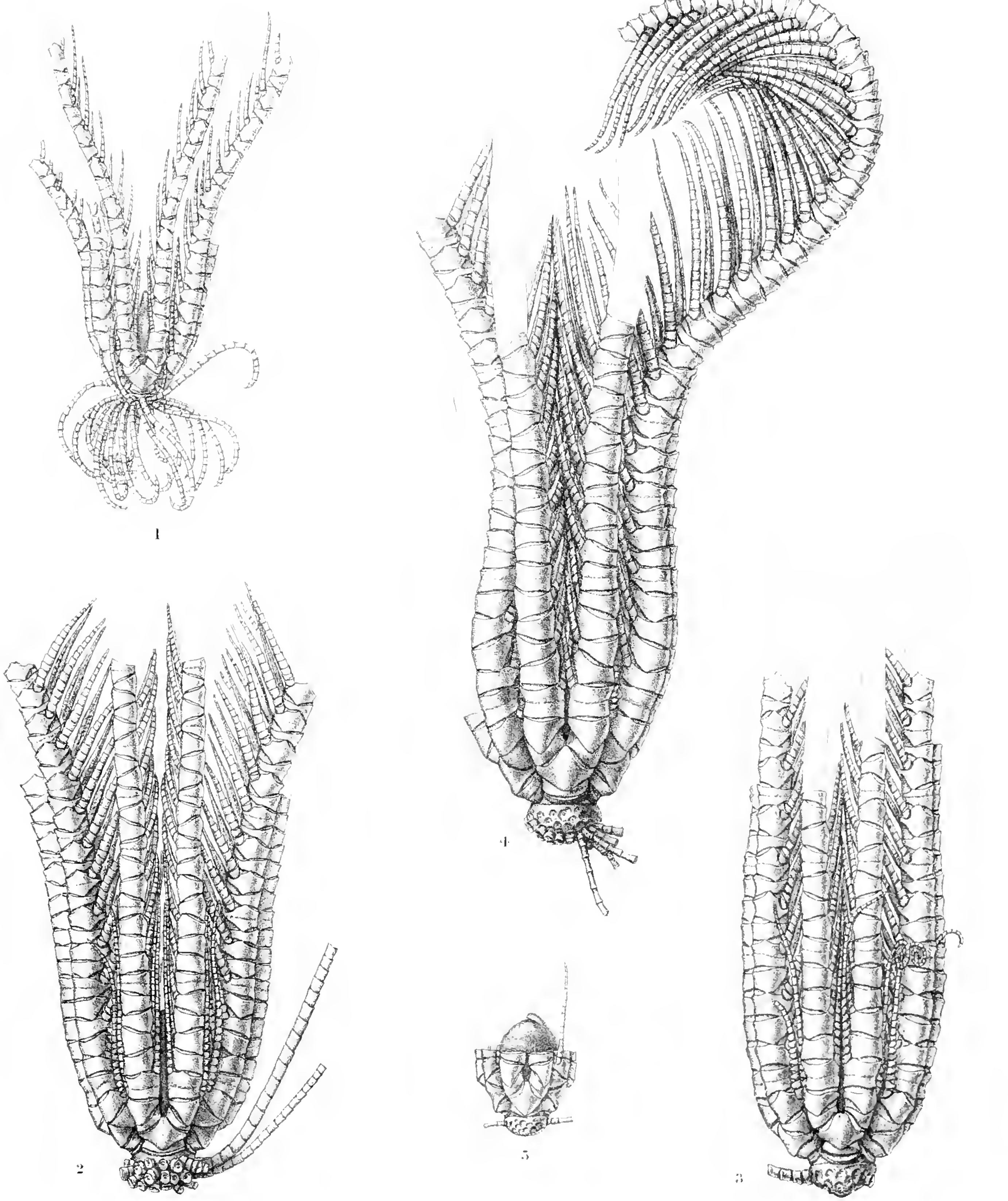
PLATE XXVI.

Figs. 1–3. ANTEDON QUADRATA, n. sp.

		Diam.	Page
Fig. 1.	A young specimen (Challenger), ...	× 4	152
Fig. 2.	An older individual (Challenger), ...	× 2	149
Fig. 3.	Another, rather small (Færoe Channel), . . .	× 3	152

Figs. 4, 5. ANTEDON AUSTRALIS, n. sp.

		Diam.	Page
Fig. 4.	A mature individual.	× 3	146
Fig. 5.	Another, much younger.	× 4	148



Berjeau & Highley del. et lith. Mintern Bros. imp.

1–3. ANTEDON QUADRATA, Sp. n. 4, 5. ANTEDON AUSTRALIS, sp. n.

PLATE XXVII.

PLATE XXVII.

Figs. 1–13. ANTEDON QUADRATA, n. sp.

	Diam.	Page
Fig. 1. Mature cirrus,	× 2	155
Fig. 2. Another, immature,	× 2	155
Fig. 3. "Small mature" cirrus,	× 2	155
Fig. 4. Normal young cirrus,	× 2	155
Figs. 5–7. Terminal, distal, and middle portions of the arms, in their dorsal aspect,	× 4	153
Figs. 8–10. The pinnules on the second, fourth, and sixth brachials of a Challenger specimen,	× 4	152
Figs. 11–13. The same pinnules in an Arctic specimen,	× 4	152

Figs. 14–20. ANTEDON AUSTRALIS, n. sp.

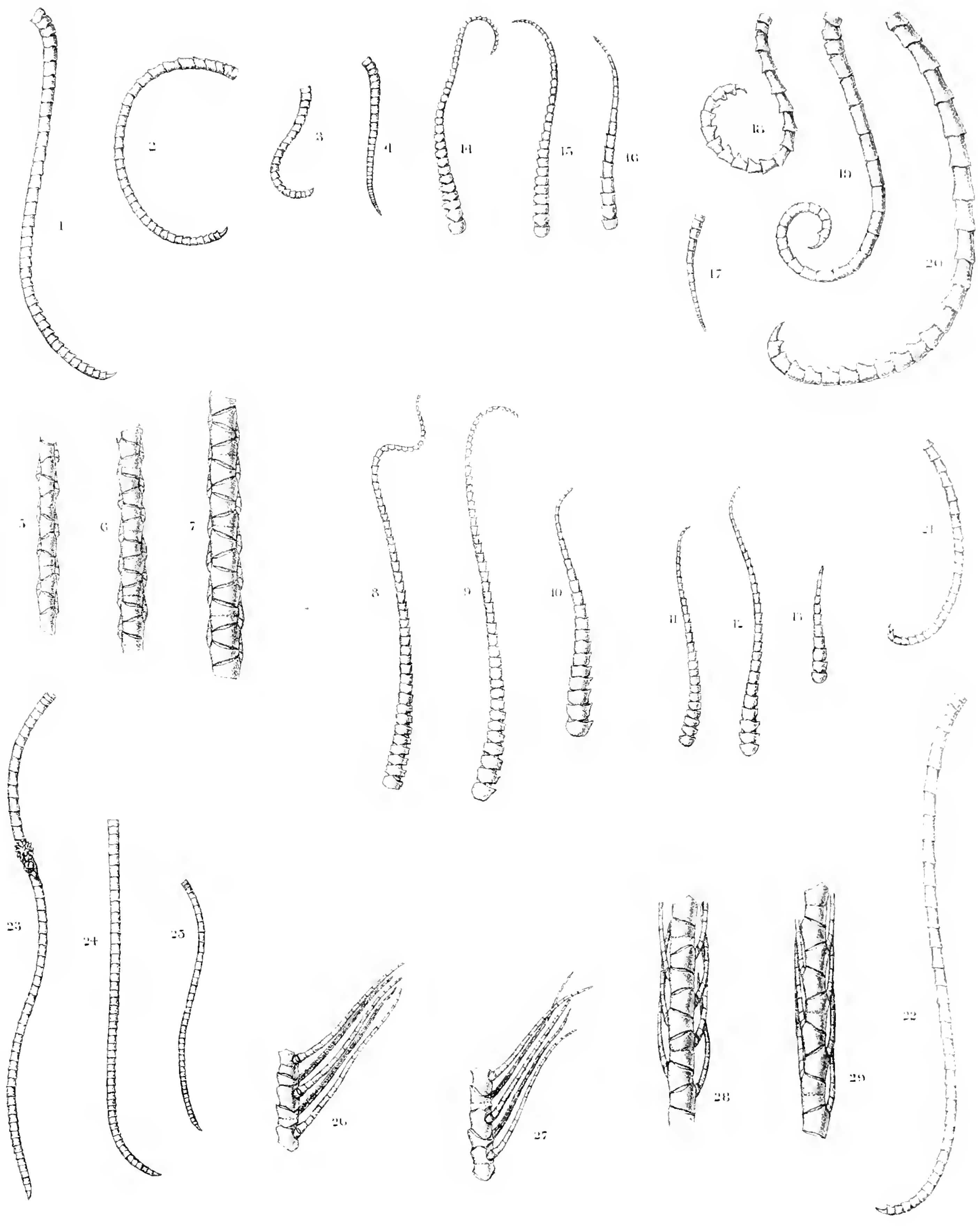
Figs. 14–16. The pinnules on the second, fourth, and sixth brachials,	× 4	147
Fig. 17. A very young cirrus,	× 5	147
Fig. 18. "Small mature" cirrus,	× 5	147
Fig. 19. Premature cirrus,	× 5	147
Fig. 20. Mature cirrus,	× 5	147

Figs. 21, 22. ANTEDON HYSTRIX, n. sp.

Fig. 21. Premature cirrus,	× 3	166
Fig. 22. Mature cirrus,	× 3	166

Figs. 23–29. ANTEDON PHALANGIUM, Müll., sp.

Fig. 23. A long-jointed cirrus,	× 2	162
Fig. 24. A short-jointed cirrus,	× 2	162
Fig. 25. A long-jointed cirrus, immature,	× 2	162
Fig. 26. Terminal arm-joints of a specimen from the Minch,	× 4	163
Fig. 27. The same part of a Mediterranean specimen,	× 4	163
Fig. 28. The later arm-joints of a specimen from the Minch, dorsal aspect,	× 5	163
Fig. 29. The same part of a Mediterranean specimen,	× 5	163



Berjeau & Highley del. et lith.

[illegible] ANTEDON [illegible] sp. n. [illegible]
[illegible] ANTEDON [illegible] sp. n. [illegible]

PLATE XXVIII.

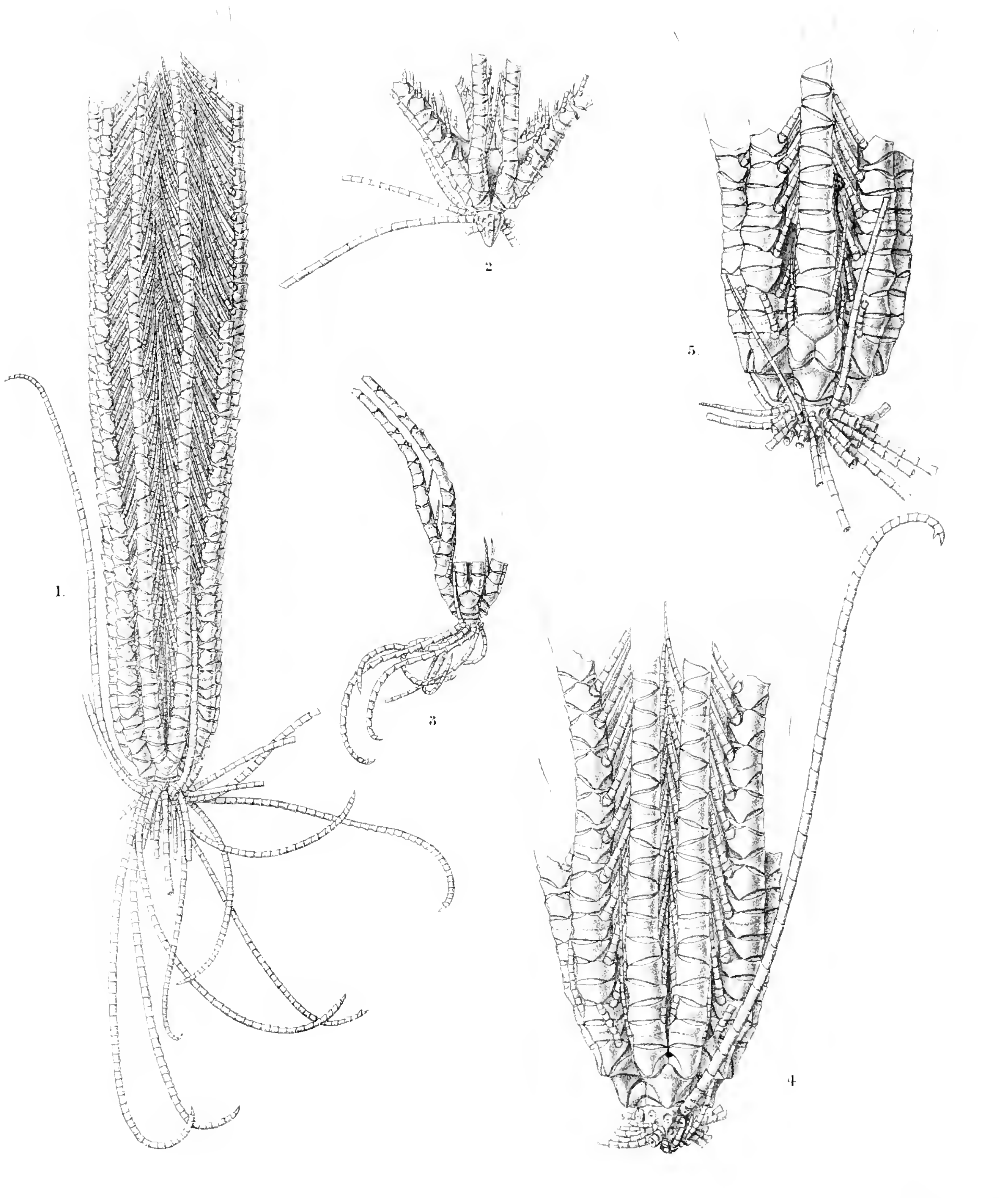
PLATE XXVIII.

Figs. 1–3. ANTEDON PHALANGIUM, Müll., sp.

		Diam.	Page
Fig. 1. Side view, radial,	×	2	159
Fig. 2. Side view, interradial,	×	2	159
Fig. 3. A young specimen,	×	6	163

Figs. 4, 5. ANTEDON HYSTRIX, n. sp.

		Diam.	Page
Fig. 4. Side view,	×	3	165
Fig. 5. Another specimen, with an abnormal ray,	×	3	167



1–3. ANTEDON PHALANGIUM, Müll. sp. 4.5. ANTEDON HYSTRIX, n. sp.

PLATE XXIX.

PLATE XXIX.

Figs. 1–4. ANTEDON ANGUSTIPINNA, n. sp.

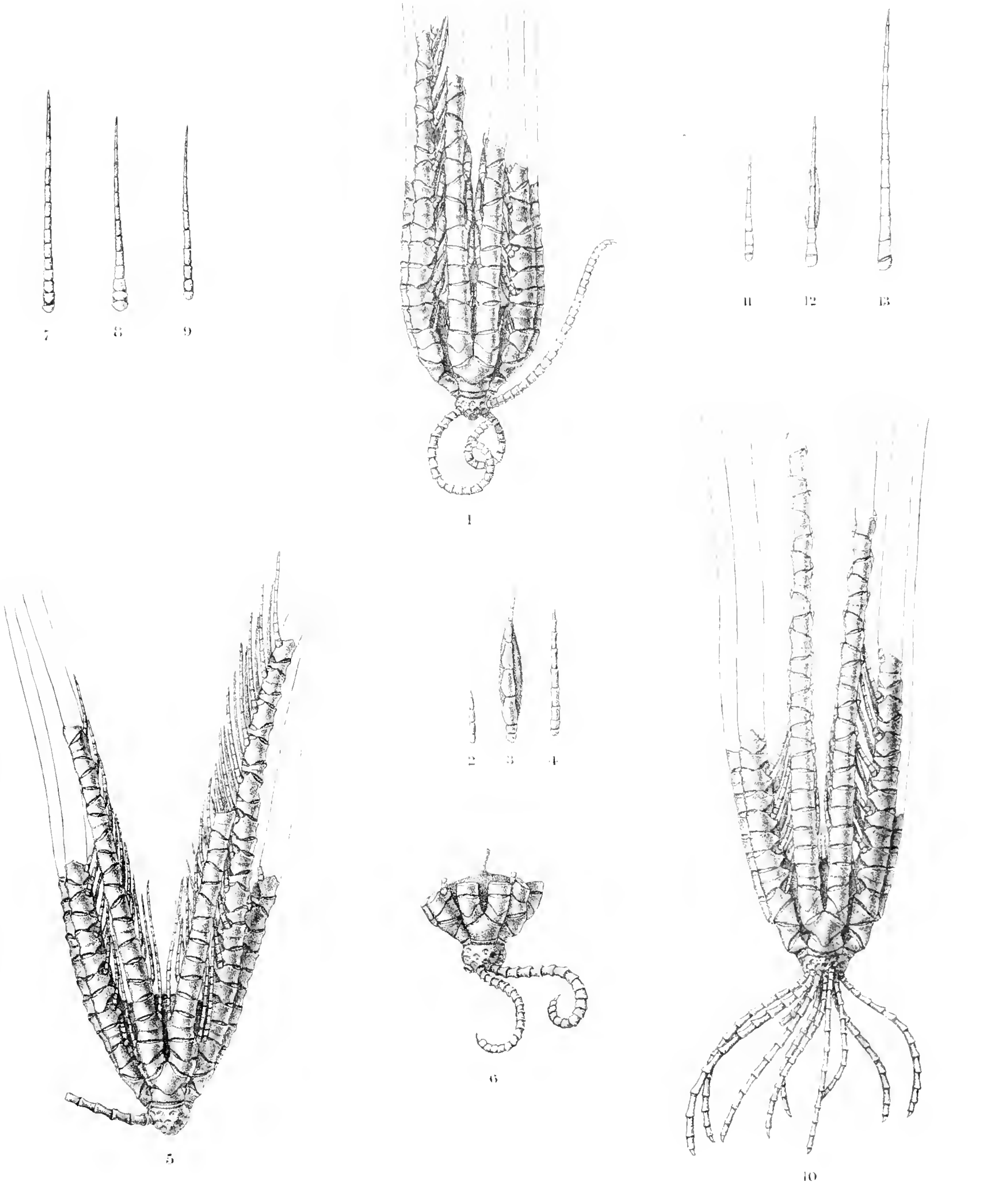
	Diam.	Page
Fig. 1. Side view,	× 4	189
Fig. 2. The pinnule on the second brachial,	× 6	189
Fig. 3. A genital pinnule,	× 6	190
Fig. 4. A distal pinnule,	× 6	190

Figs. 5–9. ANTEDON REMOTA, n. sp.

	Diam.	Page
Fig. 5. Side view,	× 4	184
Fig. 6. A calyx with only two radials in one ray,	× 4	185
Fig. 7. The pinnule on the second brachial (incomplete),	× 6	185
Fig. 8. The pinnule on the third brachial (incomplete),	× 6	185
Fig. 9. A distal pinnule,	× 6	185

Figs. 10–13. ANTEDON ABYSSORUM, n. sp.

	Diam.	Page
Fig. 10. Side view,	× 4	190
Fig. 11. The pinnule on the second brachial,	× 6	190
Fig. 12. A genital pinnule,	× 6	190
Fig. 13. A distal pinnule,	× 6	190



Berjeau & Highley del. et lith.

Mintern Bros. imp.

1–4. ANTEDON AN[illegible]STIPINNA, sp. n. [illegible] 9. A[illegible]MUTA sp. n.
10–13. ANTEDON ABYS[illegible]ORUM, sp. n.

PLATE XXX.

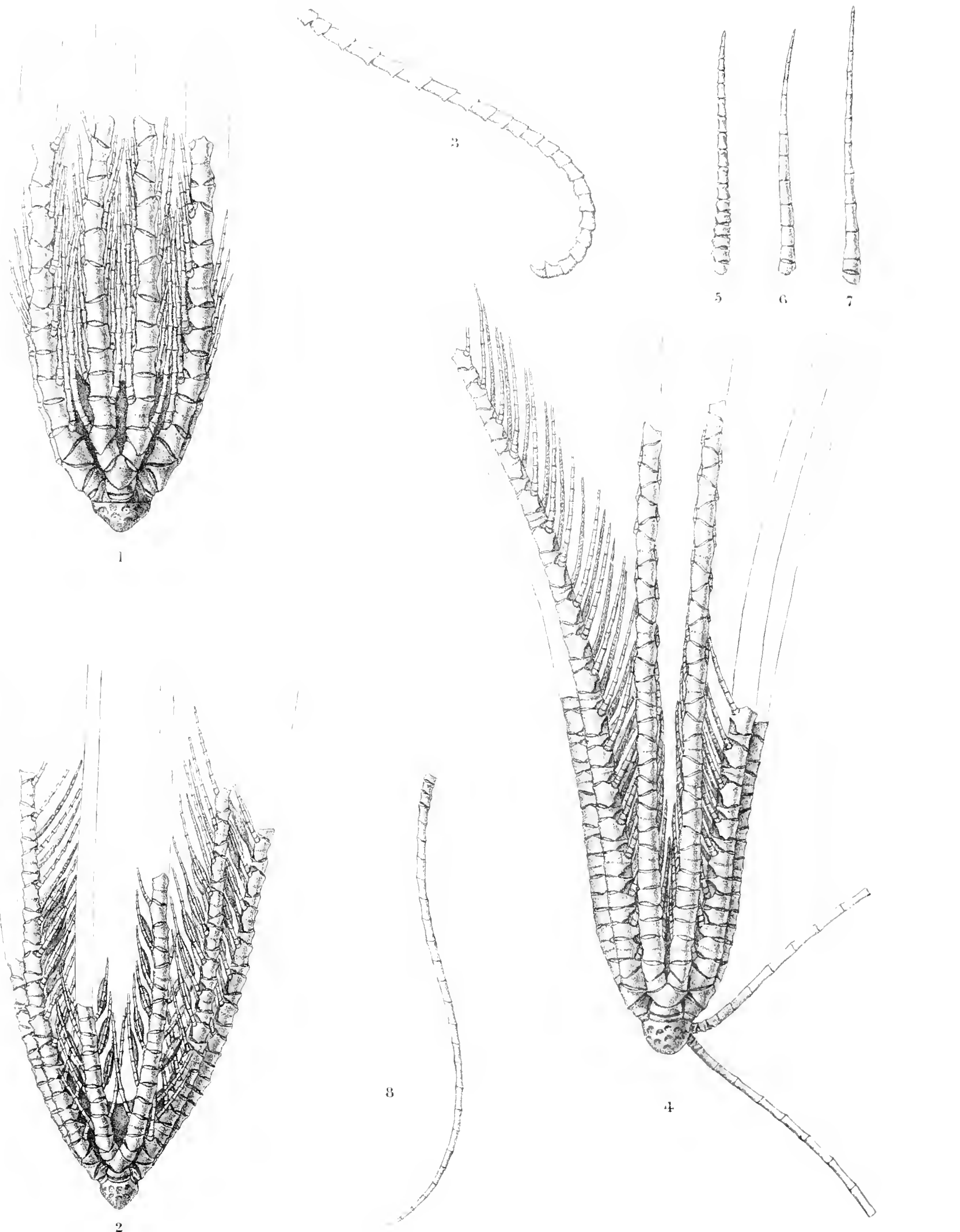
PLATE XXX.

Figs. 1–3. Antedon longipinna, n. sp.

	Diam.	Page
Fig. 1. Side view of a young individual,	× 8	186
Fig. 2. An older specimen,	× 4	185
Fig. 3. A cirrus,	× 8	185

Figs. 4–8. Antedon tenuicirra, n. sp.

	Diam.	Page
Fig. 4. Side view,	× 4	186
Fig. 5. The pinnule of the second brachial (incomplete),	× 8	187
Fig. 6. The pinnule of the fourth brachial (incomplete),	× 8	187
Fig. 7. A distal pinnule,	× 8	187
Fig. 8. A cirrus,	× 2	187



Bergeau & Highley del. et lith.

Mintern Bros. imp.

1–3 ANTEDON LONGIPINNA, sp. n. 4–8 ANTEDON TENUICIRRA, sp. n.

PLATE XXXI.

PLATE XXXI.

Figs. 1–4. ANTEDON TENELLA, Retz., sp.

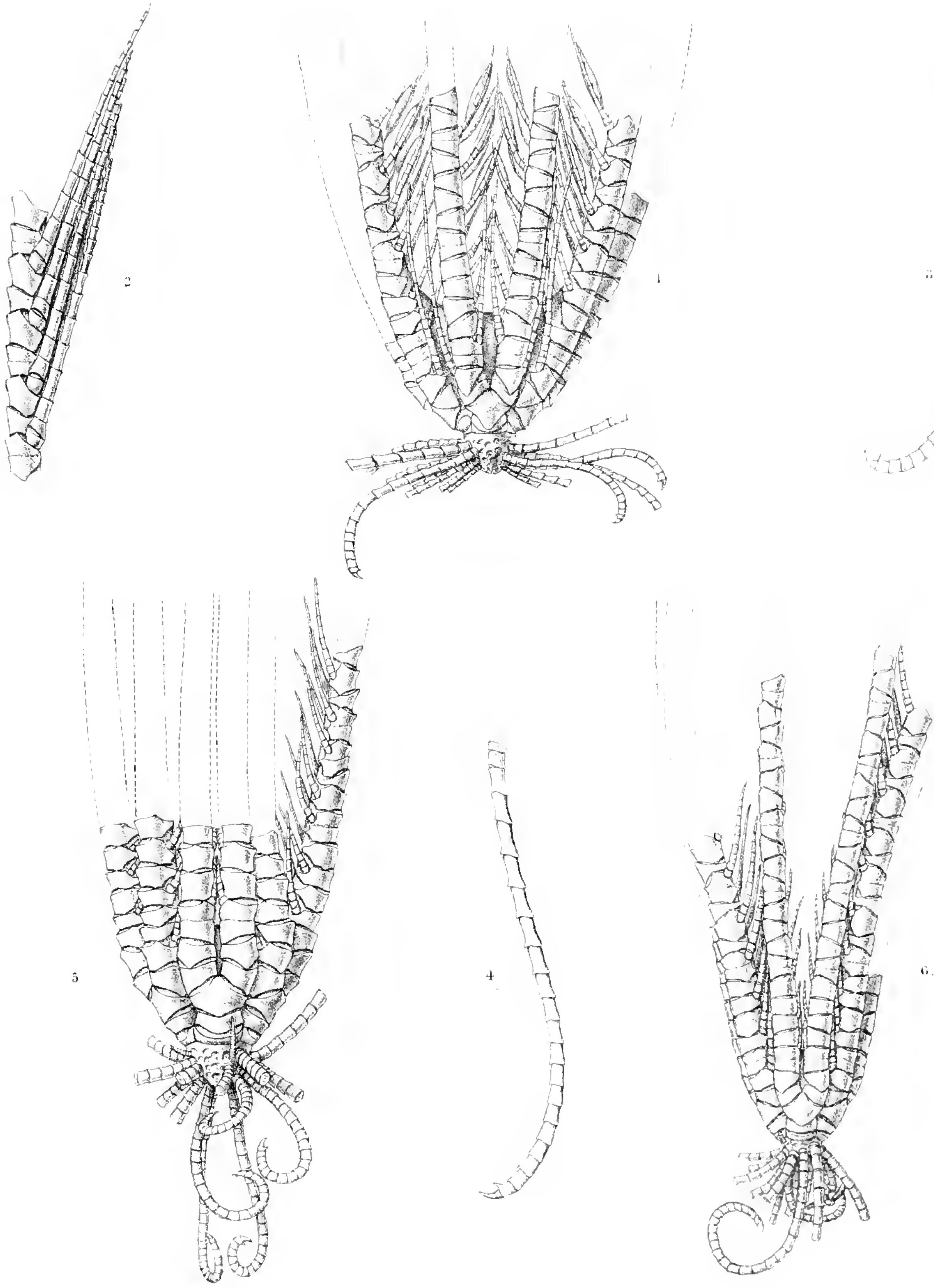
		Diam.	Page
Fig. 1. A "Porcupine" specimen,	×	4	170
Fig. 2. Portion of an arm of an individual from the West Atlantic ("Blake"),	×	6	170
Fig. 3. Cirrus of a "Porcupine" specimen,	×	6	170
Fig. 4. Cirrus of a "Blake" specimen,	×	6	170

Fig. 5. ANTEDON HIRSUTA, n. sp.

		Diam.	Page
Fig. 5. Side view,	×	4	188

Fig. 6. ANTEDON LÆVIS, n. sp.

		Diam.	Page
Fig. 6. Side view,	×	4	187



Berjeau & Highley del. et lith.

M[illegible]

1-4. ANTEDON TENELLA, Retzius sp. 5. [illegible]
6. ANTEDON [illegible], n. sp.

PLATE XXXII.

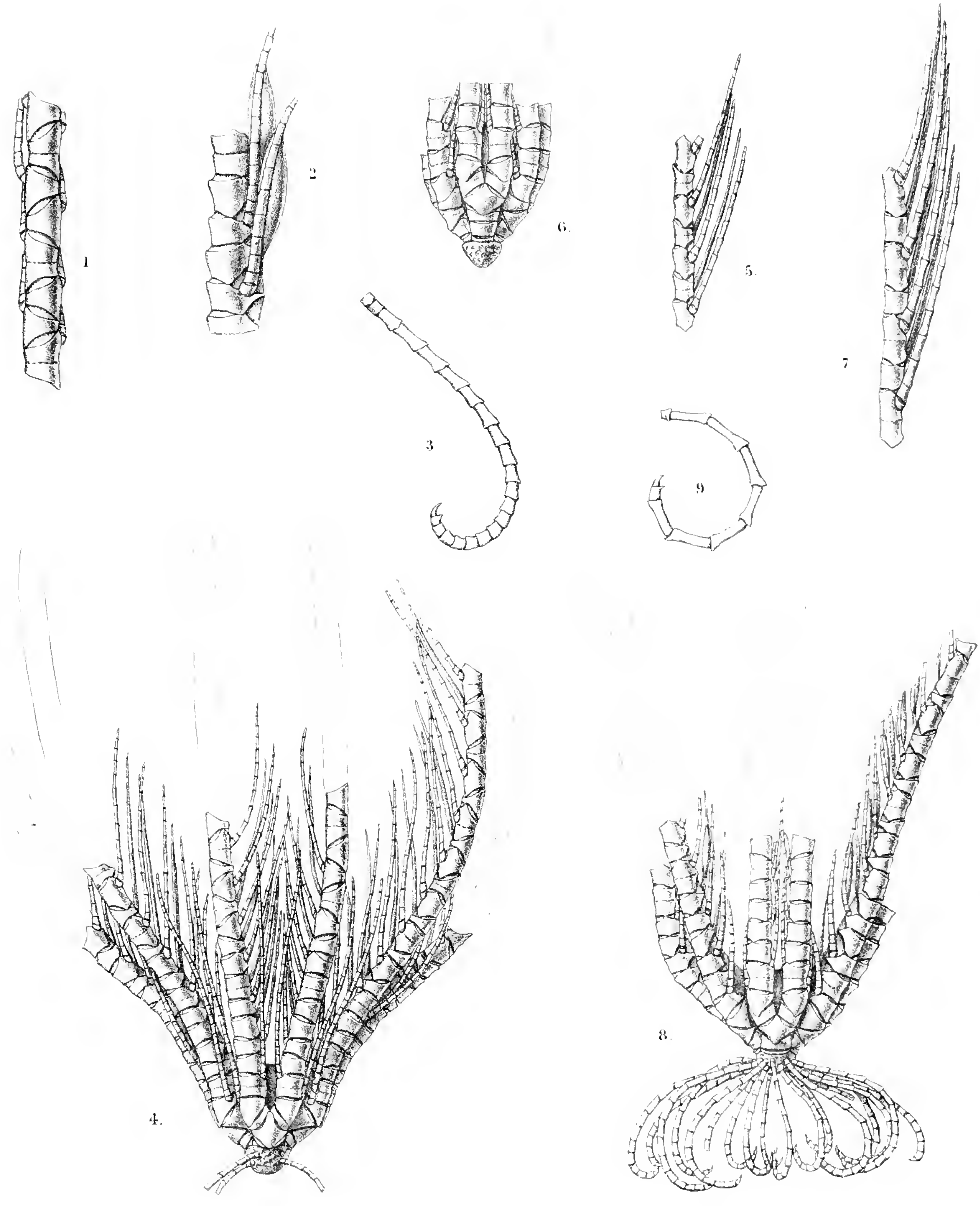
PLATE XXXII.

Figs. 1–4. ANTEDON EXIGUA, n. sp.

		Diam.	Page
Fig. 1.	Dorsal aspect of an arm,	× 6	178
Fig. 2.	Side view of an arm and pinnules,	× 6	179
Fig. 3.	A cirrus,	× 6	179
Fig. 4.	A mature individual,	× 4	178

Figs. 5–9. ANTEDON ALTERNATA, n. sp.

		Diam.	Page
Fig. 5.	Side view of a young arm and pinnules,	× 6	180
Fig. 6.	An abnormal individual with four radials in one ray,	× 4	180
Fig. 7.	Side view of an arm and pinnules,	× 6	180
Fig. 8.	A mature individual.	× 4	179
Fig. 9.	A cirrus,	× 8	180



Berjeau & Highley del et lith.

[illegible] imp.

–4 ANTEDON E[illegible]A, Sp. n. 5–9 ANTEDON ALTERNATA, Sp. n.

PLATE XXXIII.

PLATE XXXIII.

Figs. 1, 2. Antedon abyssicola, n. sp.

		Diam.	Page
Fig. 1. Individual from Station 244,	×	6	191
The tenth and fourteenth brachials are wrongly drawn as syzygial joints.			
Fig. 2. Individual from Station 160,	×	8	191
The sixth brachials are wrongly drawn as syzygial joints.			

Fig. 3. Antedon informis, n. sp.

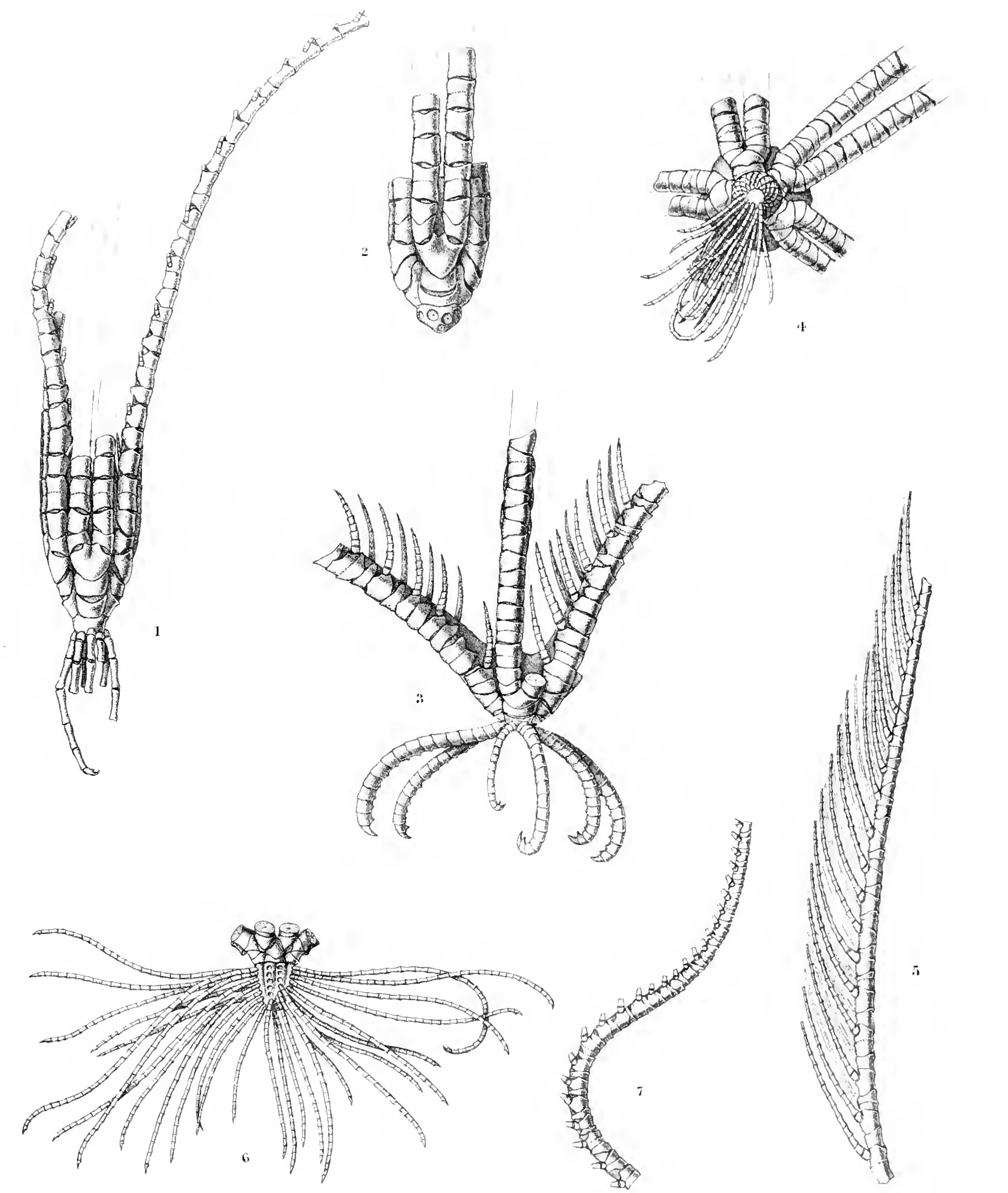
Fig. 3. Side view,	×	6	205

Figs. 4, 5. Antedon tenuicirra, n. sp.

Fig. 4. Dorsal aspect of a broken specimen,	×	4	186
Fig. 5. Side view of an arm,	×	4	186

Figs. 6, 7. Antedon balanoides, n. sp.

Fig. 6. The calyx, from the side,	×	2	207
Fig. 7. Portion of an arm,	×	2	207



Berjean & Highley del et lith.

Mintern Bros imp.

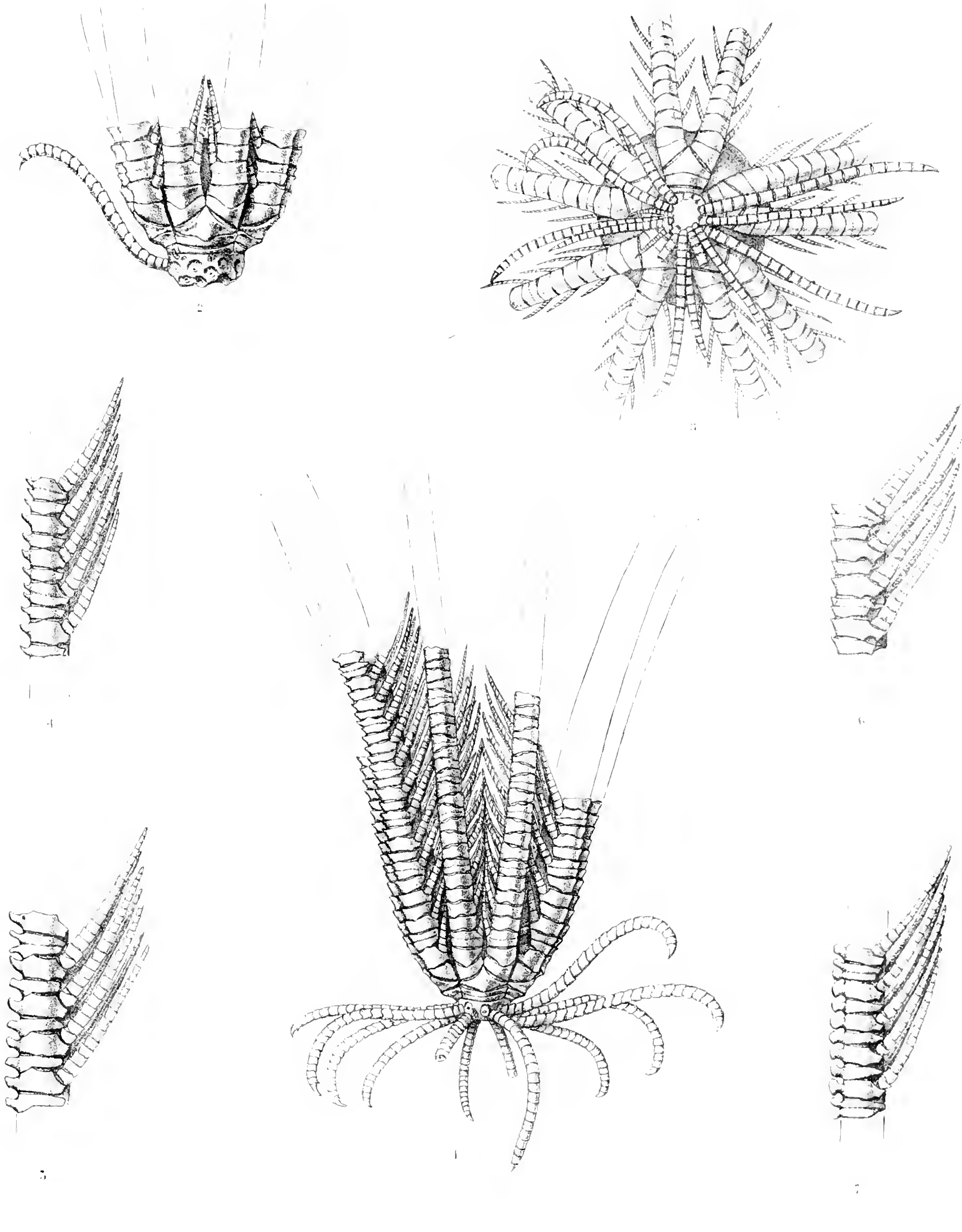
1, 2. ANTEDON ABYSSICOLA, Sp. n. 3. ANTEDON INFORMIS, Sp. n.
4, 5. ANTEDON NOTATA, Sp. n. 6, 7. ANTEDON BALANOIDES, Sp. n.

PLATE XXXIV.

PLATE XXXIV.

ANTEDON CARINATA, Lam., sp.

		Diam.	Page
Fig. 1.	Side view, ...	× 2	199
Fig. 2.	Calyx and arm-bases of an immature individual, . .	× 3	203
Fig. 3.	Dorsal aspect of the youngest individual obtained, . .	× 4	204
Figs. 4–7.	Portions of arms of different individuals, to show the varying degree of carination of the joints, . . .	× 4	203



Berjeau & Highley del. et lith.

ANTEDON ... PINNATA, Lam. sp.

PLATE XXXV.

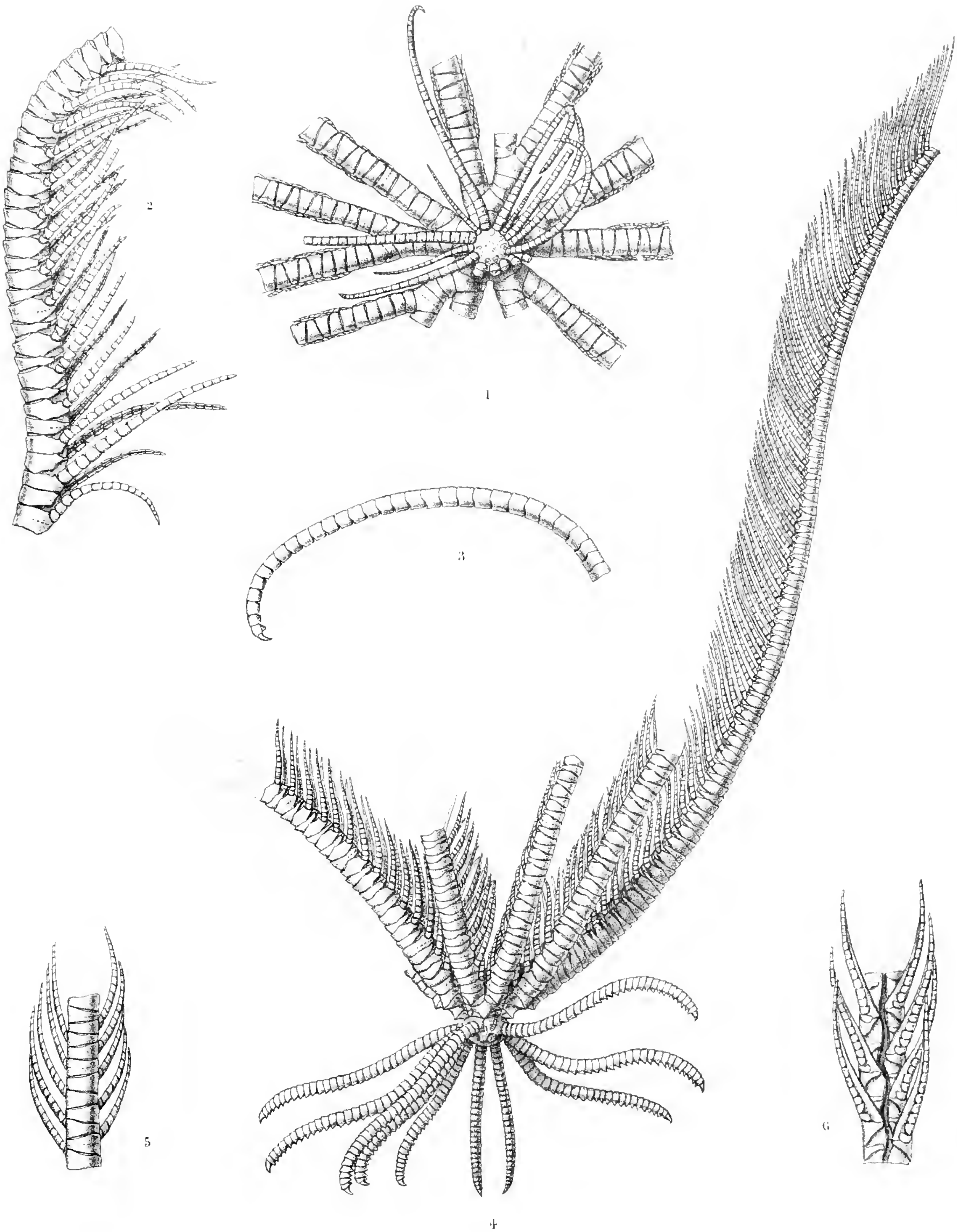
PLATE XXXV.

Figs. 1–3. ANTEDON ANCEPS, n. sp.

	Diam.	Page
Fig. 1. Dorsal aspect, ...	× 3	254
Fig. 2. Portion of an arm from the third brachial, . . .	× 4	255
Fig. 3. A cirrus, ...	× 5	254

Figs. 4–6. ANTEDON MILBERTI, Müll., sp.

	Diam.	Page
Fig. 4. Side view, ...	× 2	194
Figs. 5, 6. Dorsal and ventral views of an arm, . . .	× 4	194



Berjeau & Highley, del. et lith.   Mintern Bros. imp.

1–3. ANTEDON ANCEPS, sp. n.   4–6. ANTEDON MILBERTI, Müll., sp.

PLATE XXXVI.

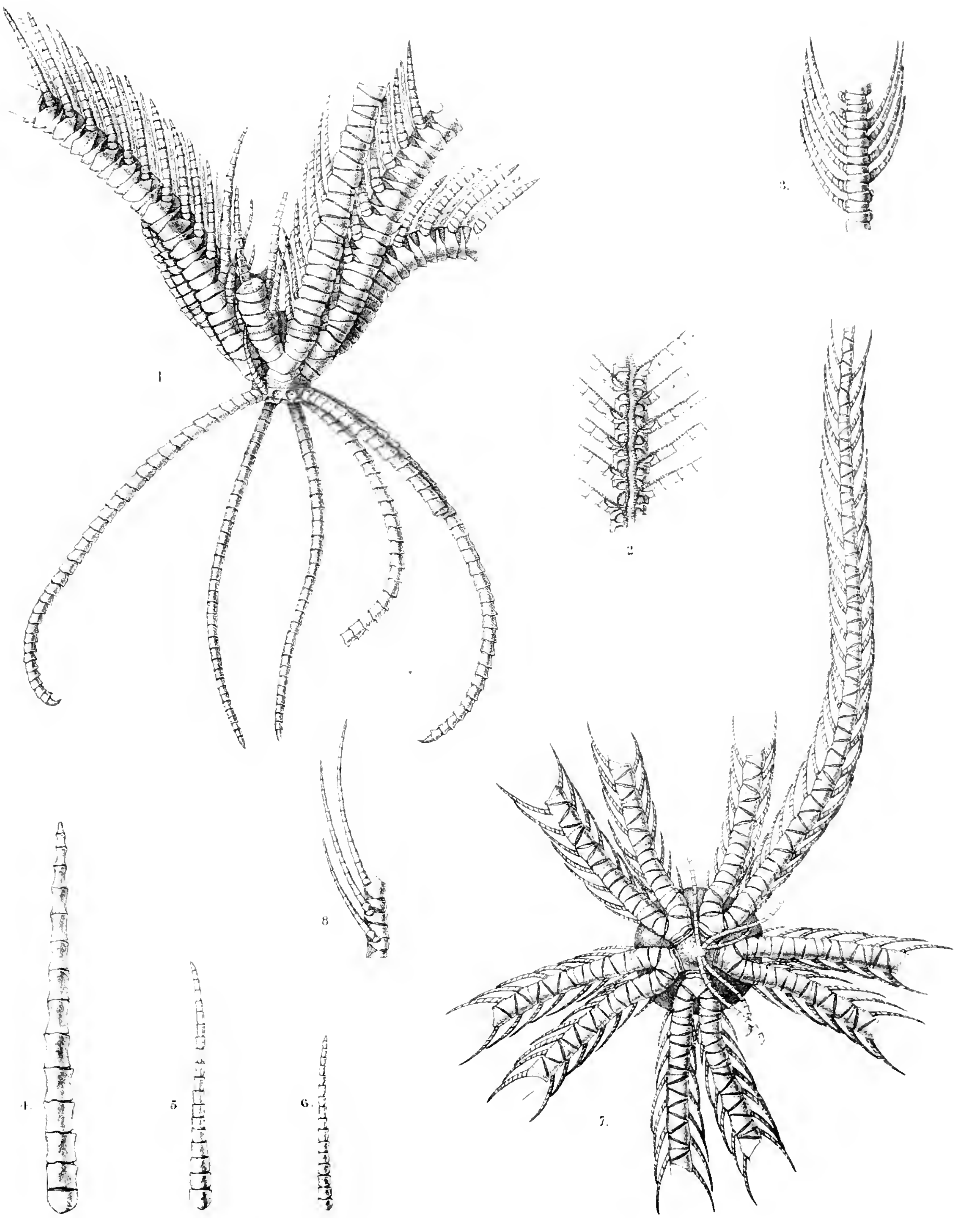
PLATE XXXVI.

Figs. 1–6. ANTEDON VARIIPINNA, Carpenter.

		Diam.	Page
Fig. 1.	Side view,	× 3	259
Figs. 2, 3.	Ventral and dorsal views of an arm,	× 3	256
Fig. 4.	Dorsal aspect of the pinnule on the sixth brachial,	× 6	260
Fig. 5.	Dorsal aspect of the pinnule on the fourth brachial,	× 6	260
Fig. 6.	Dorsal aspect of the pinnule on the second brachial,	× 6	260

Figs. 7, 8. ANTEDON PARVICIRRA, n. sp.

Fig. 7.	Dorsal aspect,	× 4	204
Fig. 8.	Lower portion of an arm in side view,	× 4	205



Berjeau & . . gnie, del et Lith.

–8 ANTEDON DUBIA Sp.n. . . . ANTED.O . . . . Sp.n.

PLATE XXXVII.

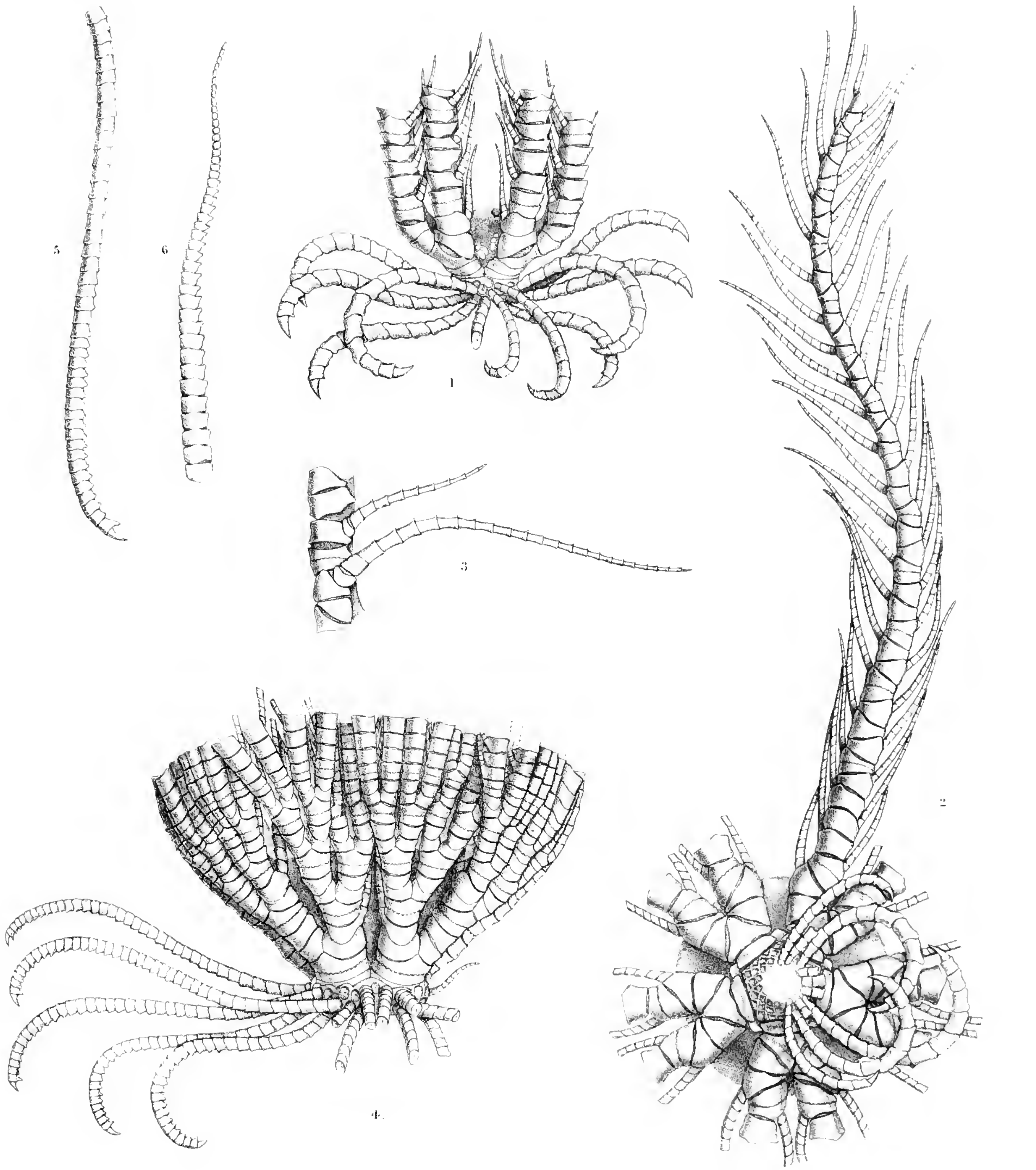
PLATE XXXVII.

Figs. 1–3. ANTEDON DÜBENI, Böhlsche.

	Diam.	Page
Fig. 1. Side view of the Challenger specimen,	× 6	181
Fig. 2. Dorsal aspect of the type specimen,	× 6	181
Fig. 3. The pinnules on its second and fourth brachials,	× 6	182

Figs. 4–6. ANTEDON MICRODISCUS, Bell.

Fig. 4. Side view,	× 3	97
Fig. 5. A cirrus,	× 4	97
Fig. 6. A palmar pinnule,	× 4	99



Berjeau & Highley del et lith.

Mintern Bros. imp.

1–3, ANTEDON DUBENI, Bohlsche. 4–6 ANTEDON [illegible]US, Bell

PLATE XXXVIII.

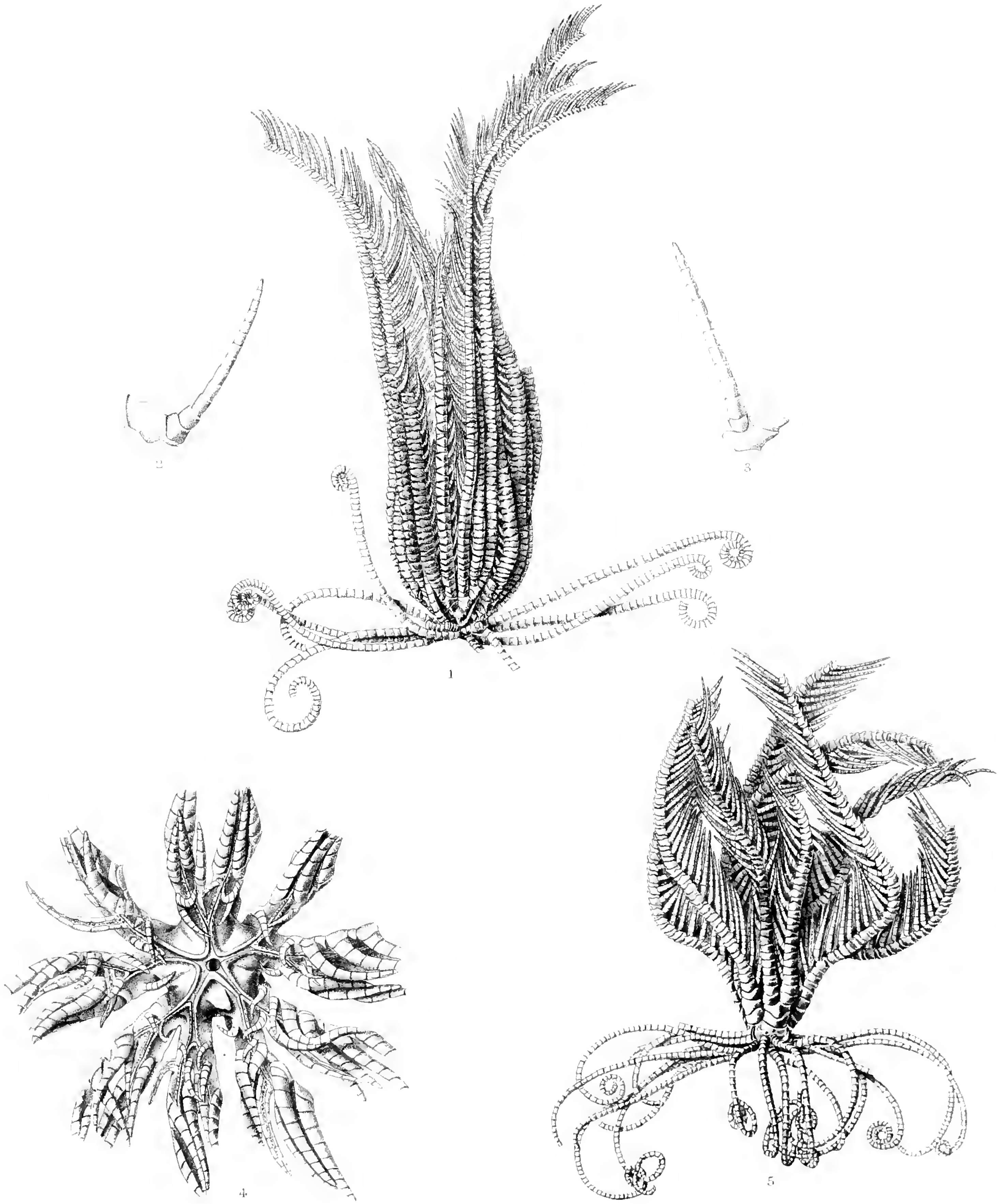
PLATE XXXVIII.

Figs. 1–3. ANTEDON QUINQUECOSTATA, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	$1\frac{1}{2}$	215
Fig. 2. A lower pinnule,	×	7	216
Fig. 3. A distal pinnule,	×	7	216

Figs. 4, 5. ANTEDON MACRONEMA, Müll., sp.

Fig. 4. Ventral aspect of the disk and arm-bases,	×	3	214
Fig. 5. Side view,	×	2	212



Parker & Coward, del. et lith.

1–3. ANTEDON QUINQUECOSTATA, sp. n. 4, 5. ANTEDON MACRONEMA, Müll.

PLATE XXXIX.

PLATE XXXIX.

Figs. 1–3. ANTEDON LUSITANICA, n. sp.

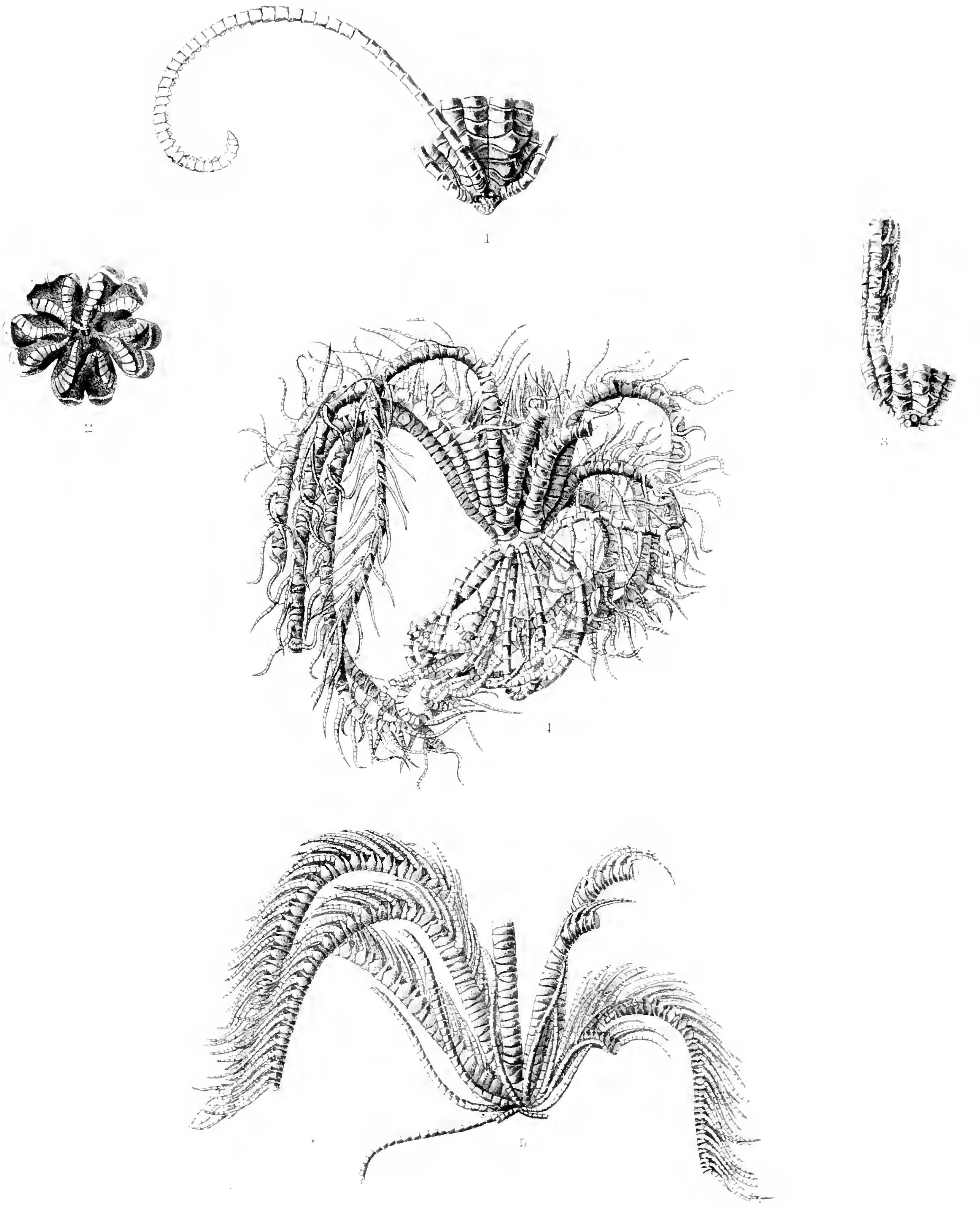
		Diam.	Page
Fig. 1. A bidistichate individual,	×	3	109
Fig. 2. Ventral aspect of the calyx and arm-bases,	×	3	109
Fig. 3. A ten-armed individual,	×	3	109

Fig. 4. ANTEDON DISCIFORMIS, n. sp.

Fig. 4. Side view,	×	$2\frac{1}{2}$	228

Fig. 5. ANTEDON CLEMENS, n. sp.

Fig. 5. Side view,	×	2	229



Parker & Coward, del. et lith.

1–3. ANTEDON LUSITANICA, sp. n.

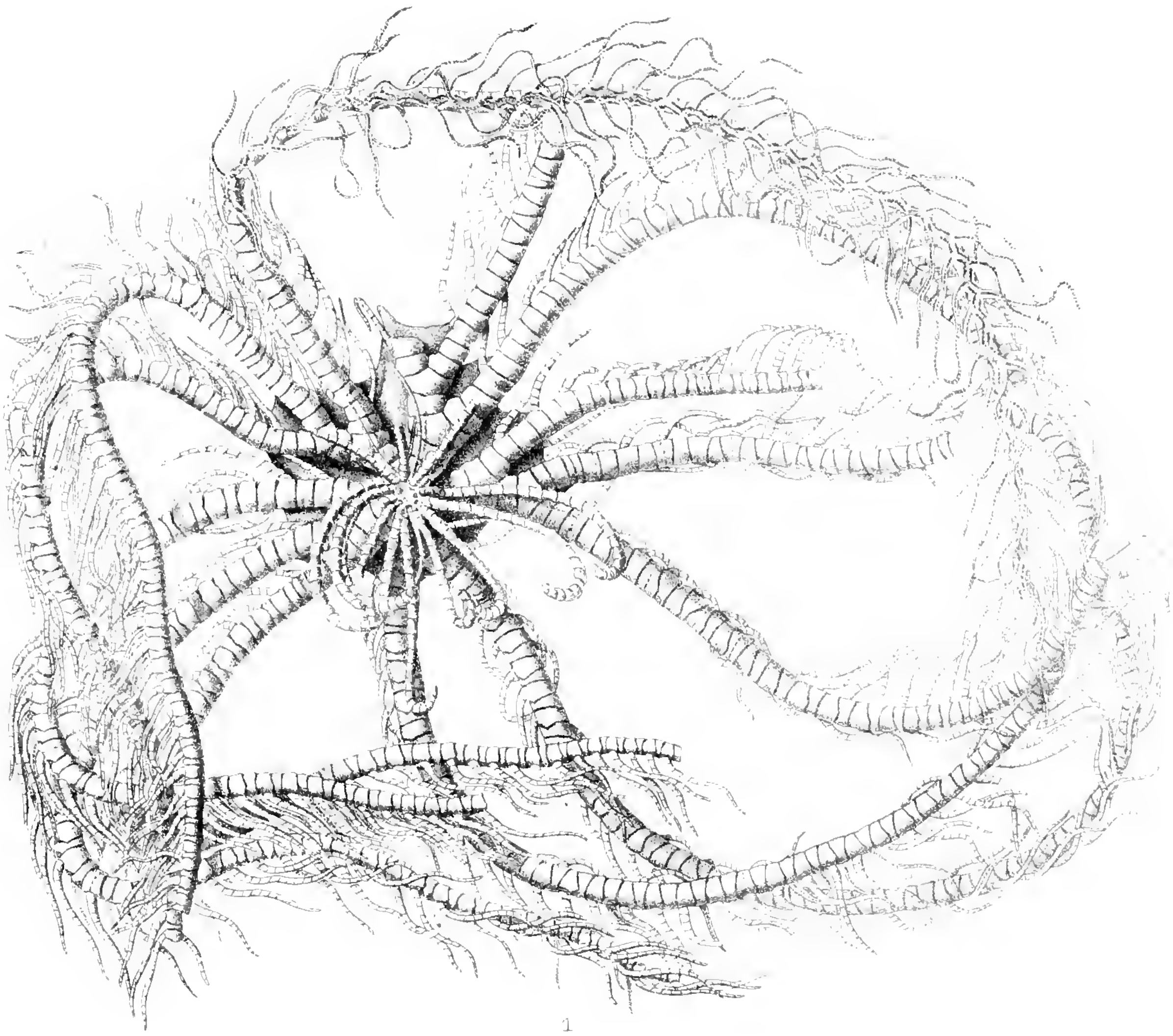
4. ANTEDON DISCIFORMIS, sp. n. 5. ANTEDON CLEMENS, sp. n.

PLATE XL.

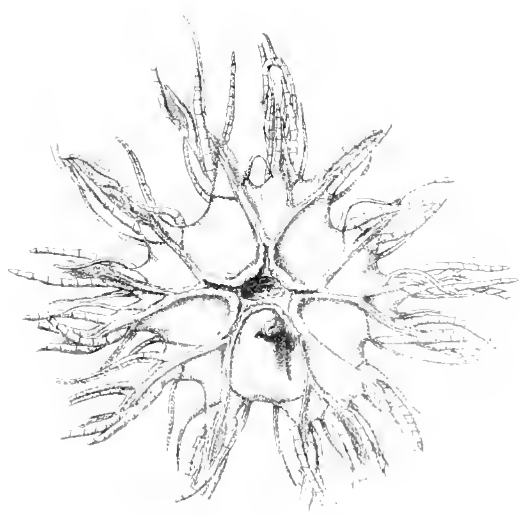
PLATE XL.

ANTEDON MARGINATA, n. sp.

		Diam.	Page
Fig. 1. Dorsal aspect,	. . . . ×	2	230
Fig. 2. The disk, from above,	. . . . . . ×	2	231



1



2

Parker & Coward del. et lith.

ANTEDON MARGINATA, sp.

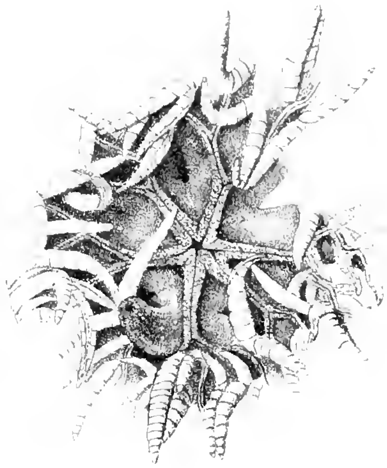
PLATE XLI.

PLATE XLI.

ANTEDON COMPRESSA, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	3	222
Fig. 2. The disk, from above,	×	3	222
Fig. 3. A distal pinnule,	×	4	222
Fig. 4. The pinnule on the fourth brachial,	×	4	222

3



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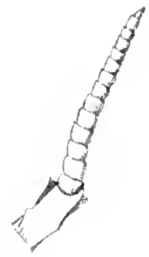

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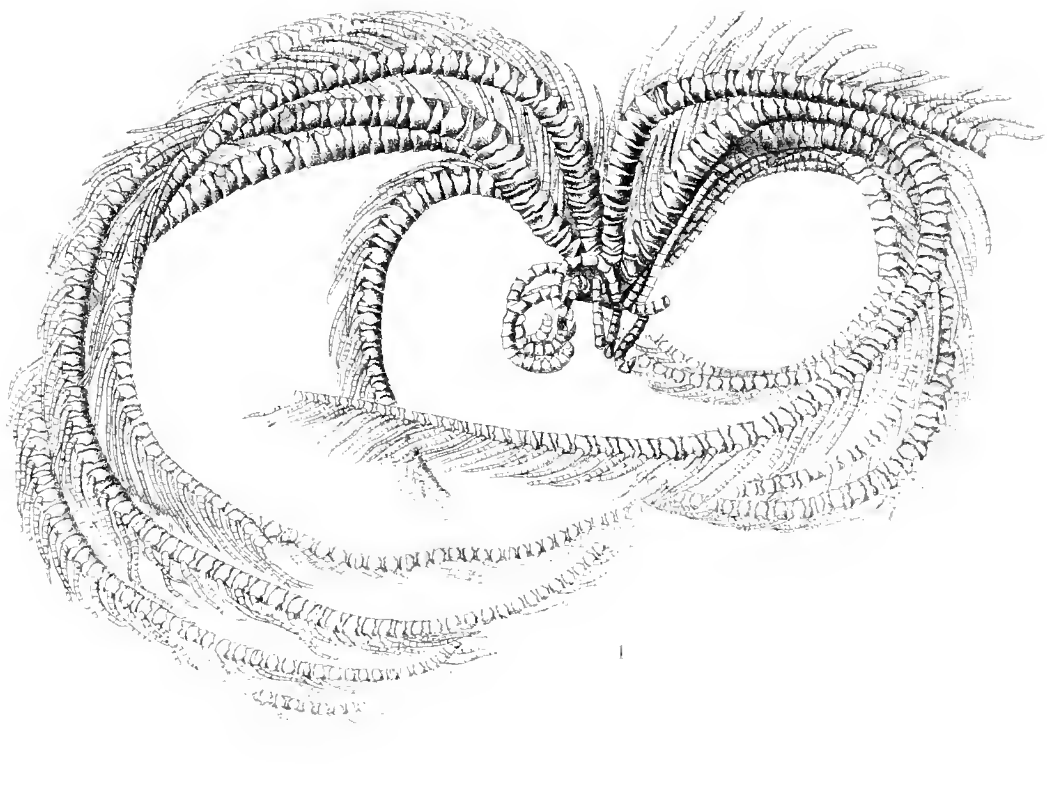


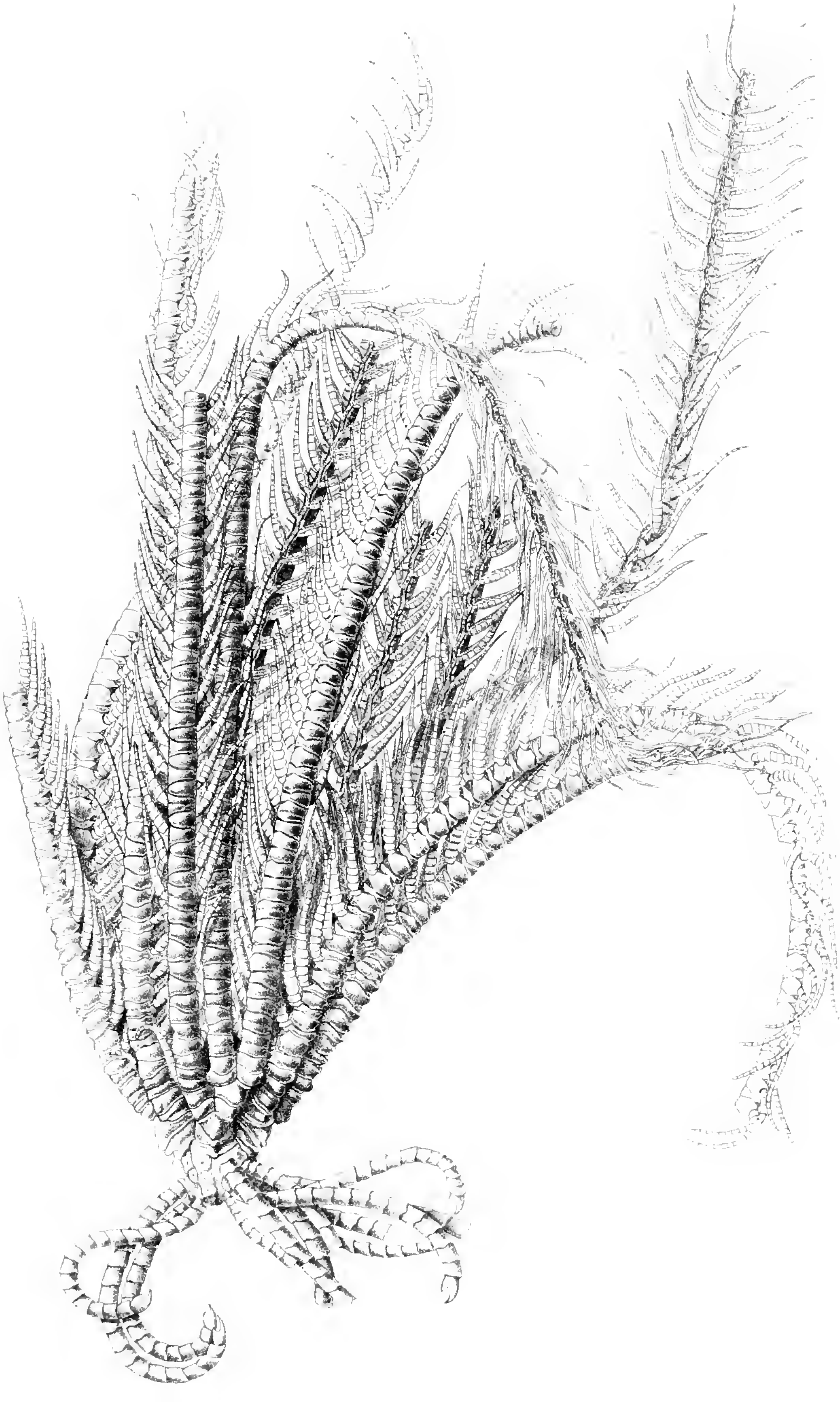
1

ANTEDON COMPRESSA,

PLATE XLII.

PLATE XLII.

		Diam.	Page
Antedon flexilis, n. sp.,	×	$1\frac{1}{2}$	217

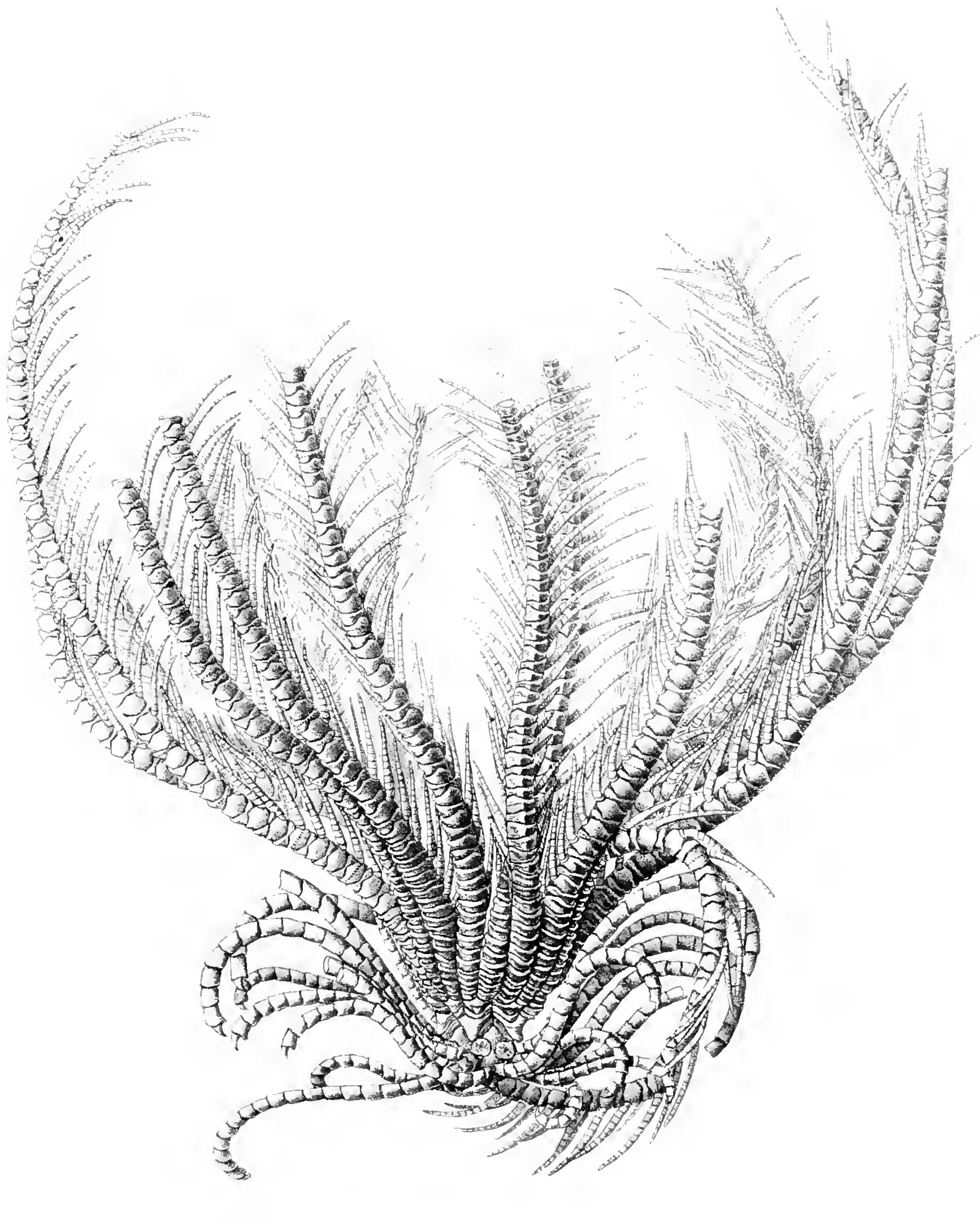


ANTEDON FLEXILIS, sp. n

PLATE XLIII.

PLATE XLIII.

		Diam.	Page
ANTEDON PATULA, n. sp.,	×	$1\frac{1}{2}$	219



Parker & Coward del. et lith.

West, Newman & Co imp.

ANTEDON PATULA, sp. n.

PLATE XLIV.

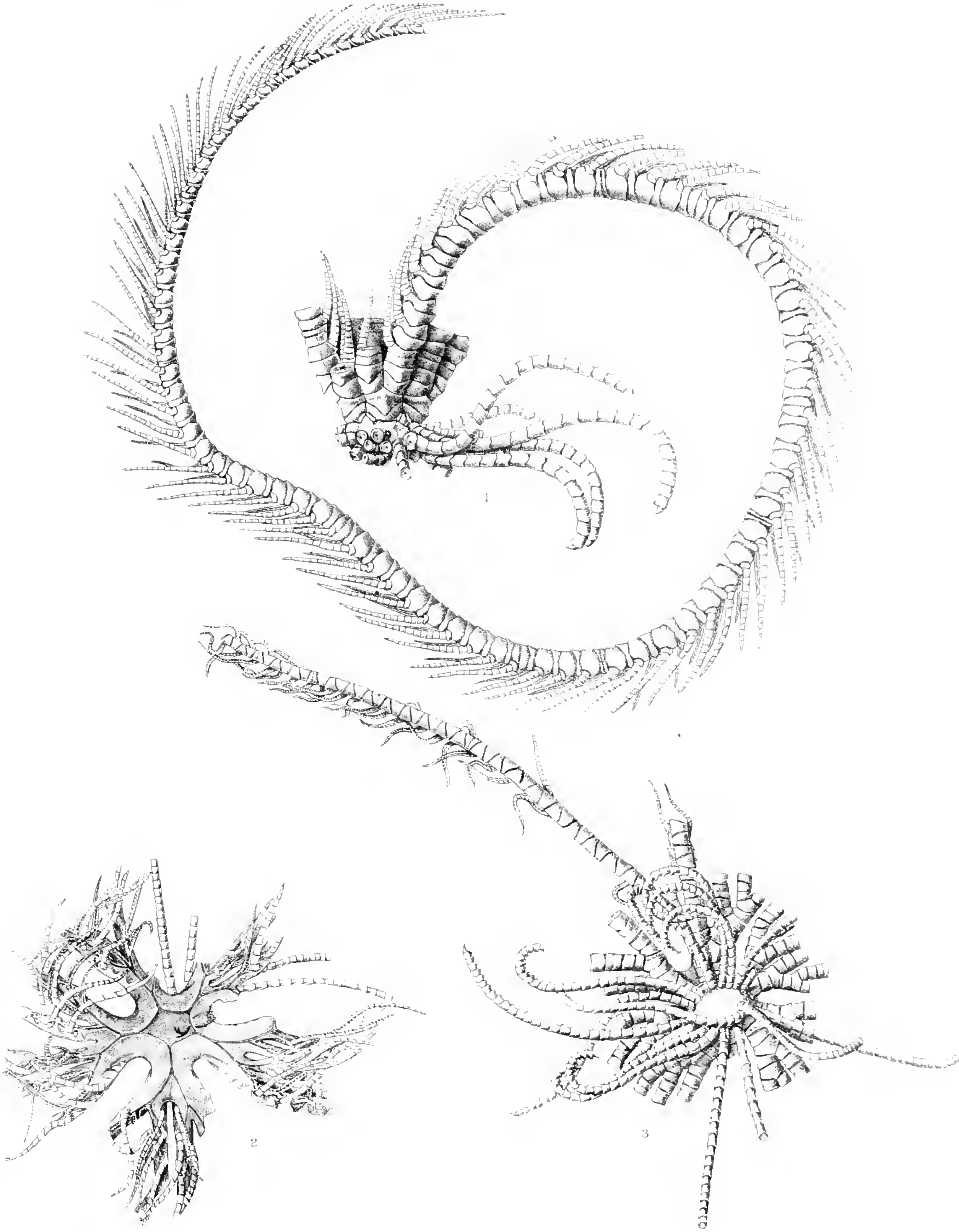
PLATE XLIV.

Fig. 1. ANTEDON ROBUSTA, n. sp.

		Diam.	Page
Fig. 1. Side view, ...	×	$1\frac{1}{2}$	220

Figs. 2, 3. ANTEDON MANCA, n. sp.

Fig. 2. Ventral aspect of the calyx and arm-bases, . . .	×	3	227
Fig. 3. Dorsal aspect of the same, ...	×	3	226



Parker & Coward del et lith

1. ANTEDON ROBUSTA sp. n. 2. 3. ANTEDON MANCA sp. n.

PLATE XLV.

PLATE XLV.

Fig. 1. Antedon conjungens, n. sp.

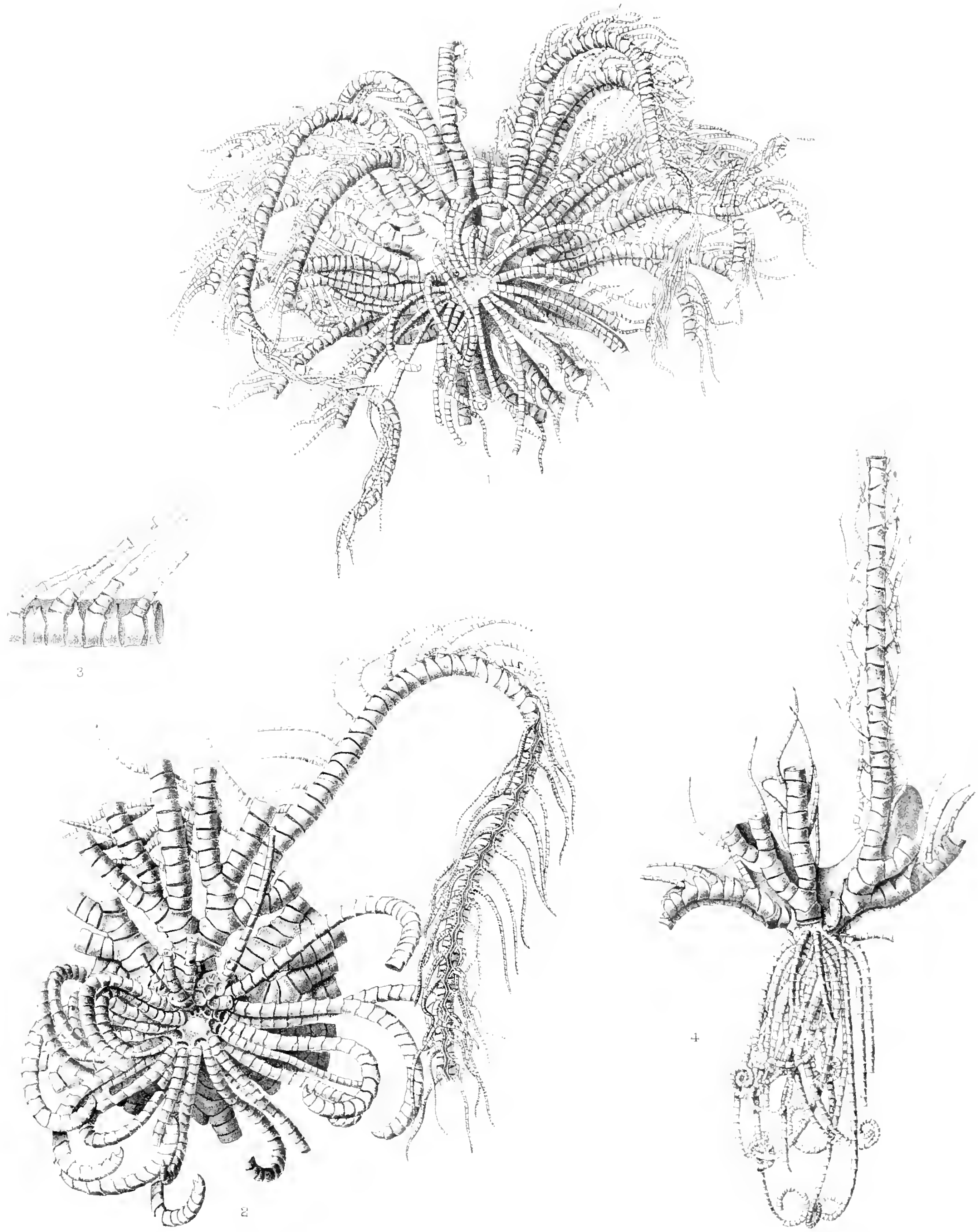
		Diam.	Page
Fig. 1. Dorsal aspect,	×	2	233

Figs. 2, 3. Antedon tuberculata, n. sp.

Fig. 2. Dorsal aspect,	×	$2\frac{1}{2}$	232
Fig. 3. The lower pinnules,	×	4	233

Fig. 4. Antedon angustiradia, n. sp.

Fig. 4. Side view,	×	3	253



Parker & Coward del et lith.

Mintern Newman & Co imp.

1. ANTEDON CONJUNGENS, sp. n.

2, 3. ANTEDON TUBERCULATA sp. n.

4. ANTEDON ANGUSTIRADIA, sp. n.

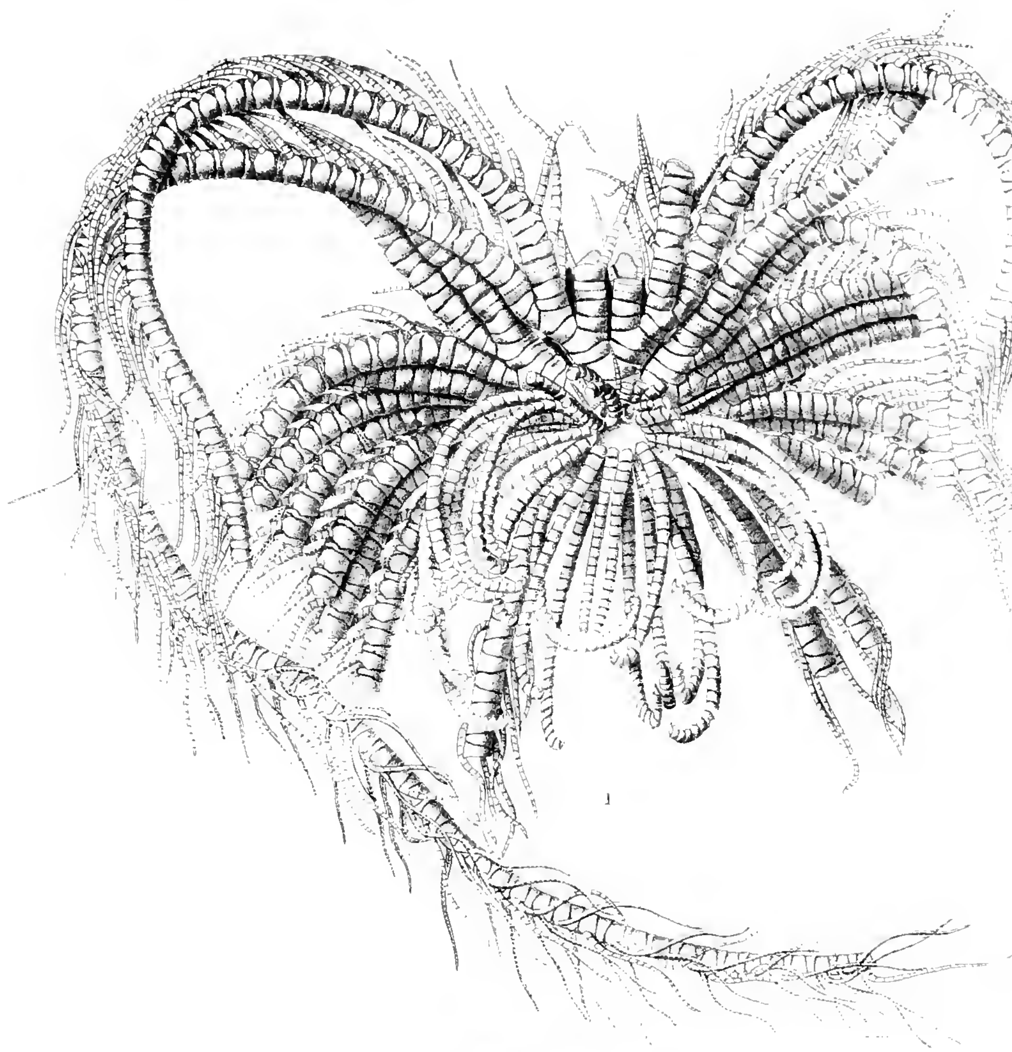
PLATE XLVI.

PLATE XLVI.

		Diam.	Page
ANTEDON REGALIS, n. sp., . .	×	$2\frac{1}{2}$	237

Fig. 1. Dorsal aspect.

Fig. 2. The disk, from above.



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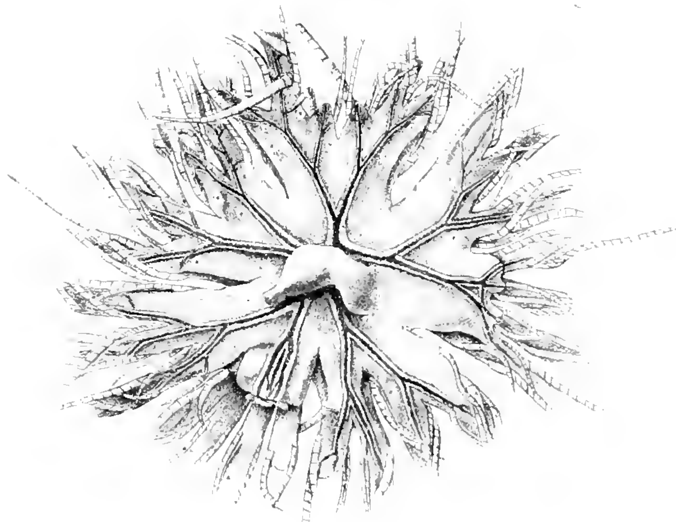


2

Parker & Coward, del. et lith.

ANTEDON REGALIS, sp. n.

PLATE XLVII.

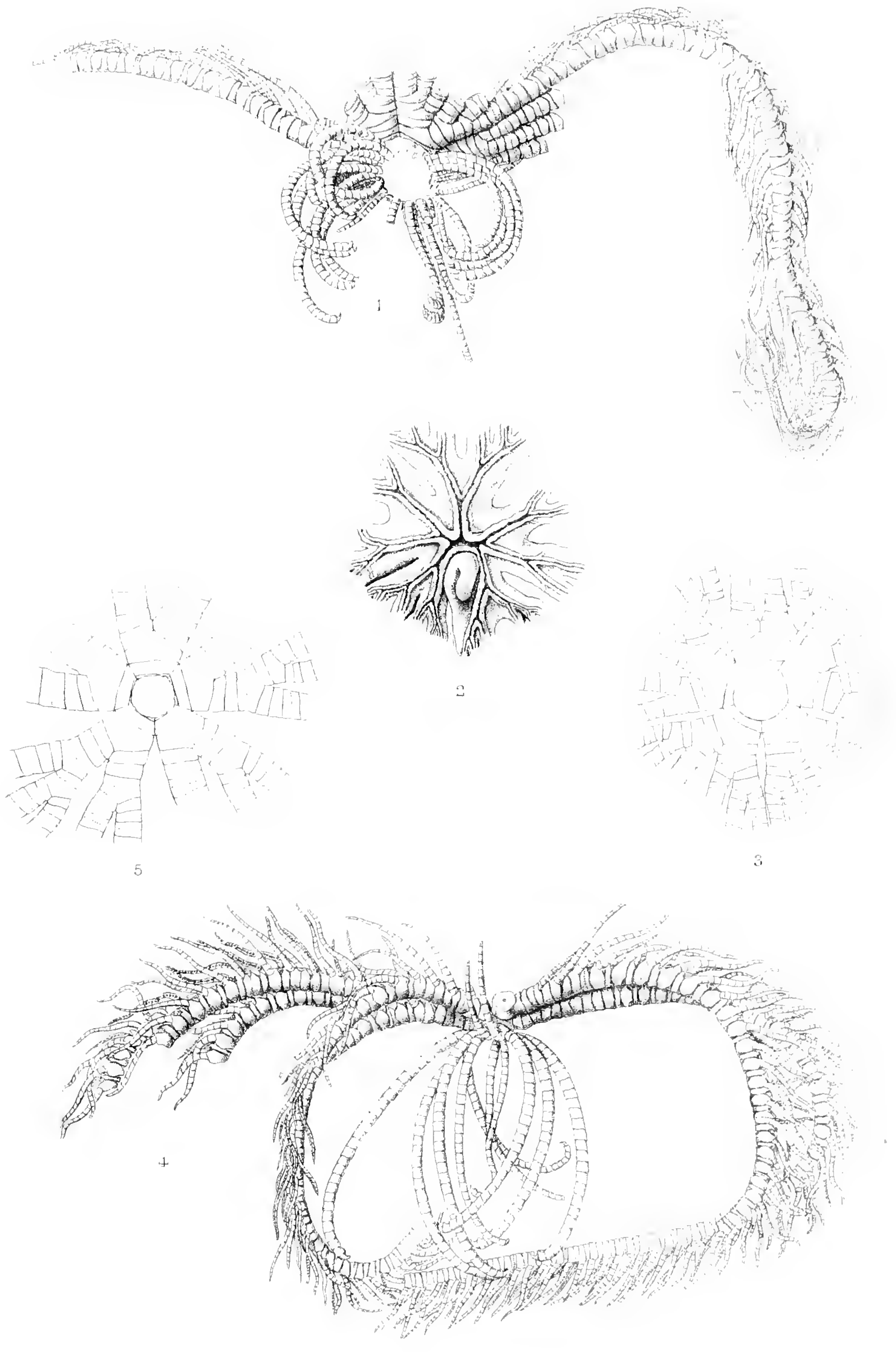
PLATE XLVII.

Figs. 1–3. Antedon similis, n. sp.

		Diam.	Page
Fig. 1. Dorsal aspect,	×	2	235
Fig. 2. The disk, from above,	×	$2\frac{1}{2}$	235
Fig. 3. Diagram of the ray-divisions,	×	$2\frac{1}{2}$	235

Figs. 4, 5. Antedon quinduplicava, n. sp.

		Diam.	Page
Fig. 4. Side view,	×	$2\frac{1}{2}$	262
Fig. 5. Diagram of the ray-divisions,	×	3	262



Parker & Coward del et lith.

W. Chevrnan & Co. imp.

1–3. ANTEDON SIMILIS, sp. n. 4, 5. ANTEDON QUINDUPLICAVA, sp. n.

PLATE XLVIII.

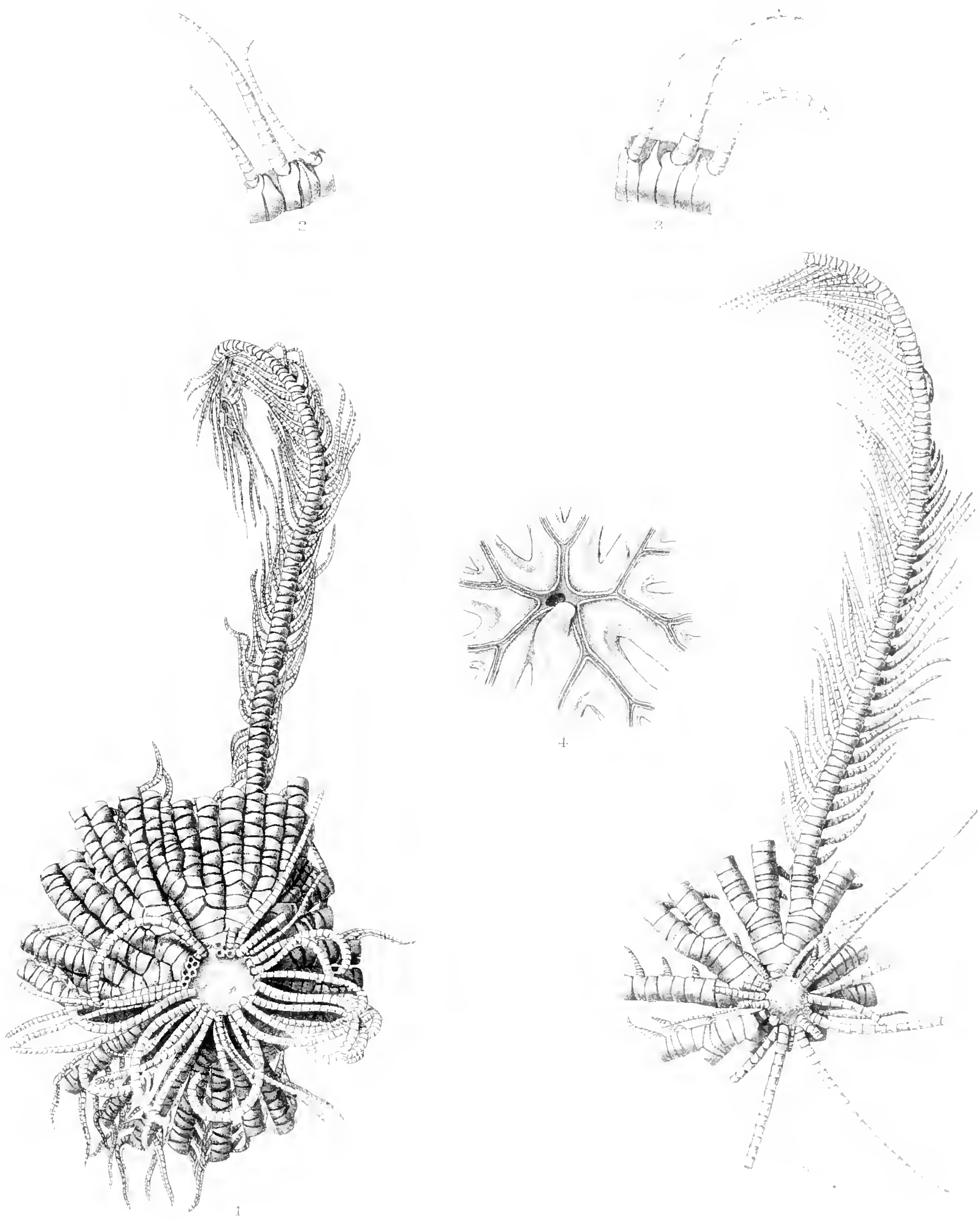
PLATE XLVIII.

Figs. 1, 2. Antedon occulta, n. sp.

	Diam.	Page
Fig. 1. Dorsal aspect, ...	× 2	236
Fig. 2. The base of an arm, with the pinnules of the second, fourth, and sixth brachials, ...	× 5	237

Figs. 3–5. Antedon variipinna, Carpenter.

	Diam.	Page
Fig. 3. The base of an arm, with the pinnules of the third, fifth, and seventh brachials, ...	× 5	260
Fig. 4. The disk, from above, ...	× 3	256
Fig. 5. Dorsal aspect, ...	× 3	256



Parker & Coward, del. et lith.

1, 2. ANTEDON OCCULTA, sp. n.   3—5 ANTEDON VARIIPINNA, Carpenter.

PLATE XLIX.

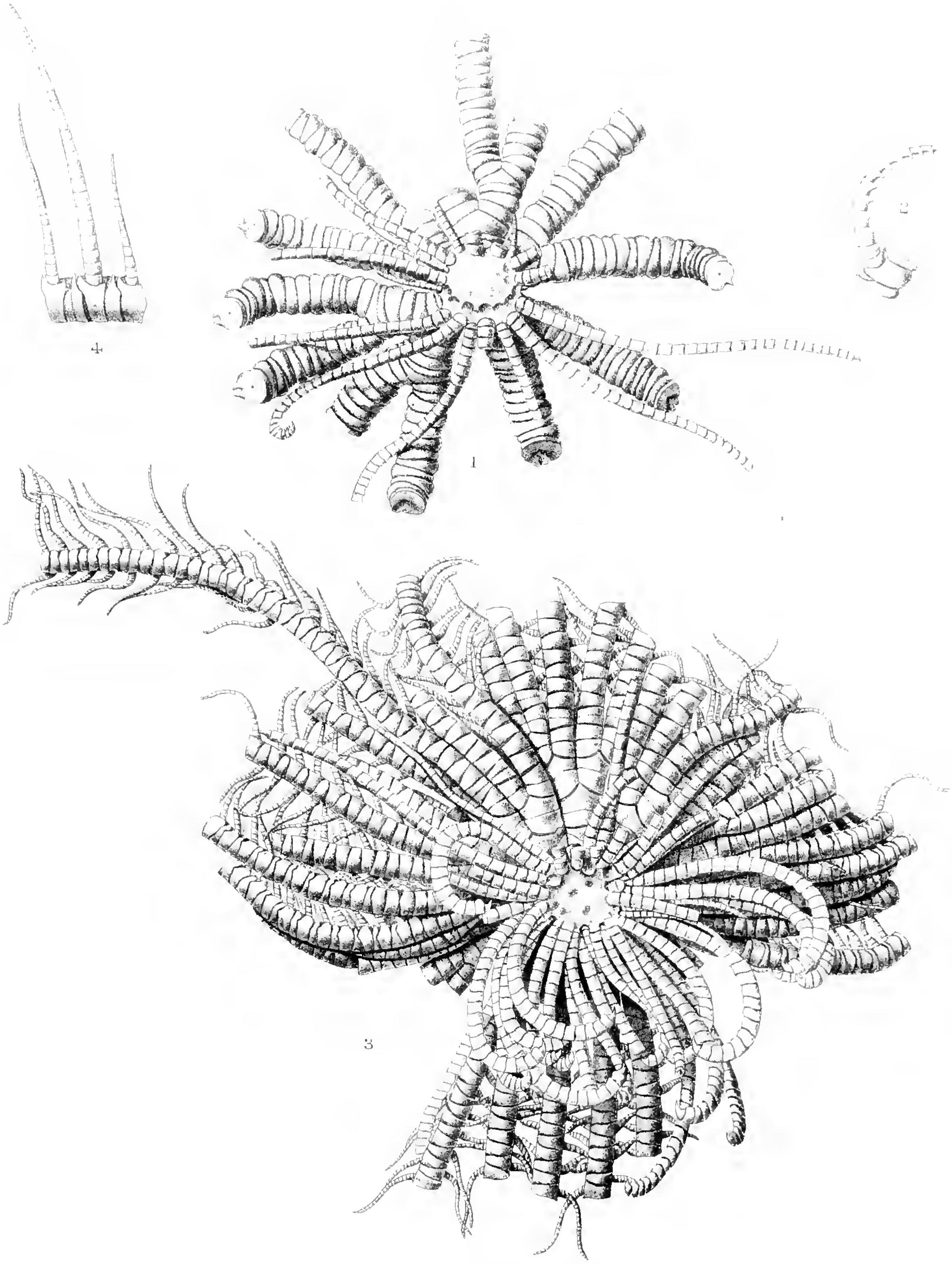
PLATE XLIX.

Figs. 1, 2. ANTEDON VARIIPINNA, Carpenter.

		Diam.	Page
Fig. 1. Dorsal aspect,	. . . .	× 3	256
Fig. 2. A lower pinnule,	. . . .	× 3	260

Figs. 3, 4. ANTEDON OCCULTA, n. sp.

		Diam.	Page
Fig. 3. Dorsal aspect,	. . . .	× 3	236
Fig. 4. The base of an arm, with the pinnules of the second, fourth, and sixth brachials,	. . . . . .	× 5	237



Parker & Coward, del et lith

West, Newman & Co imp

1, 2. ANTEDON VARIIPINNA, Carpenter. 3, 4. ANTEDON OCCULTA, sp. n.

PLATE L.

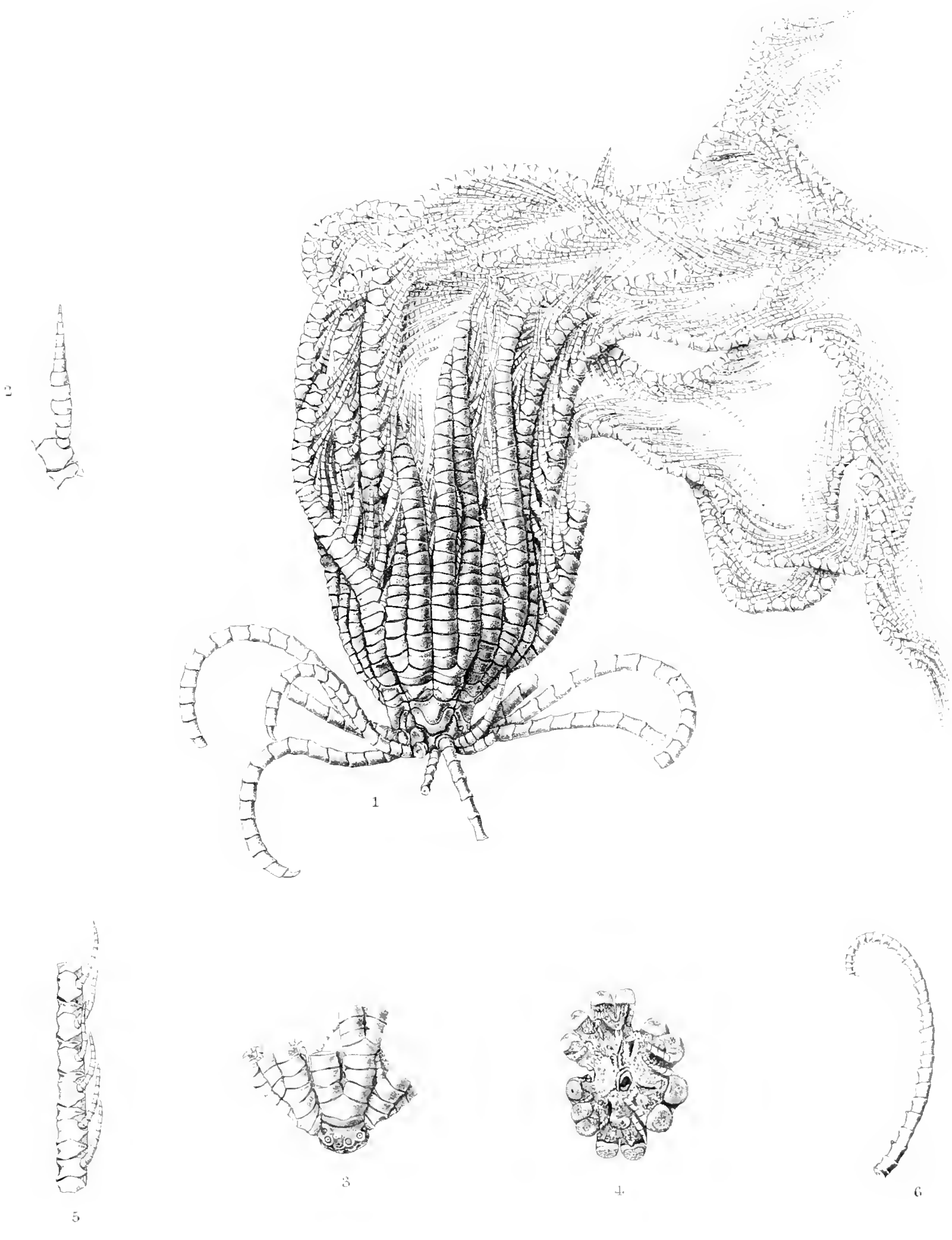
PLATE L.

Figs. 1, 2. Antedon angusticalyx, n. sp.

		Diam.	Page
Fig. 1. Side view,	×	$2\frac{1}{2}$	242
Fig. 2. A genital pinnule,	×	5	243

Figs. 3–6. Antedon multispina, n. sp.

Fig. 3. Calyx and arm-bases of a tridistichate individual,	×	3	249
Fig. 4. The disk, from above,	×	3	249
Fig. 5. Portion of an arm, in side view,	×	3	249
Fig. 6. A cirrus,	×	3	249



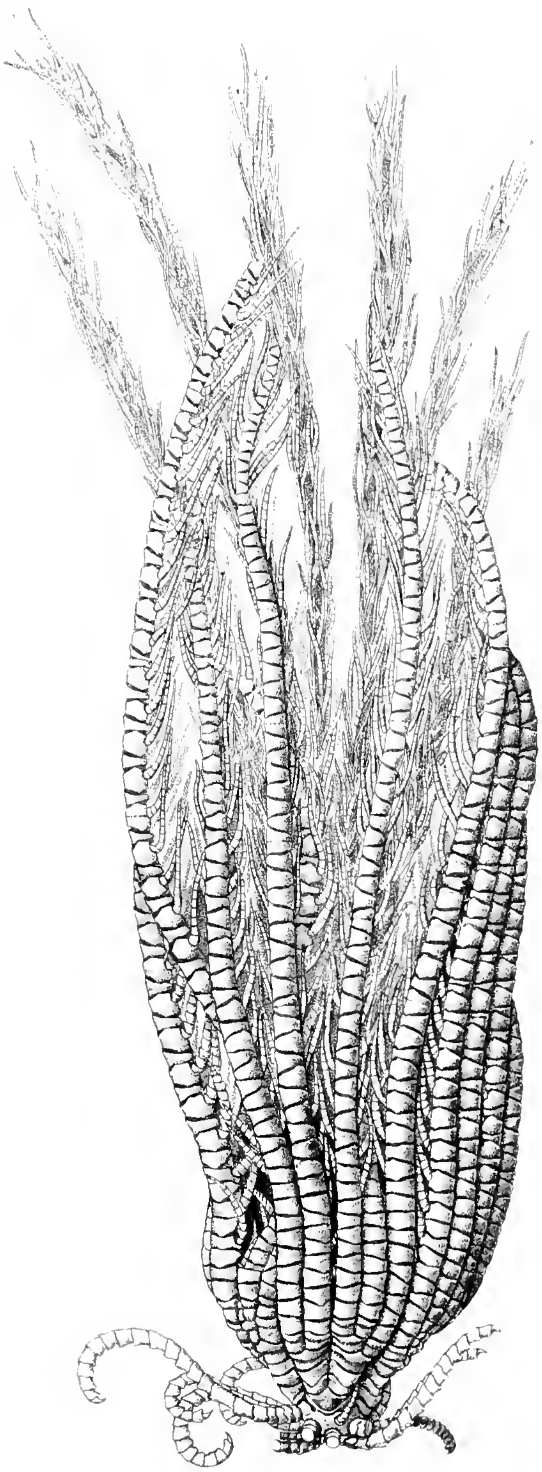
Parker & Seward, del. et lith. West, Newman & Co imp.

1, 2. ANTEDON ANGUSTICALYX, sp. n. 3-6. ANTEDON MULTISPINA, sp. n.

PLATE LI.

PLATE LI.

	Diam.	Page
Fig. 1. ANTEDON DISTINCTA, n. sp., ...	× 2	247
Fig. 2. ANTEDON INÆQUALIS, n. sp., ...	× 2	244



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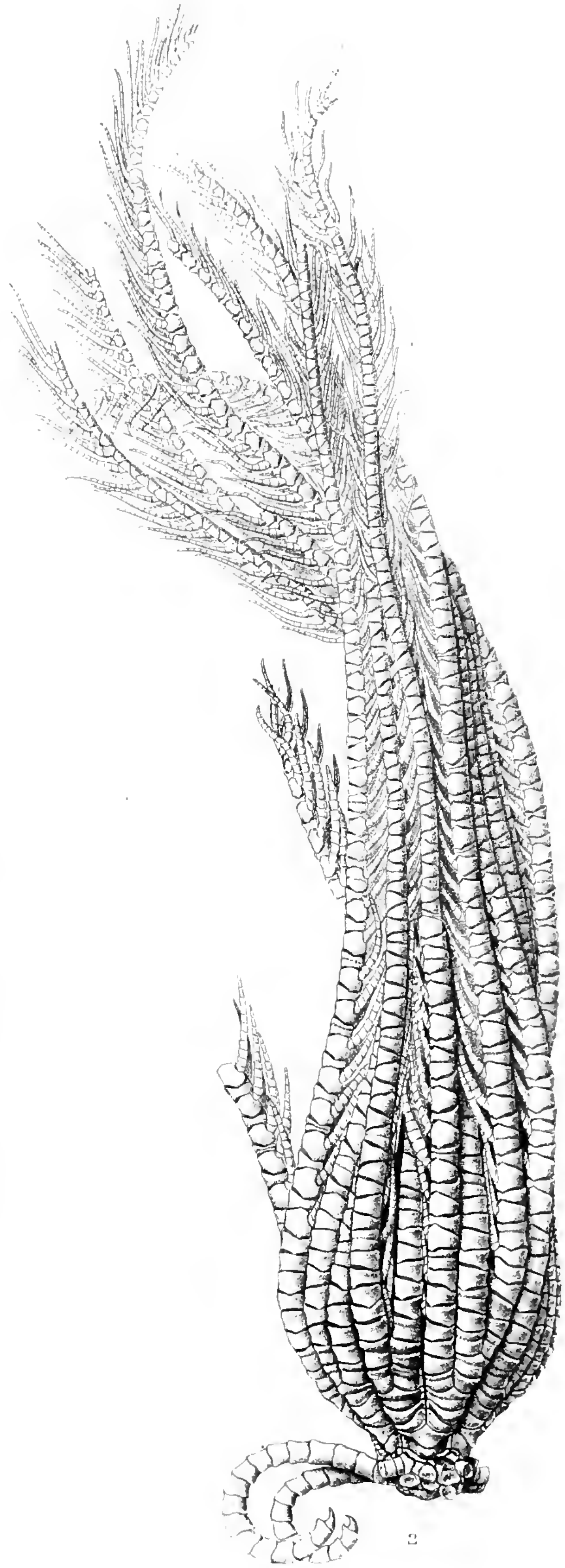


2

Parker & Coward, del. et lith.

West, Newman & Co.

1. ANTEDON DISTINCTA, sp. n. 2. ANTEDON INÆQUALIS, sp. n.

PLATE LII.

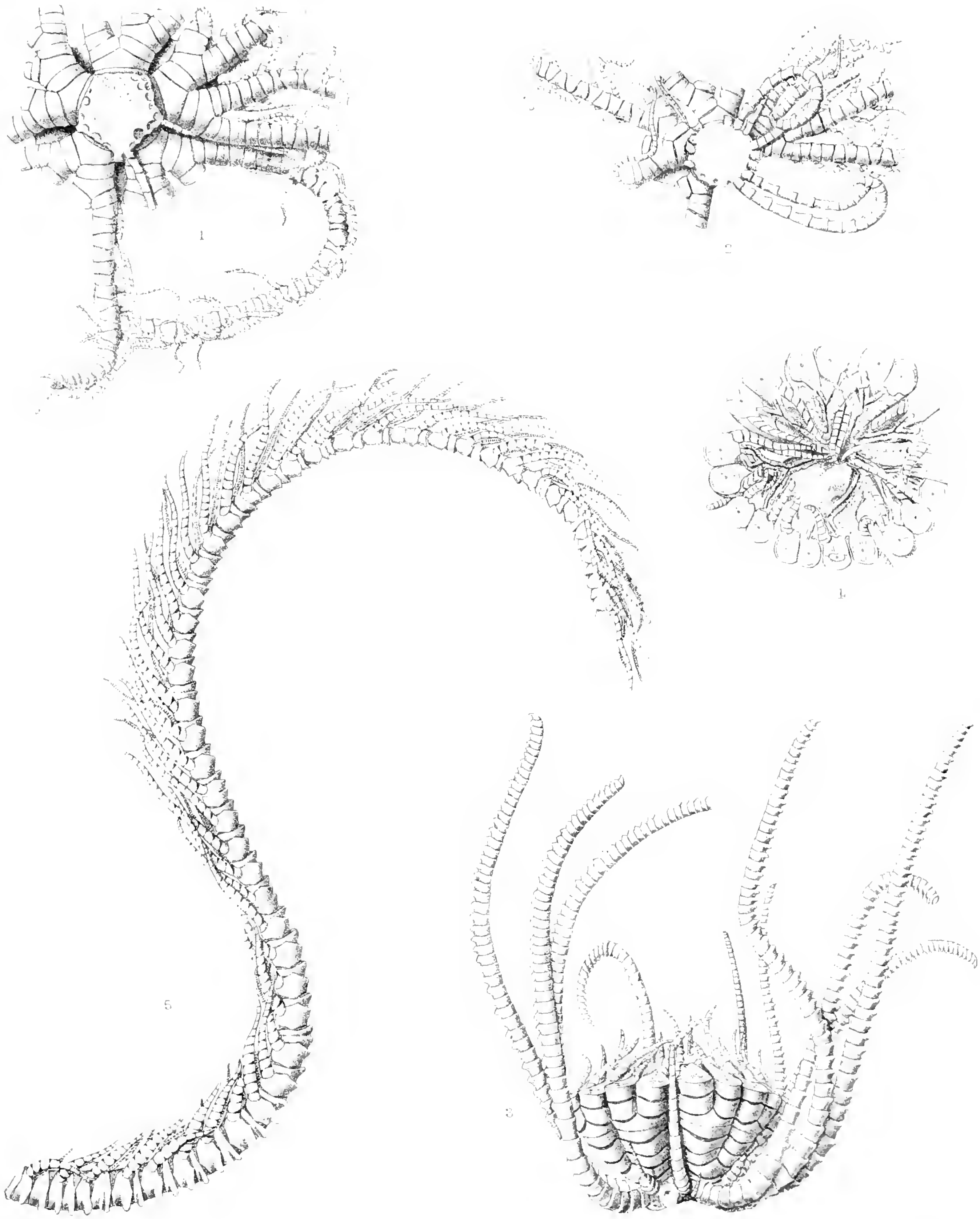
PLATE LII.

Figs. 1, 2. ACTINOMETRA PULCHELLA, Pourt., sp.

		Diam.	Page
Fig. 1. A " Porcupine " specimen, ...	×	3	301
Fig. 2. A doubtful specimen from the Arafura Sea, . . .	×	3	306

Figs. 3–5. ANTEDON PORRECTA, n. sp.

Fig. 3. The calyx and arm-bases, from the side, . . .	×	2	250
Fig. 4. The same, from above, ...	×	2	250
Fig. 5. Side view of an arm.	×	$2\frac{1}{2}$	250



Parker & Coward del. et lith.

1, 2. ACTINOMETRA PULCHELLA, Pourt., sp. 3—5. ANTEDON PORRECTA, sp. n.

PLATE LIII.

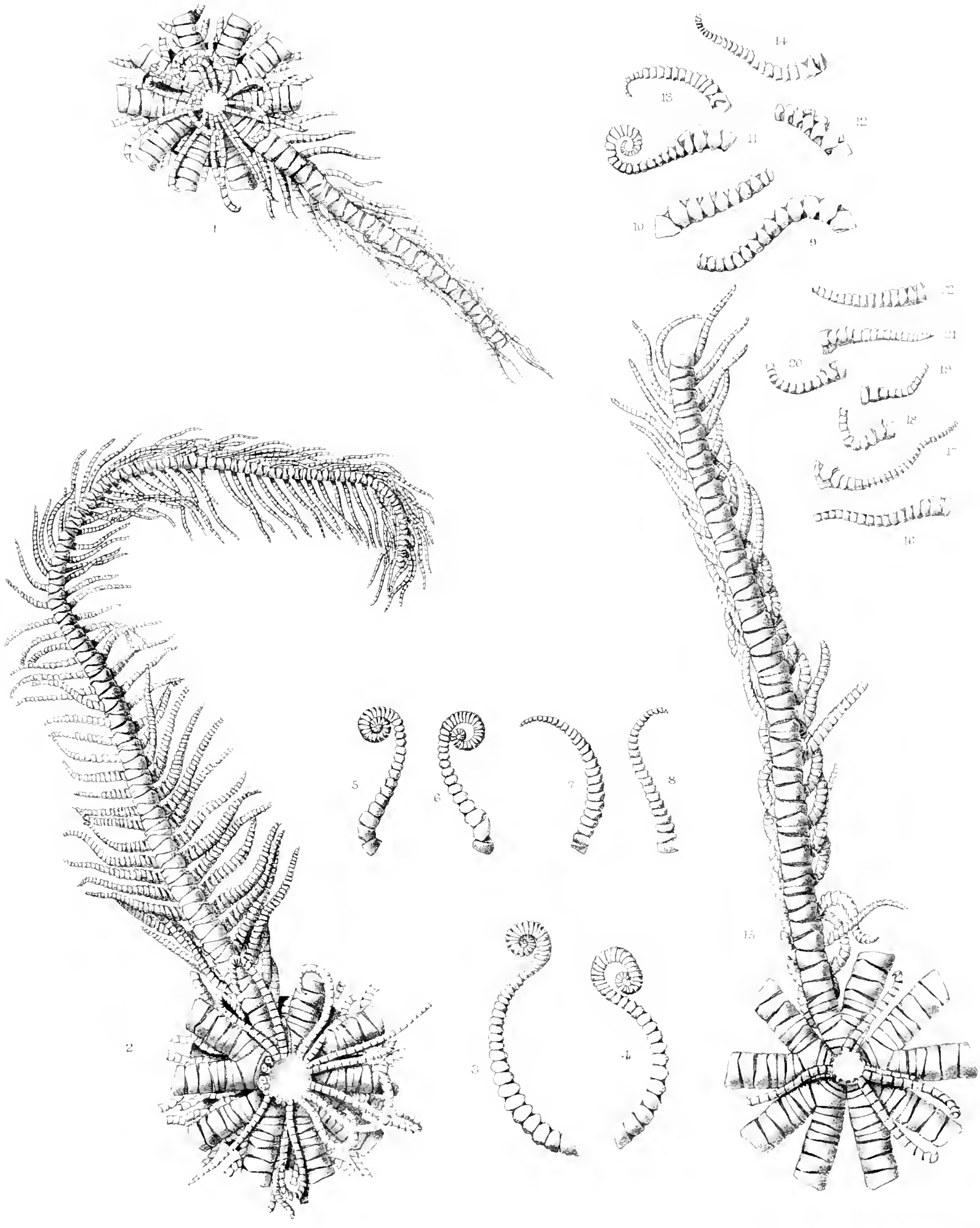
PLATE LIII.

Figs. 1–14. Actinometra solaris, Lam., sp.

		Diam.	Page
Fig. 1. Dorsal aspect of a young individual.	×	3	290
Fig. 2. An older individual.	×	$1\frac{1}{2}$	288
Figs. 3, 4. The first pair of pinnules.	×	3	281
Figs. 5, 6. The second pair of pinnules.	×	3	282
Figs. 7, 8. The third pair of pinnules.	×	3	288
Figs. 9, 10. The first pair of pinnules in another example.	×	3	282
Figs. 11, 12. Its second pair.	×	3	281
Figs. 13, 14. Its third pair.	×	3	281

Figs. 15–22. Actinometra pectinata, Retz., sp.

Fig. 15. Dorsal aspect.	×	$1\frac{1}{2}$	285
Figs. 16, 17. The first pair of pinnules.	×	3	281
Figs. 18, 19. The second pair of pinnules.	×	3	281
Figs. 20, 21. The third pair of pinnules.	×	3	281
Fig. 22. The pinnule on the eighth brachial.	×	3	285



Parker & Coward del et lith

West Newman imp.

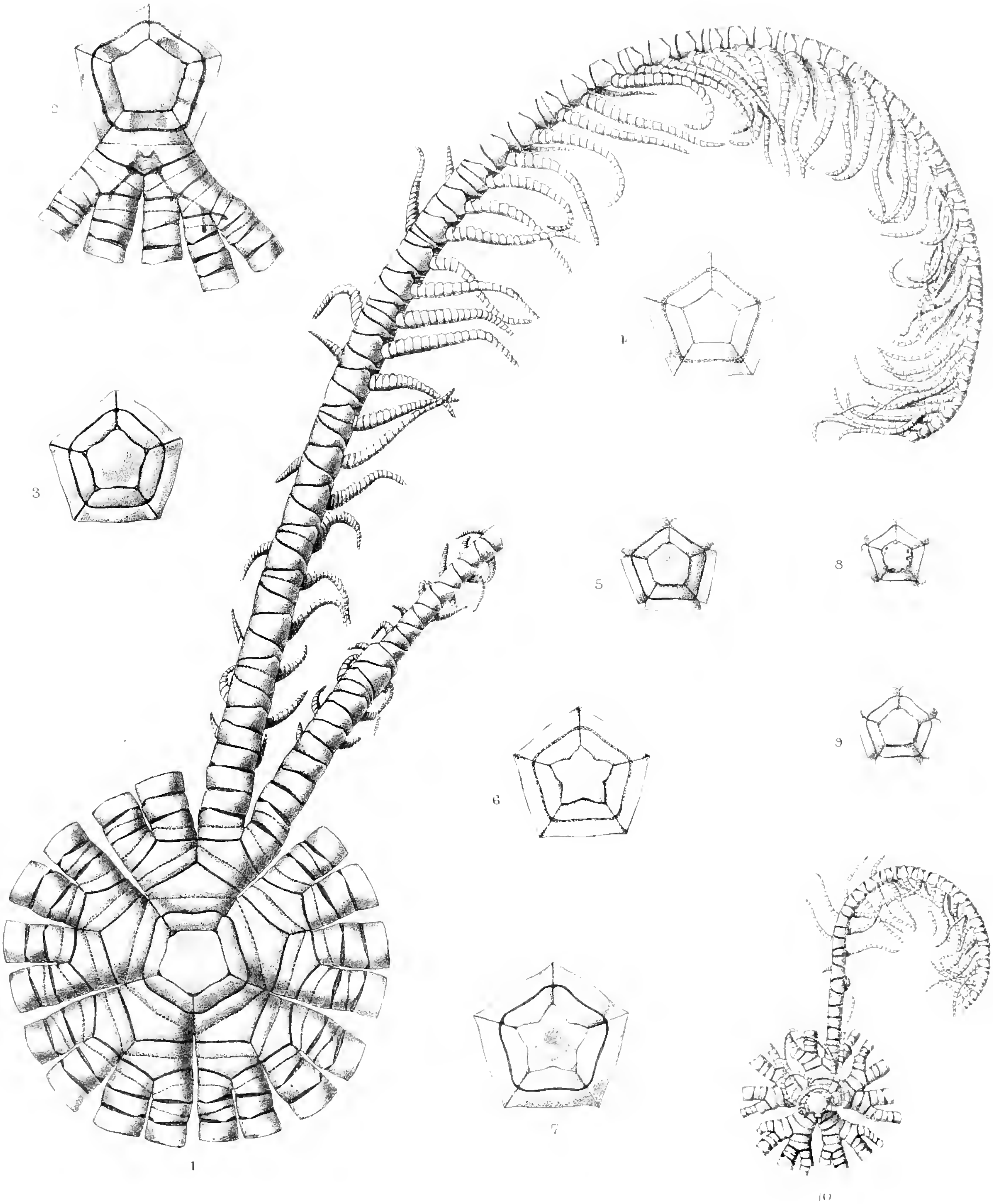
1—14. ACTINOMETRA SOLARIS, Lam., sp. 15—22. ACTINOMETRA PECTINATA, Retz., sp.

PLATE LIV.

PLATE LIV.

Actinometra paucicirra, Bell.

		Diam.	Page
Fig. 1. Dorsal aspect,	.	× 3	291
Fig. 2. Dorsal aspect of the calyx and one ray with a palmar series,	.	× 3	293
Figs. 3–9. Various stages in the modification of the centro-dorsal,	.	× 3	14
Fig. 10. The youngest specimen obtained,	.	× 3	293



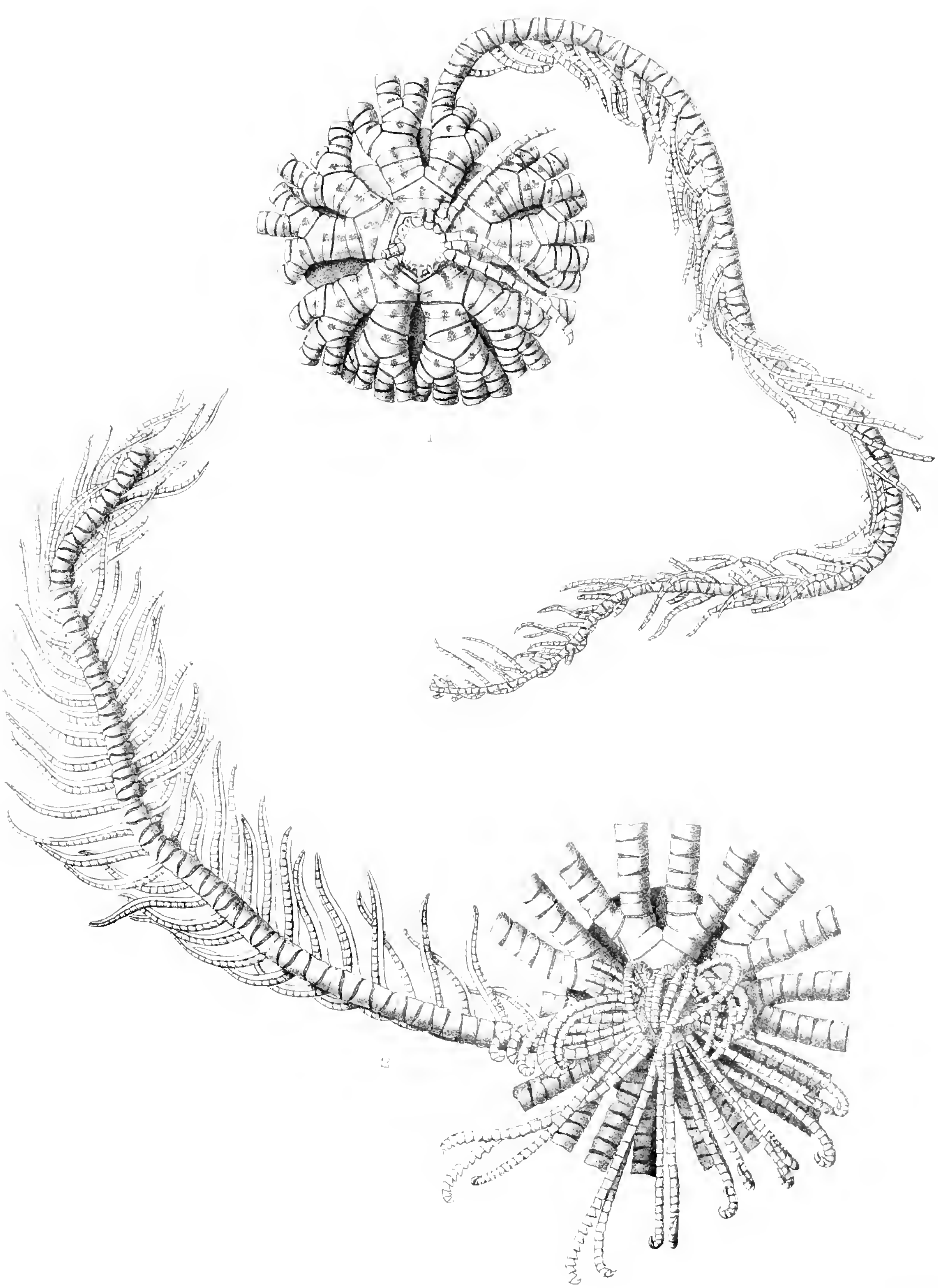
Parker & Coward, del. et lith.

ACTINOMETRA PAUCICIRRA.

PLATE LV.

PLATE LV.

		Diam.	Page
Fig. 1.	Actinometra distincta, n. sp., ...	× 3	295
Fig. 2.	Actinometra maculata, n. sp., ...	× 3	307



Berjeau & Coward del. et lith.

1, ACTINOMETRA DISTINCTA sp. n. 2, ACTINOMETRA MACULATA, sp. n.

PLATE LVI.

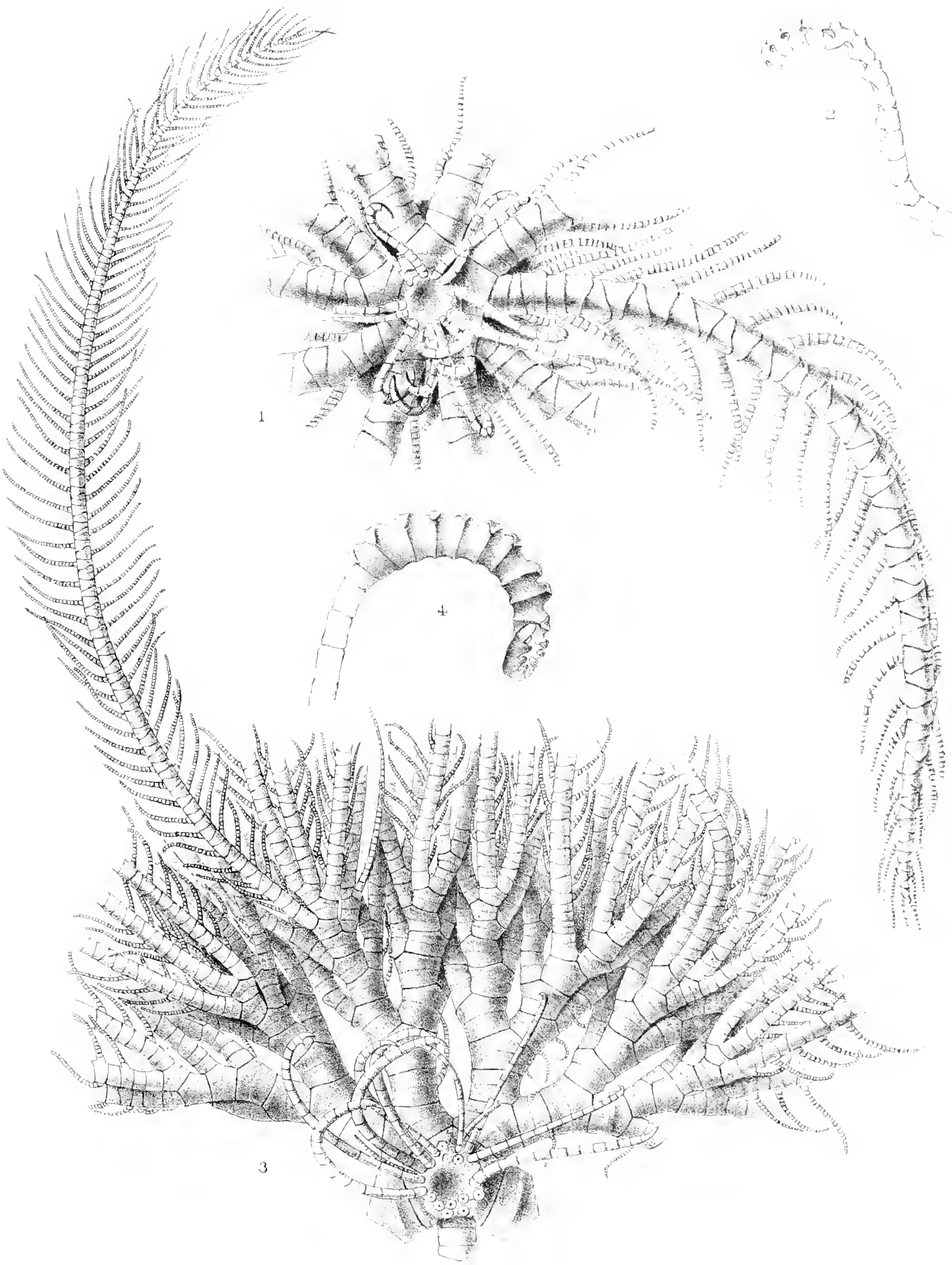
PLATE LVI.

Figs. 1, 2. ACTINOMETRA MERIDIONALIS, Pourt., sp.

		Diam.	Page
Fig. 1.	Dorsal aspect, ...	× 4	301
Fig. 2.	Terminal comb of a lower pinnule, ...	× 20	276

Figs. 3, 4. ACTINOMETRA MULTIBRACHIATA, n. sp.

Fig. 3.	Dorsal aspect of the calyx and two rays, . . .	× 2	299
Fig. 4.	Terminal comb of a lower pinnule, ...	× 20	276



Geo West & Sons del lith et imp

1, 2. ACTINOMETRA MERIDIONALIS, Pourt., sp.
3, 4. ACTINOMETRA MULTIBRACHIATA, sp. n.

PLATE LVII.

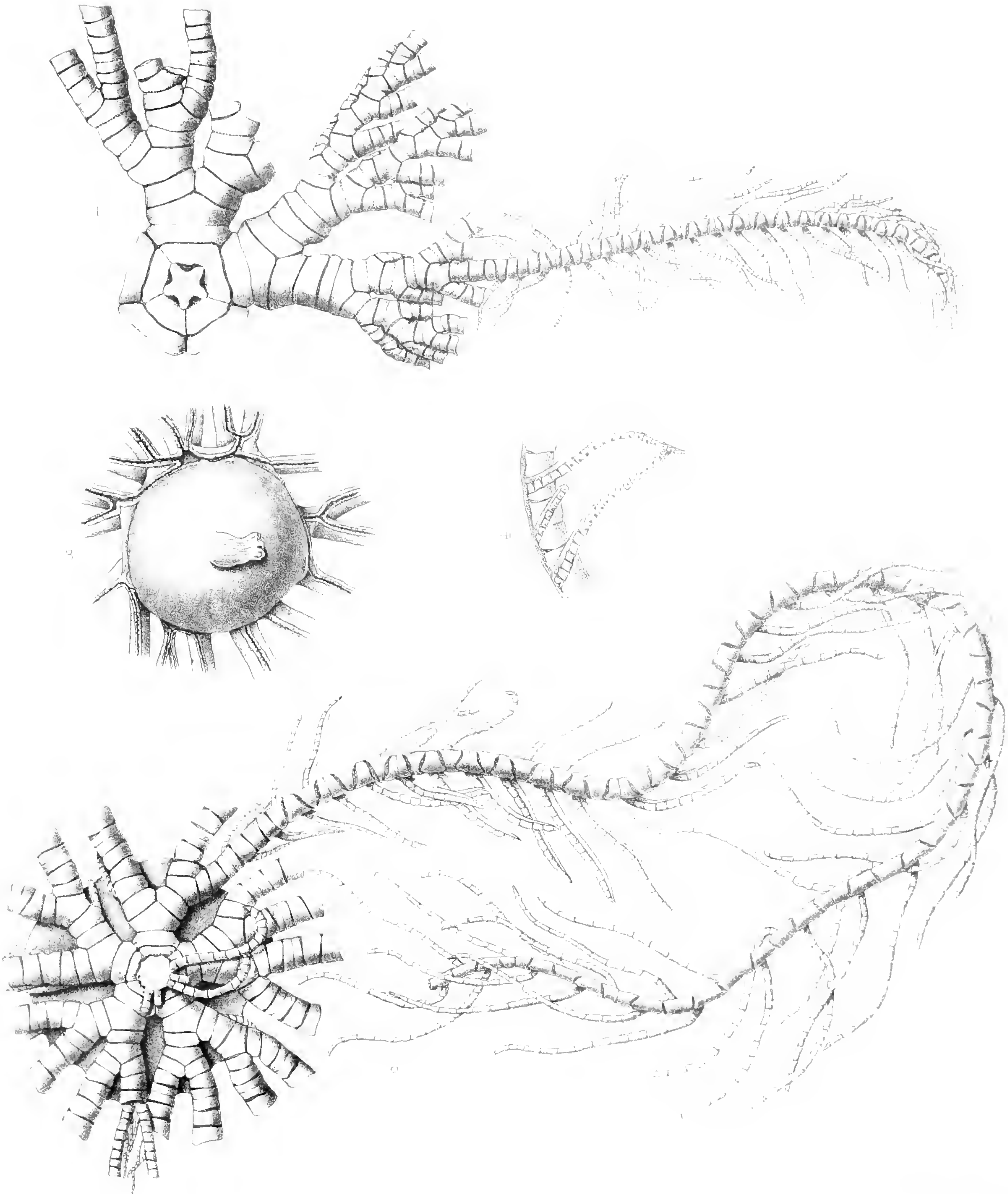
PLATE LVII.

Fig. 1. Actinometra typica, Lovén, sp.

	Diam.	Page
Fig. 1. Dorsal aspect of the calyx and two rays, . . .	× 3	296

Figs. 2–4. Actinometra elongata, n. sp.

	Diam.	Page
Fig. 2. Dorsal aspect, ...	× 4	311
Fig. 3. Ventral aspect of the disk, ...	× 4	273
Fig. 4. Pinnules with "ovoid bodies,"	× 5	275



Parker & Coward, del et lith.

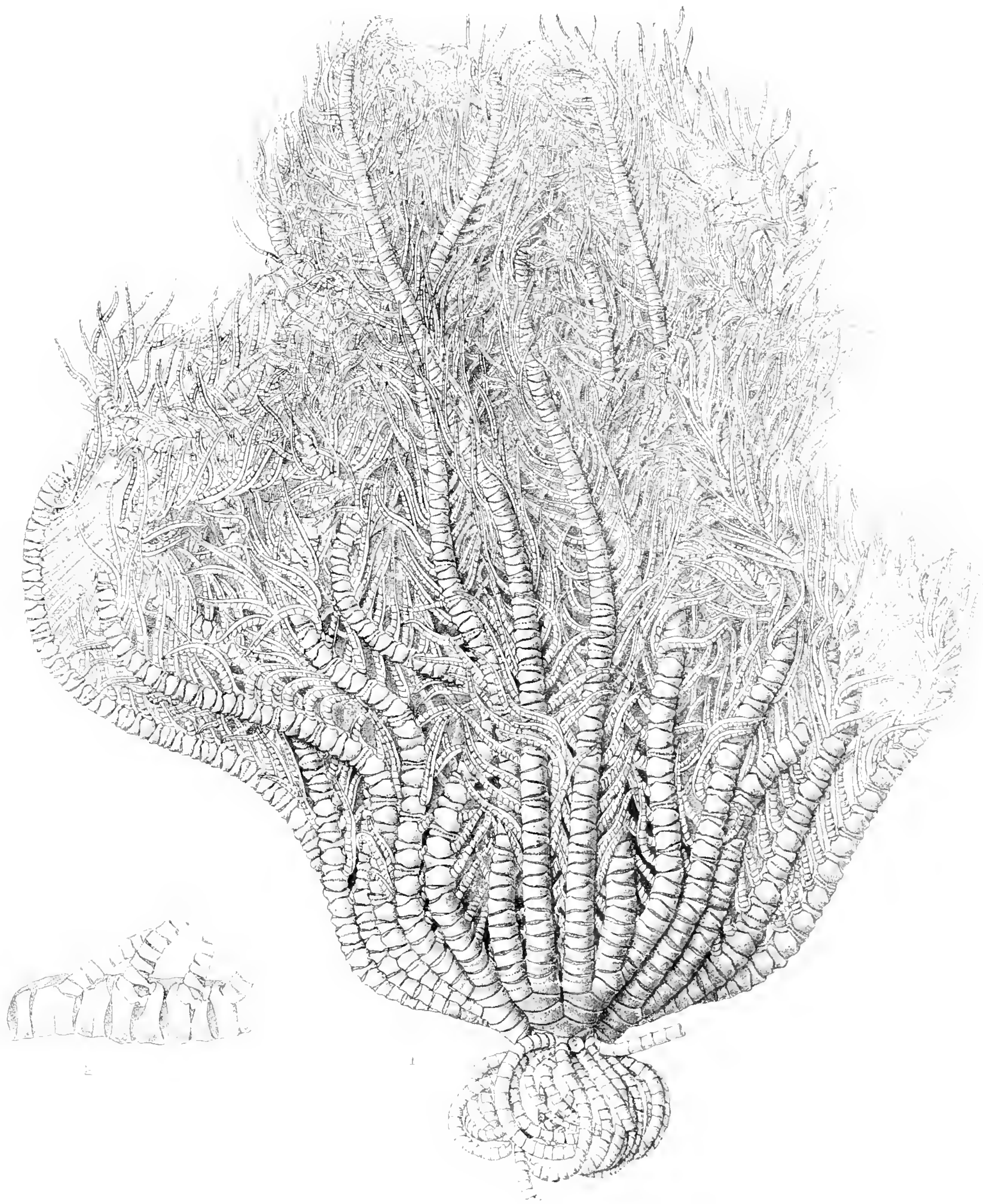
1, ACTINOMETRA TYPICA, Lovén, sp. 2–4, ACTINOMETRA ELONGATA.

PLATE LVIII.

PLATE LVIII.

ACTINOMETRA STELLIGERA, n. sp.

	Diam.	Page
Fig. 1. Side view, ...	× 2	308
Fig. 2. The lower pinnules, ...	× 4	308



1

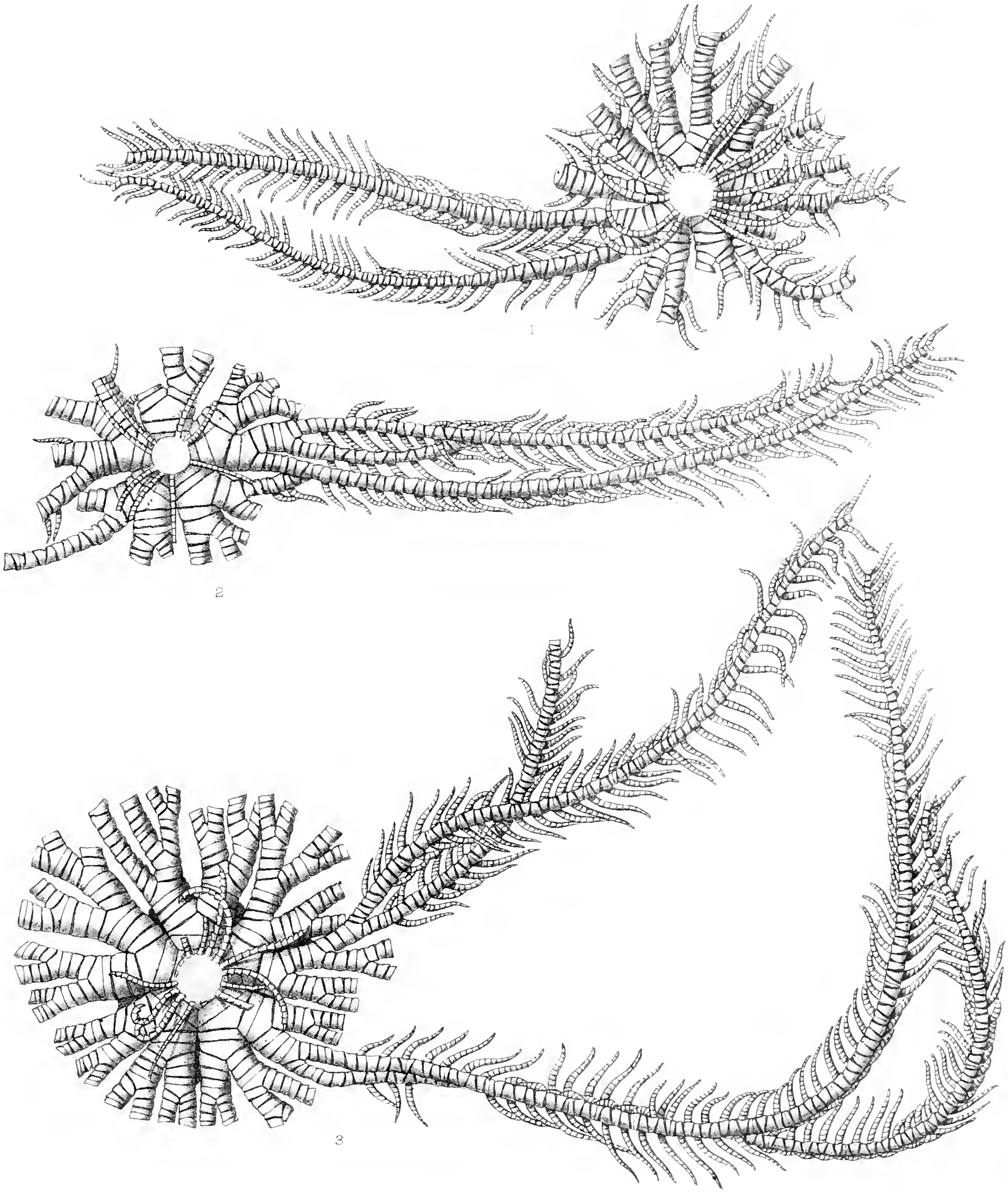
2

ACTINOMETRA STELLIGERA. sp. n.

PLATE LIX.

PLATE LIX.

		Diam.	Page
Fig. 1.	Actinometra simplex, n. sp., ...	× 3	312
Fig. 2.	Actinometra rotalaria, Lam., sp., ...	× 3	313
Fig. 3.	Actinometra valida, n. sp., ...	× 2	314



W. P. Evans, del.
Parker & Coward, lith.

West, Newman & Co. imp.

1. ACTINOMETRA SIMPLEX, sp. n.
2. ACTINOMETRA ROTALARIA Lam., sp. 3. ACTINOMETRA VALIDA, sp. n.

PLATE LX.

PLATE LX.

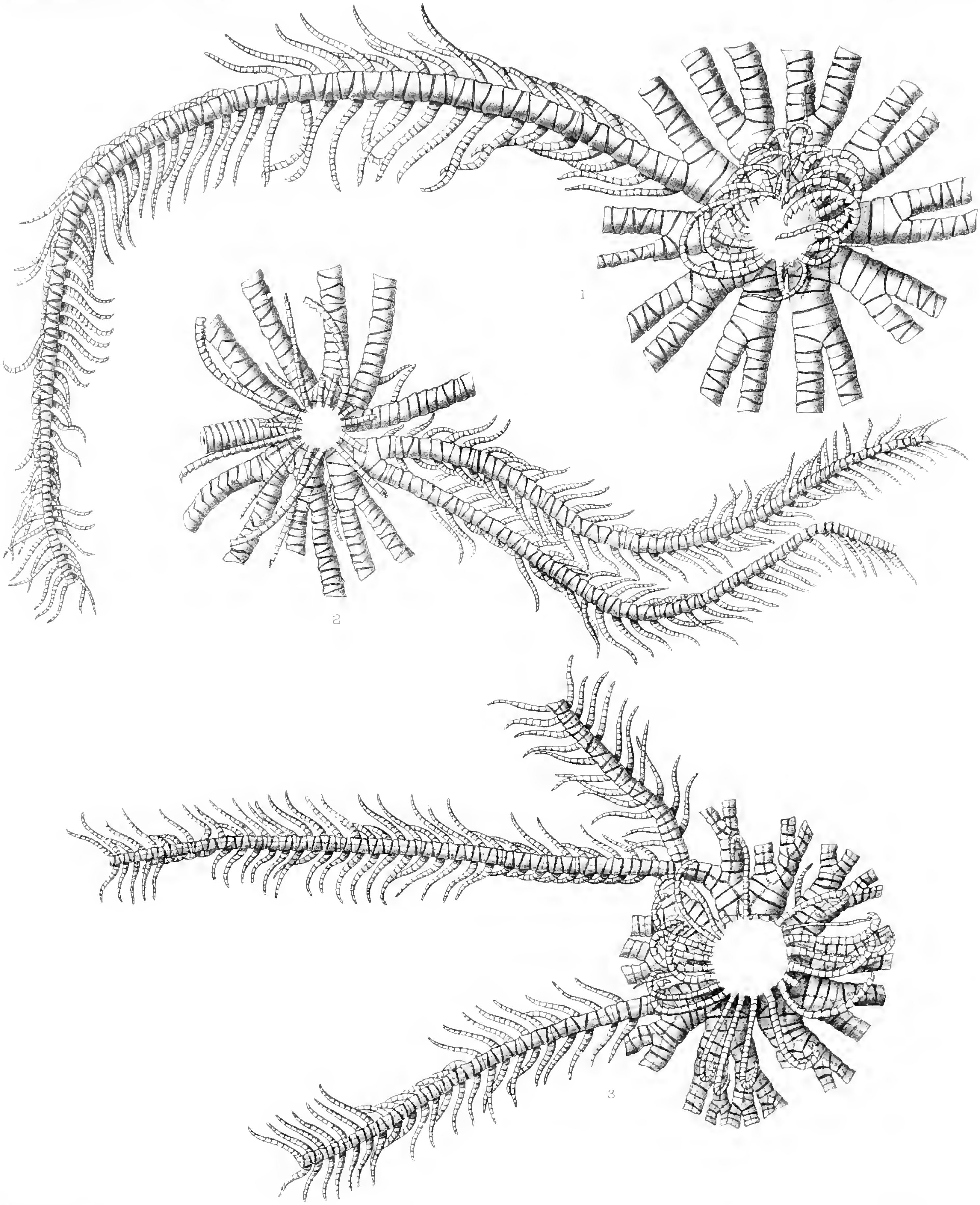
Figs. 1, 2. ACTINOMETRA COPPINGERI, Bell.

		Diam.	Page
Fig. 1. An individual from Samboangan, ...	×	3	320
Fig. 2. Another from Banda, ...	×	3	320

Fig. 3. ACTINOMETRA LINEATA, n. sp.

Fig. 3.	×	3	327

N.B.—Some of the cirri have been represented by the artist with too many joints.



Parker & Coward, lith.

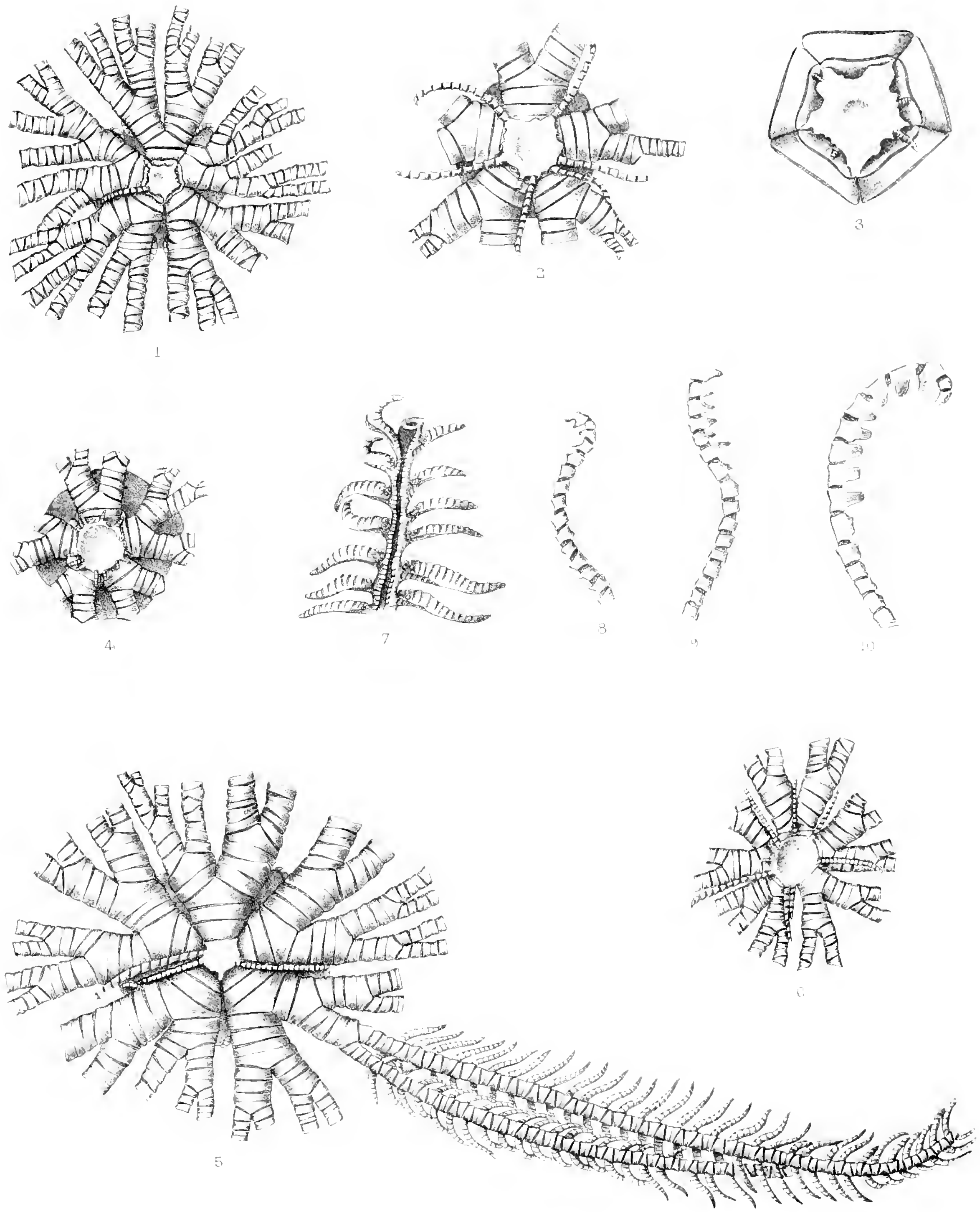
1, 2. ACTINOMETRA COPPINGERI, Bell. 3. ACTINOMETRA LINEATA, sp. n.

PLATE LXI.

PLATE LXI.

ACTINOMETRA PARVICIRRA, Müll., sp.

		Diam.	Page
Fig. 1.	A specimen with many arms and few cirri; the second radial is absent in one ray,	× 2	343
Fig. 2.	A smaller individual, without palmars,	× 6	343
Fig. 3.	The calyx of another example with stellate centro-dorsal bearing rudimentary cirri,	× 3	343
Fig. 4.	Another specimen with more rounded centro-dorsal,	× 4	343
Fig. 5.	A larger form with post-palmars,	× 3	338
Fig. 6.	Another example from Simon's Bay,	× 3	343
Fig. 7.	Ventral aspect of its arm with the ova attached,	× 4	344
Figs. 8–10.	Modifications of the terminal comb on the lower pinnules,	× 10	343



W. S. Evans, del.
Parker & Coward, lith.

West, Newman & Co. imp.

ACTINOMETRA PARVICIRRA, MÜLL., sp.

PLATE LXII.

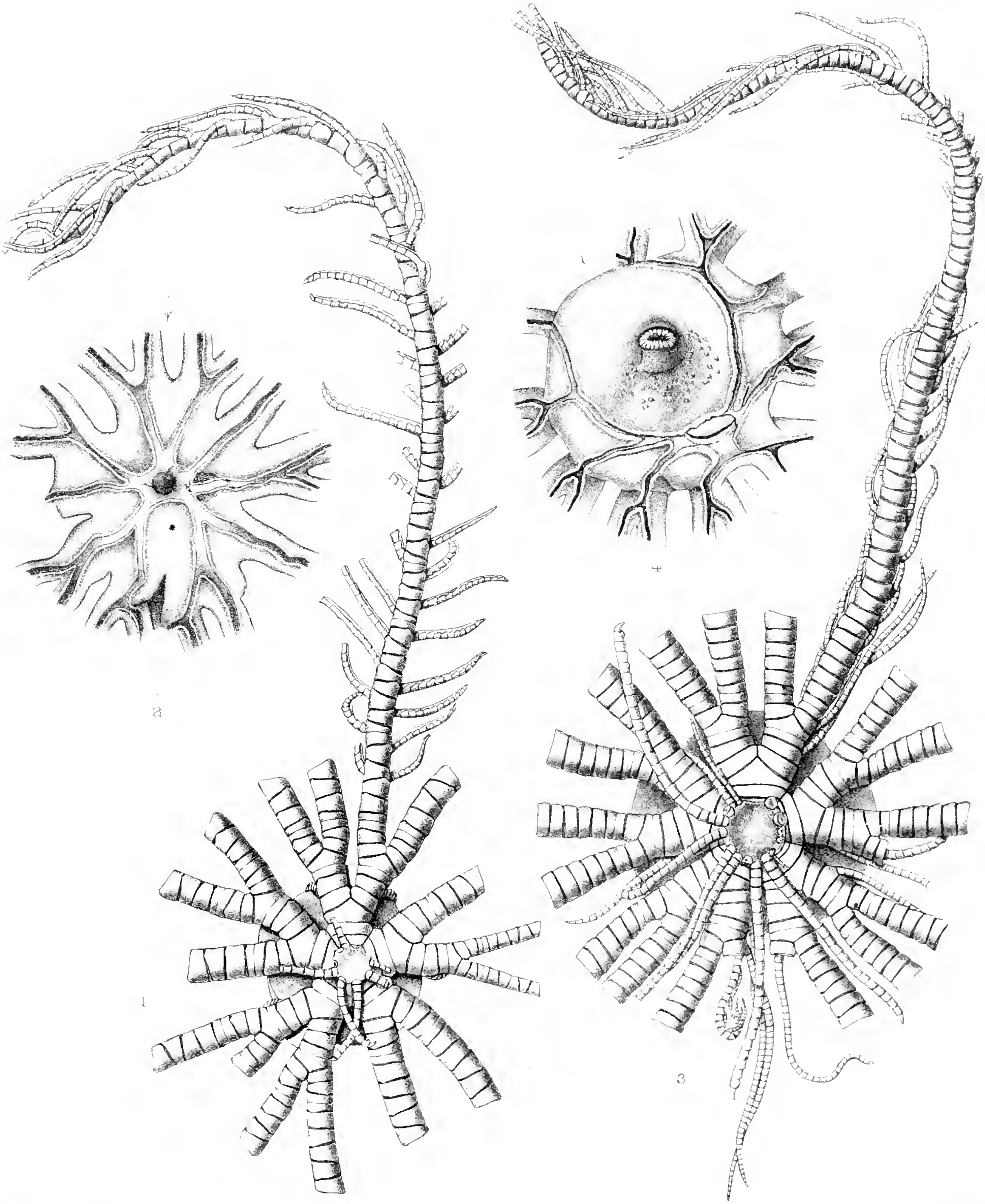
PLATE LXII.

Fig. 1. ACTINOMETRA QUADRATA, n. sp.

	Diam.	Page
Fig. 1. Dorsal aspect.	× 4	331

Figs. 2–4. ACTINOMETRA FIMBRIATA, Lam., sp.

	Diam.	Page
Fig. 2. Ventral aspect of an unusually symmetrical disk, . .	× 3	319
[The arrow indicates the line of the antero-posterior axis.]		
Fig. 3. Dorsal aspect, ...	× 3	317
Fig. 4. A more normal disk, ...	× 3	319



Parker & Coward, del. et lith.

West, Newman & Co. imp.

1, ACTINOMETRA QUADRATA, sp. n. 2–4, ACTINOMETRA FIMBRIATA Lam. sp.

PLATE LXIII.

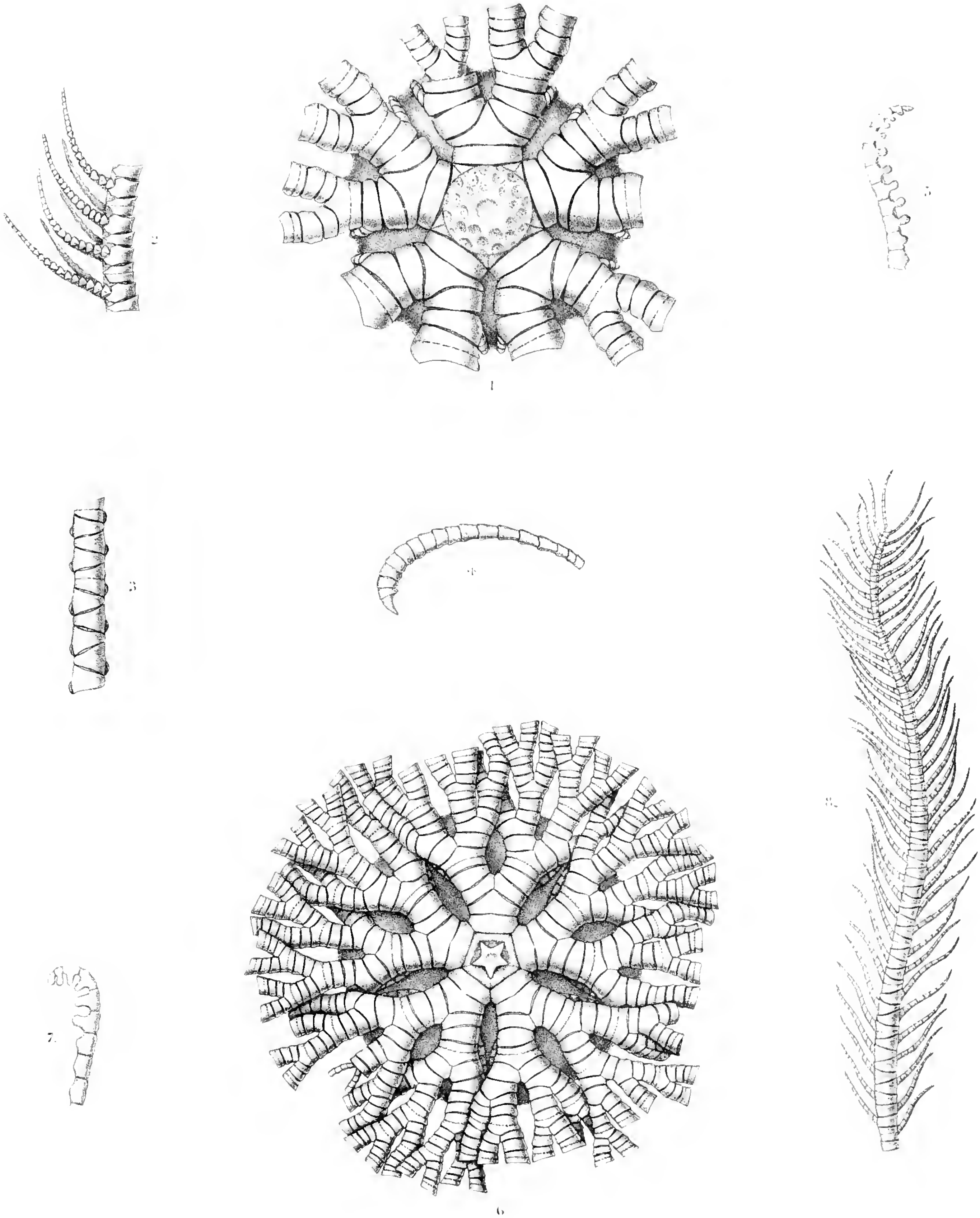
PLATE LXIII.

Figs. 1–5. ACTINOMETRA TRICHOPTERA, Müll., sp.

	Diam.	Page
Fig. 1. Dorsal aspect,	× 6	345
Fig. 2. Portion of an arm, from the side,	× 4	345
Fig. 3. The same, from above,	× 4	345
Fig. 4. A cirrus,	× 6	345
Fig. 5. Terminal comb of a lower pinnule,	× 15	276

Figs. 6–8. ACTINOMETRA DIVARICATA, n. sp.

	Diam.	Page
Fig. 6. Dorsal aspect,	× 2	332
Fig. 7. Terminal comb of a lower pinnule,	× 7	276
Fig. 8. Dorsal aspect of an arm,	× $2\frac{1}{2}$	332



Berjeau & Highley del. et lith.

Mintern Bros. imp.

1-5 ACTINOMETRA ECHINOPTERA, J. Müll. sp. 6-8 ACTINOMETRA DIVARICATA, sp. n.

PLATE LXIV.

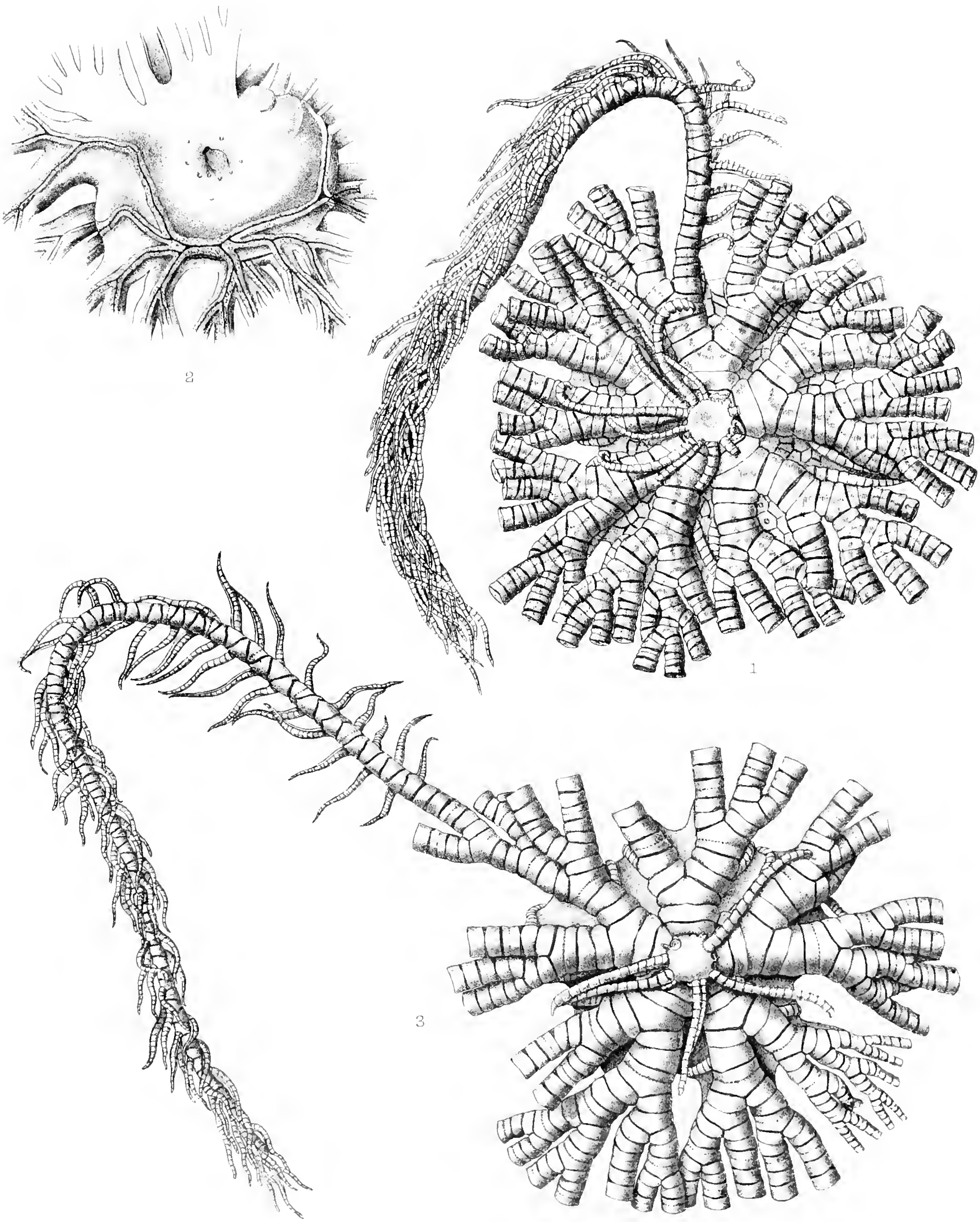
PLATE LXIV.

Figs. 1, 2. ACTINOMETRA BELLI, n. sp.

		Diam.	Page
Fig. 1. Dorsal aspect, ...	×	2	334
Fig. 2. The disk, from above, ...	×	$1\frac{1}{2}$	335

Fig. 3. ACTINOMETRA DUPLEX, n. sp.

Fig. 3. Dorsal aspect, ...	×	3	335



2

1

3

Parker & Coward, del. et lith.

West, Newman & Co. imp.

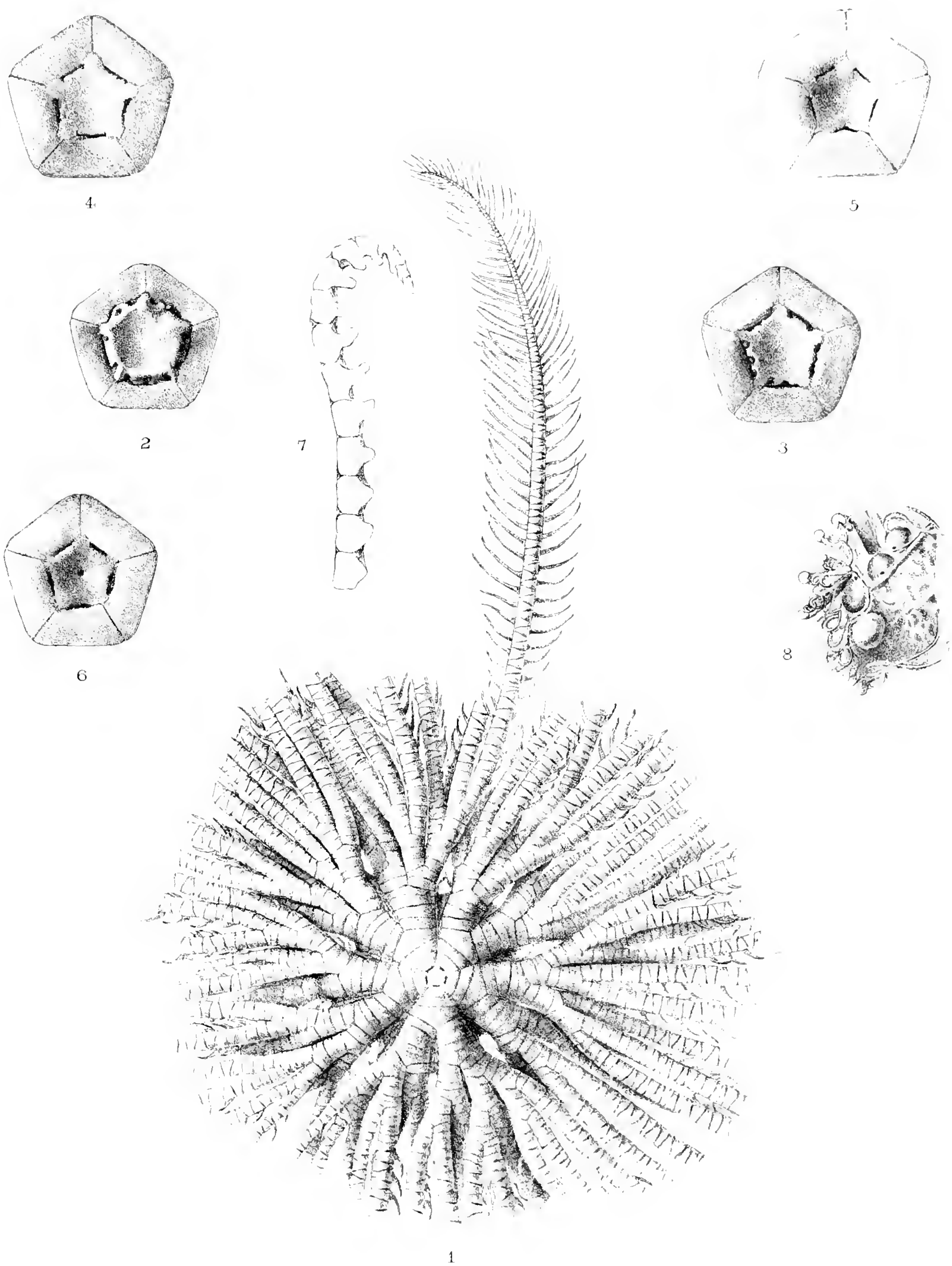
1, 2. ACTINOMETRA BELLI, sp. n. 3. ACTINOMETRA DUPLEX, sp. n.

PLATE LXV.

PLATE LXV.

Actinometra nobilis, n. sp.

	Diam.	Page
Fig. 1. Dorsal aspect, ...	nat. size	336
Figs. 2–6. Various stages in the modification of the centro-dorsal, .	× $3\frac{1}{2}$	15
Fig. 7. Terminal comb of a lower pinnule, ...	× 20	276
Fig. 8. Portion of the disk, with cysts of *Myzostoma platypus*, .	× 2	338



Geo West & Sons del lith et imp

ACTINOMETRA NOBILIS, sp. n.

PLATE LXVI.

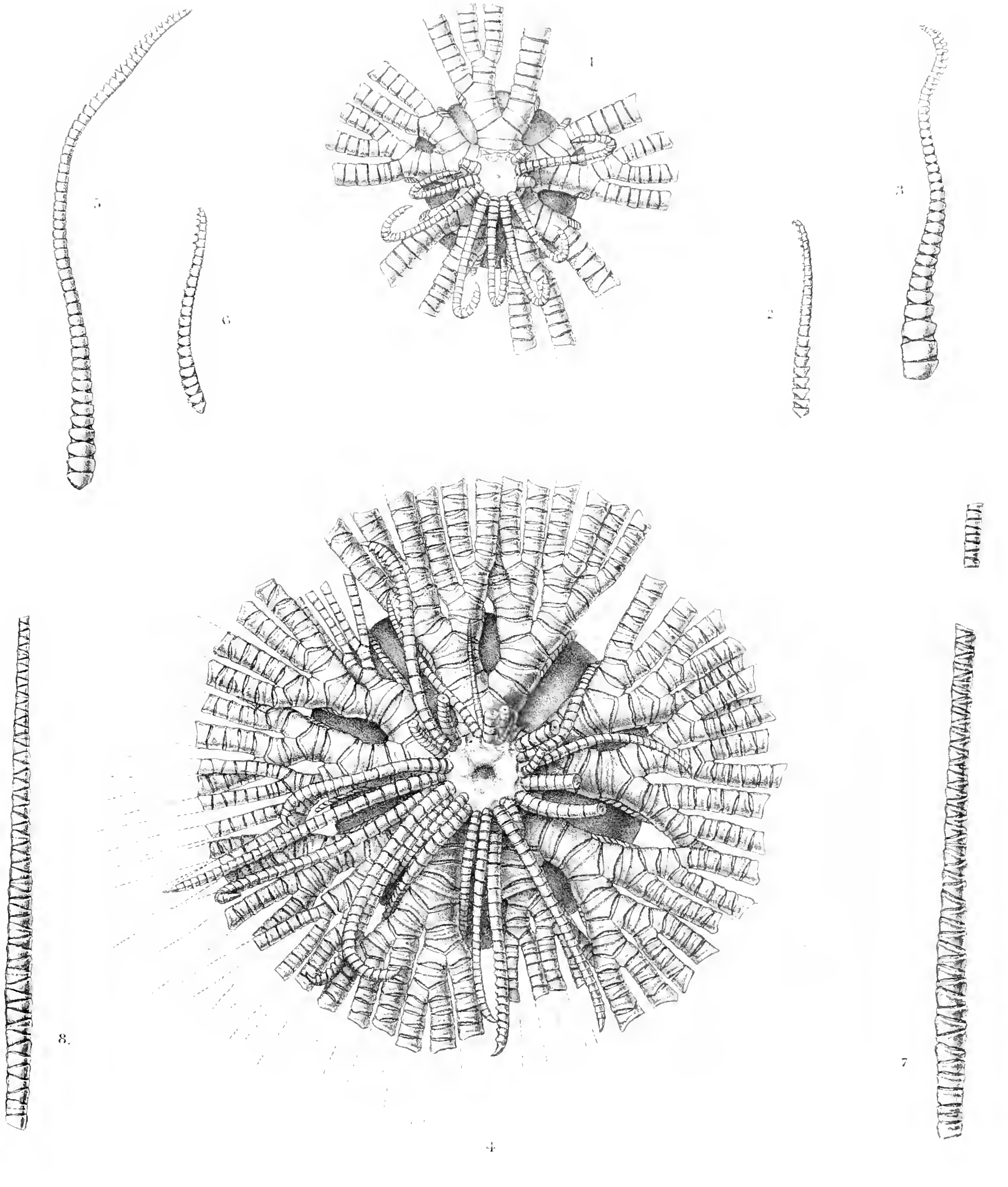
PLATE LXVI.

Figs. 1–3, 8. ACTINOMETRA MULTIRADIATA, Linn., sp.

	Diam.	Page
Fig. 1. Dorsal aspect, ...	× 2	322
Fig. 2. A terminal pinnule, ...	× 4	322
Fig. 3. A lower pinnule, ...	× 4	276
Fig. 8. Dorsal aspect of an arm, ...	× 2	322

Figs. 4–7. ACTINOMETRA SENTOSA, n. sp.

Fig. 4. Dorsal aspect, ...	× 2	325
Fig. 5. A lower pinnule, ...	× 4	276
Fig. 6. A terminal pinnule, ...	× 4	325
Fig. 7. Dorsal aspect of an arm, ...	× 2	325



Bergeau & Highley del et lith. Mintern Bros. imp.

1–3, 8 ACTINOMETRA MULTIRADIATA, Linn. sp.
4–7 ACTINOMETRA SENTOSA, sp. n.

PLATE LXVII.

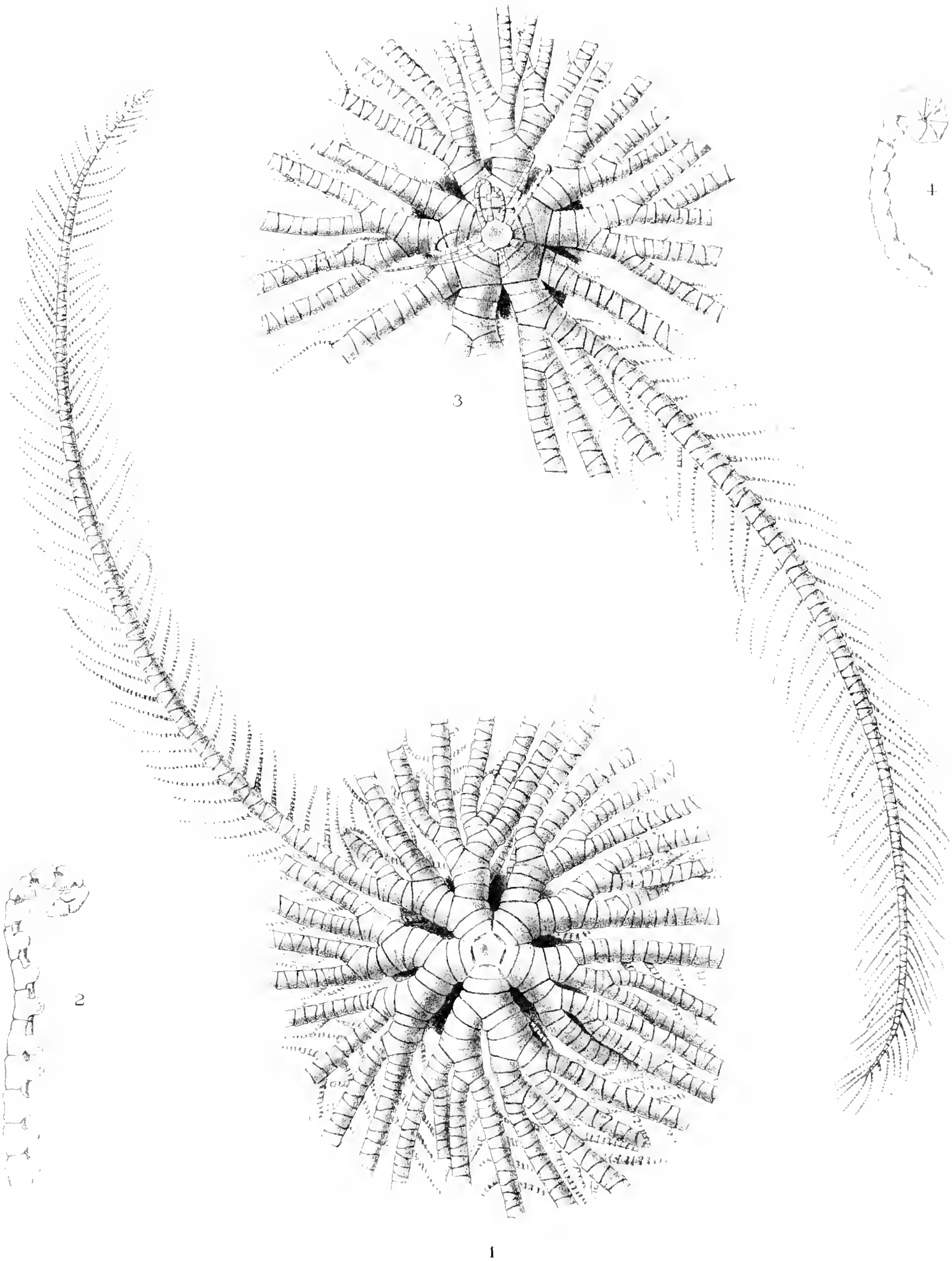
PLATE LXVII.

Figs. 1, 2. ACTINOMETRA LITTORALIS, n. sp.

		Diam.	Page
Fig. 1. Dorsal aspect,	. . . .	× 2	346
Fig. 2. Terminal comb of a lower pinnule,	. . . .	× 20	276

Figs. 3, 4. ACTINOMETRA PARVICIRRA, Müll., sp.

Fig. 3. Dorsal aspect,	. . . .	× 2	338
Fig. 4. Terminal comb of a lower pinnule,	. . . .	× 20	276



Geo West & Sons del lith et imp

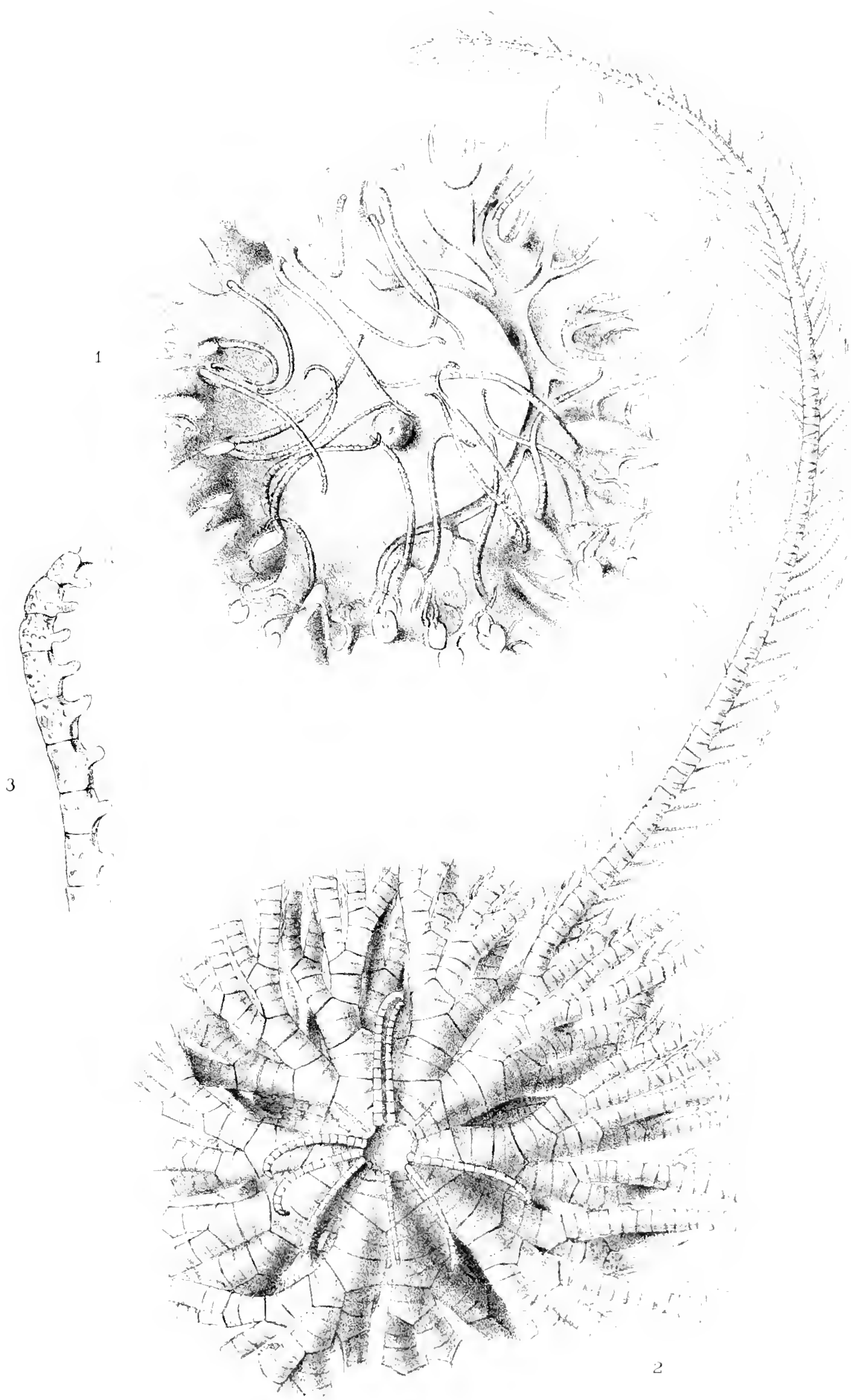
1, 2. ACTINOMETRA LITTORALIS, sp. n.
3, 4. ACTINOMETRA PARVICIRRA, Müll. sp.

PLATE LXVIII.

PLATE LXVIII.

ACTINOMETRA REGALIS, n. sp.

		Diam.	Page
Fig. 1.	The disk, from above,	× 2	274
Fig. 2.	Dorsal aspect,	× 2	347
Fig. 3.	Terminal comb of a lower pinnule,	× 20	276



Geo West & Sons del lith et imp

ACTINOMETRA REGALIS, sp. n.

PLATE LXIX.

PLATE LXIX.

Figs. 1–4. Antedon multispina, n. sp.

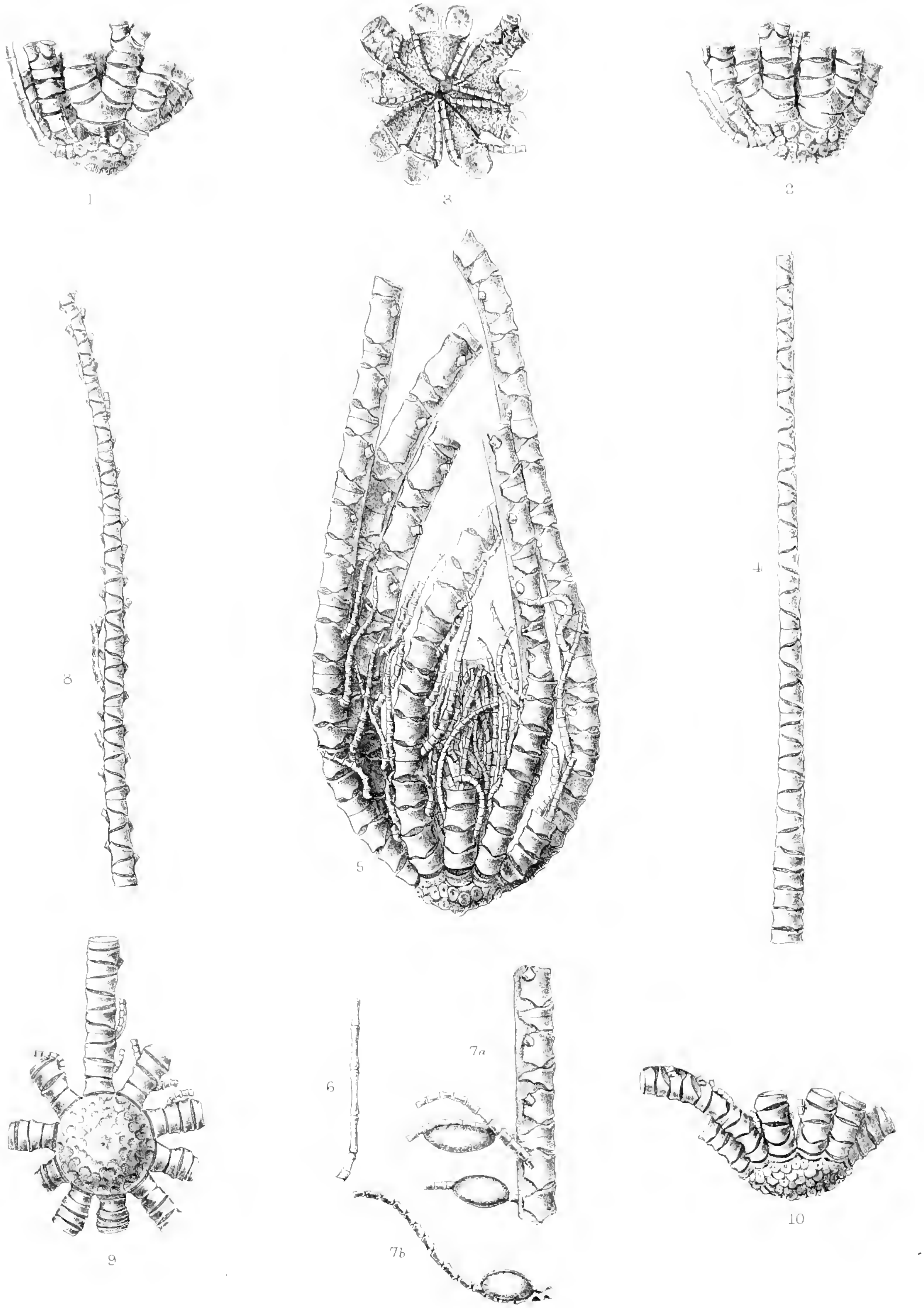
		Diam.	Page
Figs. 1, 2. Side views of a tridistichate individual,	×	4	249
Fig. 3. The disk, from above,	×	4	249
Fig. 4. Dorsal aspect of an arm,	×	4	117

Figs. 5–7. Promachocrinus abyssorum, n. sp.

Fig. 5. Side view,	×	4	351
Fig. 6. Basal portion of a cirrus,	×	4	351
Fig. 7. (*a*, *b*) Arm fragment with genital pinnules,	×	4	351

Figs. 8–10. Promachocrinus naresi.

Fig. 8. Dorsal aspect of an arm,	×	2	352
Fig. 9. Dorsal aspect of the calyx,	×	2	352
Fig. 10. The calyx, from the side,	×	2	352



Parker & Coward, del. et lith.

West, Newman & Co. imp.

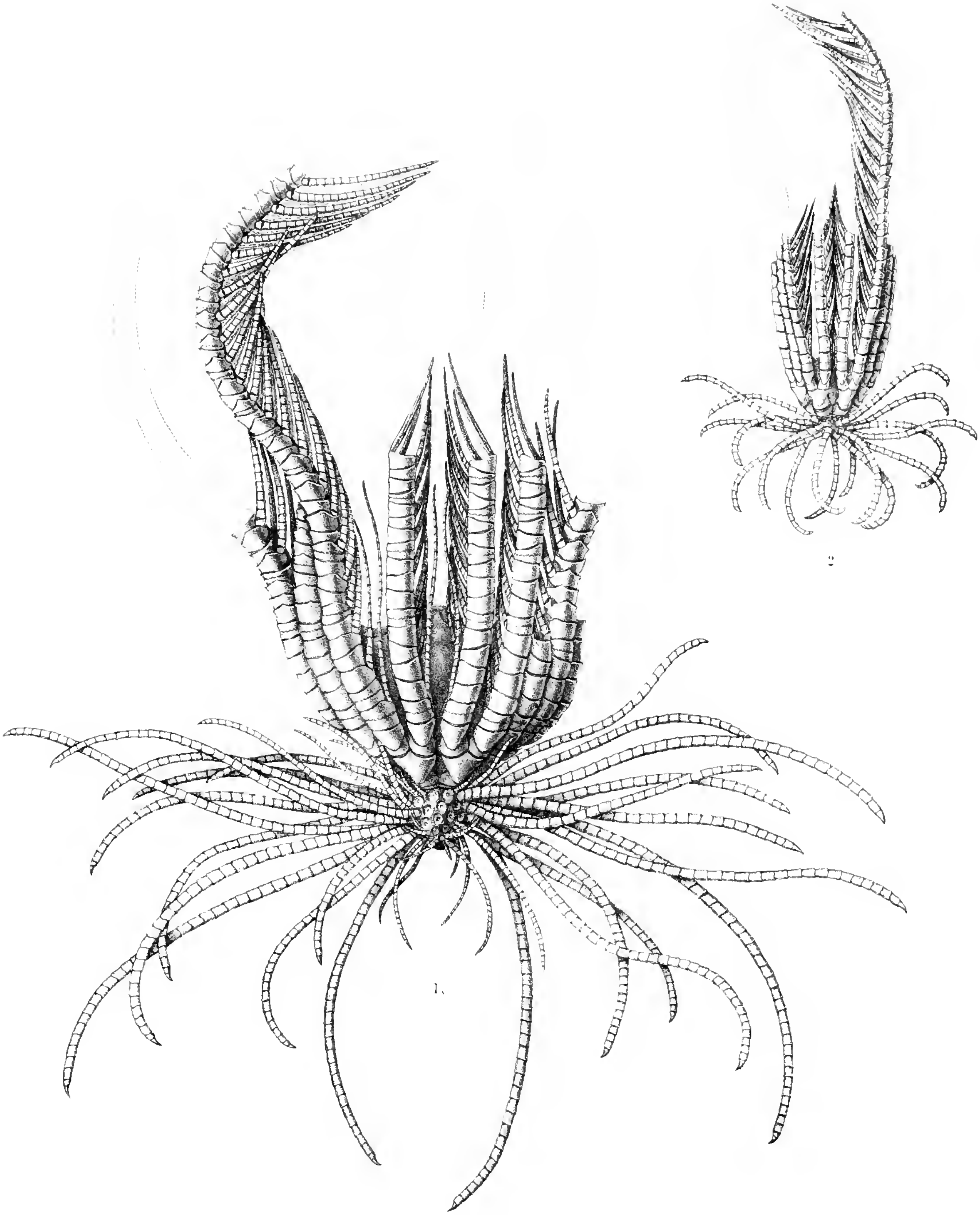
1–4. ANTEDON MULTISPINA, sp. n.
5–7. PROMACHOCRINUS ABYSSORUM, sp. n. 8, 9, PROMACHOCRINUS NARESI, sp. n.

PLATE LXX.

PLATE LXX.

Promachocrinus kerguelensis, n. sp.

	Diam.	Page
Fig. 1. Side view,	× 2	350
Fig. 2. A young individual,	× 4	351



Berjeau & Highley del. et lith.

Mintern Bros. imp.

PROMACHOCRINUS KERGUELENSIS, sp. n.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the SEALS collected during the Voyage of H.M.S. Challenger in the Years 1873-76. By Sir WILLIAM TURNER, Knt., M.B., LL.D., F.R.SS. L. & E., Professor of Anatomy in the University of Edinburgh, Member of the General Medical Council.

IN the first volume of the Reports of the Scientific Results of the Voyage of H.M.S. Challenger (Zoology, vol. i., part iv., 1880) I gave an account of the Bones of the Cetacea which had been collected by the expedition.

In this Report it is my intention to describe the Seals, and therefore to complete the account of the Marine Mammals which were entrusted to me for examination and description.

Specimens of Seals were procured by the expedition in the following localities:—

The Kerguelen Group of Islands.

Heard Island.

Messier Channel, off the west coast of Patagonia.

The Falkland Islands.

Juan Fernandez.

These specimens belong to the genera *Macrorhinus*, *Leptonychotes*, *Otaria*, and *Arctocephalus*.

CONTENTS.

PART I.

DESCRIPTION OF GENERA AND SPECIES.

Macrorhinus, F. Cuvier.

Macrorhine, F. Cuvier, Mém. du Muséum, xi. p. 200, 1824.

In the Narrative of the Voyage of the Challenger it is stated that the Elephant Seal was seen on Marion Island, in the South Atlantic: on Kerguelen Island and on Heard Island;[1] whilst reference is made to the observations by previous voyagers of the occurrence of this Seal on the Crozet Islands, Tristan da Cunha, Inaccessible Island, and Juan Fernandez, which places were also visited by the Challenger. Specimens were secured and sent home both from Kerguelen Island and Heard Island. They were males and females of the great Elephant Seal of the Southern Ocean, and are all I believe to be referred to one species, *Macrorhinus leoninus.*

Macrorhinus leoninus (Linnæus) (Pls. I., II., III., IV.).

Phoca leonina, Linnæus, Syst. Nat., ed. 12, i. p. 55, 1766.

Elephant Seal.

The specimens of this Seal consisted of (*a*) the carcase of a well-grown female, (*b*) the skin of another female containing bones of the limbs, (*c*) the complete skeleton of another female, and (*d*) the skull of a young female from which the brain had been removed, all killed at Christmas Harbour, Kerguelen, January 7, 1874; also (*e*) the skeleton of a well-grown male, (*f*) the skull and some of the cervical vertebræ of a large female shot at Betsy Cove, Kerguelen, January 9, 1874, together with (*g*) a young skull, apparently of a female, picked up on the same beach; also (*h*) the skull of a large male picked up by Professor Moseley on the shore of Heard Island, February 6, 1874.

External Characters.—I have been able to examine the external characters of the Sea Elephant in the carcase of the well-grown female (*a*) and the skin of another female (*b*), both killed on Kerguelen Island and preserved in salt. The carcase with the skin on had been cut into halves immediately behind the pectoral limbs, and the abdominal viscera had been removed, so as to allow it to be packed in a barrel. It is from this specimen that the drawings in Pl. I. have been made. When the halves were placed in contact in

[1] Narr. Chall. Exp., vol. i. pp. 294, 354, 373, 377.

the plane of section the animal measured along the curve of the back, from the muzzle to the tip of the tail, 6 feet 2 inches, and to the most distal point of the hind limb, when it was elongated behind the tail, 7 feet 2 inches. The free part of the tail was only $2\frac{7}{8}$ inches long, the girth immediately behind the pectoral limb was 3 feet 2 inches in the eviscerated carcase. The other female, judging from the dimensions of the separated skin, had apparently been somewhat bigger, as the length from muzzle to tip of hind limb was 7 feet 8 inches.

Between thirty and forty black bristles arranged in six rows on each upper lip, projected for the most part backwards, and the more posterior bristles were longer than the anterior. The lips overhung the mouth, the slit of which was $2\frac{3}{4}$ inches long on each side. The nostrils opened forwards on the face, but there was no proboscis. Immediately above these orifices were three transverse wrinkles in the skin, from the upper of which a single black bristle projected at each end, and by the depression of these wrinkles, through the contraction of the facial muscles, that peculiar appearance of the face is produced, which, in the Narrative of the Voyage, the animal is stated to assume when disturbed. The palpebral fissure was $1\frac{3}{4}$ inch wide, and seven black bristles projected from the skin, a short distance above the inner end of each of these fissures. A large extensile third eyelid was situated at the inner canthus, which could be drawn outwards so as to cover the front of the globe. The orifice of the external meatus, so small as only to admit a fine probe, was situated $2\frac{1}{4}$ inches behind the external canthus.

The pectoral limb was 12 inches long and 4 inches in greatest width ; five digits, each with a long and strong convex nail on the dorsum, were individualised at the distal border of the manus. A groove on the surface of the limb, between the pollex and index, was short and shallow, but the surface grooves which differentiated the other digits became deeper and more elongated as one passed from the second to the fifth digit, and possessed a narrow intermediate web. Both surfaces of the limb were covered with hair, and the nails projected beyond the distal border of the limb.

The left hind limb measured from the head of the thigh bone to the tip of the innermost digit $25\frac{1}{2}$ inches, and from the fold at the root of the tail to the tip of the same digit $12\frac{1}{4}$ inches ; but the corresponding measurements were not quite so long on the right side. The pes was pentadactylous. The first and fifth toes were very much longer and bigger than the three intermediate digits, so that the posterior free border of the foot was deeply concave. A broad and deep web connected the toes together, and only the tips of the three intermediate digits projected beyond the free border of the web, but their outline was distinct on both the dorsal and plantar surfaces, more especially on the latter. The web was longitudinally wrinkled, and permitted the toes to be approximated or drawn widely asunder, so as to make the greatest width of the foot 11 inches. Both the dorsal and plantar surfaces of the foot were haired up to the free distal border of both web and toes, and no trace of nails was seen.

The vent was elongated from before backwards, and was situated a little in front of the ventral aspect of the tail. Into it the urethra, vagina, and rectum opened. A pair of nipples projected from the abdominal wall about 16 inches in front of the vent; when pressed on, each nipple receded into a depression in the integument.

The hair of the face and back was dark grey, dashed with a brown or yellow tint; down the sides and belly it was lighter and more yellow, with a dash of reddish-brown, but the brownish tint was to some extent due to discoloration from the oil which had escaped out of the blubber amongst the hair. In Dr. Gray's figure of a female Elephant Seal in the Voyage of the "Erebus" and "Terror" (pl. ix.), the face and the sides and belly are coloured a lighter yellow than was seen in my specimen. Mr. Eaton [1] does not refer to the yellow colour of the hair, which he says in some specimens is uniformly reddish-brown, in others is pale, blotched and spotted with darker grey.

SKELETON.—There does not appear to be on record any detailed description of the skeleton of the Elephant Seal, or of the characters which differentiate the bones of the male and female. F. Cuvier has given [2] a short description of the skull. Some measurements both of the skull and other bones have been recorded by Mr. J. A. Allen in his monograph on the North American Pinnipeds.[3] Professor Flower has described some characters of the cranium of a splendid specimen of a large male from the Falkland Islands,[4] and in the Catalogue of the Skeletons of the Mammals in the Museum of the Royal College of Surgeons of England[5] he has given the length of the articulated skeleton as 4500 mm. from tip of nose to end of tail, and 4890 mm. to end of posterior digits. Dr. St. George Mivart has also published[6] short notes on the cranium. A more detailed description is still, however, a desideratum. It is especially necessary to make a comparison of the male and female crania, as they differ from each other so much in size, and to some extent in relative proportions, that a naturalist, in ignorance of the animals from which they had been obtained, might easily regard them as belonging to different species. As the collection contained crania in different stages of growth, some observations on the influence of age on the skull have also been made.

Skull.—The skulls which have been examined whilst writing the following description consisted not only of those collected by the Challenger, both males and females (p. 3), but of a fine male, which had been shot on Heard Island, presented to me for the Anatomical Museum of the University of Edinburgh by my former pupil and assistant, Professor J. Halliday Scott of Dunedin, N.Z.

In the following table I have stated the measurements of the three male skulls, and of the large female (*f*) shot at Betsy Cove; and to allow their relative size to be compared with that of other recorded specimens, I have, in addition to a number of new measurements, also adopted those employed by Professor Flower in his account of the skull of

[1] *Proc. Roy. Soc. Lond.*, vol. xxiii. p. 502, 1875, and *Phil. Trans.*, vol. clxviii. p. 96, 1879.
[2] *Mém. du Muséum*, t. xi. p. 200, pl. 14, 1824.
[3] U.S. Geol. Survey, Washington, 1880.
[4] *Proc. Zool. Soc. Lond.*, January 4, 1881.
[5] London, 1884.
[6] *Proc. Zool. Soc. Lond.*, May 19, 1885.

the Elephant Seal obtained from the Falkland Islands, and, for convenience of reference, have included in the table the measurements of his specimen.

From this table it will be seen that none of these skulls equalled in length the Falkland Island specimen, or indeed two other large skulls referred to in Professor Flower's table on p. 147 of his memoir, but that they closely approached in length the skull in the Berlin Museum obtained in Kerguelen Island by the German Transit of Venus expedition. In their other dimensions also they were much smaller than the skull from the Falkland Islands above referred to, which is much the largest specimen that has yet been measured. The very material difference between the dimensions of the male skulls and the largest female will at once be recognised. It will be of importance therefore to determine, if possible, whether this difference is sexual or merely due to a difference in relative age. The female skull is, I believe, to be regarded as approaching adult, for the occipito-sphenoidal synchondrosis was obliterated, except for a faint trace on the surface of the bone on each side, and the junction between the pre- and post-sphenoids was only indicated by a surface mark. But it should be stated that in the cervical vertebræ which accompanied this skull the plate-like epiphyses of the bodies were not ankylosed. In the female skull next in size to the above, the condylo-premaxillary length of which was 274 mm., both the basi-cranial synchondroses were unossified, though the interval between them was narrow.

Table I.—Crania of Elephant Seal.

	♂ Challenger. Heard Island. *h.* mm.	♂ Prof. Scott. Heard Island. mm.	♂ Challenger. Kerguelen Island. *e.* mm.	♀ Challenger. Kerguelen Island. *f.* mm.	♂ Prof. Flower. Falkland Islands. mm.
Length from front of premaxilla to occipital condyle,	486	493	402	300	564
,, ,, to occipital crest,	508	497	392	296	597
Extreme interzygomatic width,	354	350	281	222	384
Extreme width between occipital crests,	203	201	187	171	242
Greatest width at posterior edge of external meatus,	284	303	253	199	...
Greatest width of palate,	178	154	124	89	185
Width of maxilla across middle of rostrum,	168	160	122	73	176
Width between outer sides of base of upper canines,	160	146	106	62	158
,, ,, upper lateral incisors,	58	...	43	31	60
,, ,, lower canines,	...	83	64	38	93
Length of palate from mesial notch behind to incisor teeth,	250	248	176	128	272
Height of skull from basion to middle of occipital crest,	167	160	141	112	...
Smallest inter-frontal width in plane of upper surface,	65	71	52	38	...
Length of nasals,	55	65	55	43	...
Greatest width of anterior nares,	98	96	82	48	...
Vertical diameter of mes-ethmoid at anterior nares,	80	85	64	48	...
From antero-inferior angle of mes-ethmoid to central incisor,	158	145	127	85	...
Greatest length of mandible,	350	326	253	191	375
Greatest width at condyles of lower jaw,	...	318	236	195	352

In Dr. Scott's male the occipito-sphenoidal synchondrosis was obliterated mesially, but on each side a gap about 1 mm. wide separated the two bones; the synchondrosis between the pre- and post-sphenoids was, however, open both mesially and laterally.

This skull, therefore, had not yet reached a stage in which the possibilities of additional growth in length at the basis cranii were exhausted. In the Challenger specimens from Heard and Kerguelen Islands both the occipito-sphenoidal and intra-sphenoidal synchondroses were still unossified, so that if these animals had lived, their crania would undoubtedly have increased in length and in other dimensions. It will be noticed from the measurements given in Table I. that though the condylo-premaxillary length in Professor Scott's specimen was more than the same dimension in the Challenger skull from Heard Island, yet that the length to the extreme projection of the occipital crest was greater in the latter cranium. The difference in absolute dimensions between the male and female crania is clearly therefore to be regarded as a sexual differentiation.

Important sexual characters were seen also in the teeth in the two sexes. In both the males and females the formula was—incisors $\frac{2-2}{1-1}$, canines $\frac{1-1}{1-1}$, post-canines either $\frac{5-5}{5-5}$ or $\frac{4-4}{4-4}$, although in one female there were six post-canines on one side of each jaw. But the relative size of the teeth in the two sexes varied very materially, especially in the canine and incisor teeth. In Table II. I have given the comparative dimensions of some of the teeth in one of the Heard Island males and in the largest female from Betsy Cove, Kerguelen; all these measurements were taken in a straight line.

TABLE II.—RELATIVE SIZE OF TEETH.

	♂ Heard Island. mm.	♀ Kerguelen Island. *f.* mm.
Length of upper canine,	153	...
,, its enamelled crown,	24	16
Greatest transverse diameter at alveolar border,	36	12
Length of upper inner incisor,	44	...
,, its enamelled crown,	5	7
Length of upper outer incisor,	75	...
,, its enamelled crown,	7	8
Length of first post-canine,	39	...
,, its enamelled crown,	5	6
Length of last post-canine,	22	...
,, its enamelled crown,	4	4
Length of lower canine,	140	...
Greatest transverse diameter at alveolar border,	39	9

The incisor and canine teeth had conical crowns and elongated single fangs, which in the canine teeth were fluted. The crowns of the post-canines were somewhat laterally compressed, and many of them were marked by shallow, vertical grooves, which indicated a division into two or even three imperfect lobes or cusps; the fangs were all simple. In the older crania the greatest circumference of the teeth was after they had emerged from the alveoli, and where in the living animal they would have been embraced by the gum. Also in these older crania the entrance into the pulp cavity was obliterated, excepting in the canines, but in the younger skulls the communication with the pulp cavity at the tip of the fang was freely open in all the teeth. In both of the large males the canines were not only worn down somewhat at the apex, but the lateral aspects, where the upper and lower canines had rubbed against each other, were much flattened. In the Kerguelen Island male (*e*) the teeth showed very slight signs of wear, so that this animal was far from being adult.

When the skulls of the females were placed side by side with that of either of the large males, other differences than that of relative size were observed. In the female skull the summit from the occipital crest to the fronto-nasal suture was almost flat, but sloped downwards and forwards on the nasal bones; the occipital crests were only faintly indicated; the skull possessed great width in the occipital, parietal, and temporal regions, and then suddenly narrowed in the frontal and interorbital regions. The temporo-zygomatic fossa was capacious and continuous with the orbit, and the zygomatic arch was massive and bulged outwards. In both the large males the temporo-zygomatic fossæ and arches were like those in the female, but on a larger scale. The summit of the skull was not flat, but concavo-convex from behind forwards, the posterior concavity being due to the elevation of the occipital crests and posterior border of the parietal bones. The frontal bones were also somewhat depressed below the plane of the two parietals, between the anterior borders of which they were received, but further forwards the frontals were raised into a slight convexity in the interorbital region, and at their anterior ends subsided into a hollow corresponding to the fronto-nasal suture. In the Kerguelen Island young male (*e*) the occipital crests were much lower than in the other males, and the summit of the cranium was less removed from the flattened form of the skull seen in the female, and this flattening of the vertex was a character in all the young skulls, both male and female. The frontal region in all the crania was constricted as compared with the great breadth of the occipital, parietal, and temporal regions; but in the males the frontal width in front was proportionally more than in the female, owing to the greater width of the anterior nares in the former sex. In the younger crania the interfrontal width was not so constricted posteriorly as in the adult skulls. The greatest width of the skull at the zygomata was at a point about midway between the two ends of the arch.

The relative size of the orbits and temporo-zygomatic fossa was studied by comparing the diameter, measured from the anterior surface of the cranial box at or near the fronto-parietal suture to the tip of the antorbital process, with the orbital diameter from the tip of that process to the apex of the ascending or orbital process of the malar. In the two older males the orbital diameter, as measured between the above two points, was about two-thirds that of the entire distance; in the younger male (*e*) the orbital diameter was about four-fifths that of the entire distance, whilst in the female (*f*) and in the youngest skulls, both male and female, the orbital diameter was almost equal to the distance from the cranial box to the antorbital process, so that the orbital process of the malar bone was almost in the same transverse plane as the anterior wall of the cranial box, instead of being considerably in front of it as in the older male crania. The temporo-zygomatic fossa had therefore a greater relative antero-posterior diameter in the adult males than in the female and in the younger skulls of both sexes, and this was correlated with a greater elongation of the constricted part of the frontal region. The zygomatic process of the temporal was bent abruptly upwards behind the orbital process of the malar, as far as, or almost as far as its tip, and the two bones formed a lofty process in this region of the face. The antero-inferior angle of the parietal bone articulated with the alisphenoid.

The nasal bones in both sexes were relatively short, triangular, and with the apices received between the anterior diverging borders of the frontals; the base was forwards and with a notch marking the interval between the two bones. The anterior edge of the mes-ethmoid was vertical, and grooved for the reception of the nasal cartilage; in the males it came forward as far as the anterior border of the nasals above, but in the females not quite so far forwards; whilst below it was lodged in the bottom of the spout-like vomer, the anterior end of which projected horizontally for some distance beyond the mes-ethmoid and the anterior border of the nasals. The premaxillary bones consisted only of a horizontal part, which was prolonged far in front of the anterior nares, so that in the males this bone had the extreme length of about 140 mm., and in the largest female 69 mm. In the larger skulls each bone possessed a *premaxillary tubercle* above the incisor teeth. The anterior end of the beak was broadly truncated in the males, and the superior maxillæ with their canines were almost in the same transverse plane as the incisor teeth. In both sexes the upper surface of each premaxilla was almost horizontal and fitted on to the inner surface and anterior end of the superior maxilla; it bifurcated posteriorly, the inner fork articulating with the outer side of the anterior end of the spout-like vomer, whilst the outer broader fork rested on the horizontal portion of the superior maxilla. As the premaxilla did not possess an ascending part it did not enter into the formation of the lateral boundary of the anterior nares.

The anterior nares were wide, and owing to the vertical direction of the mes-ethmoid and their steep and almost vertical lateral boundaries, were in the vertical transverse plane of the face almost on a level with the front of the zygomatic arch. They were bounded above by the nasals, laterally by the nasal process of each superior maxilla, and below by the vomer, superior maxillæ and premaxillæ, whilst the interval between the mes-ethmoid and outer wall of each chamber was filled up by the highly subdivided maxillo-turbinal, which came forwards so as to be in the plane of the opening. In Table I. the height and width of the anterior nares in the two sexes are given, from which it will be seen that in the male the width is proportionally greater than the height. In the male also the upper jaw is prolonged in front of the anterior nares, both absolutely and relatively more than in the female, and the superior maxillæ in the male extend laterally beyond the premaxillæ, much more than in the female, which is due partly to the much greater magnitude of the incisor and canine teeth in the male sex, and partly to this region of the skull being associated with the development of a proboscis in the male and not in the female. There is therefore a marked difference in the two sexes between both the length and breadth of the pre-nasal part of the skull, and between the adult and younger male crania in the same region.

As the nasal cartilages had been preserved in the Kerguelen Island male skull I examined their arrangement and connections. Attached to the anterior border of the two nasal bones was a triangular cartilaginous plate, 80 mm. long, the apex of which was directed forwards. It prolonged the roof of the nose forwards in the plane of the nasal bones, and had at one time evidently been divided into two lateral halves, as traces of a median suture could be seen on its upper surface. By its under surface it was fused with the septal cartilage, which was prolonged forwards in the mesial plane from the anterior border of the mes-ethmoid for 12 mm. in front of the premaxillaries. Where it rested in the vomer and on the premaxillæ it was broadened out into a base varying in width from 30 to 40 mm. Attached to each lateral border of the roof cartilage of the nose was a lateral cartilage, which passed outwards as far as the superior maxilla, where it formed the side wall of the anterior nares. The two formed a pair of alar cartilages, and were near their maxillary attachment fibrous in their structure.

The antorbital (maxillary) process was a well-marked triangle in both sexes, and was situated immediately behind the anterior nares, whilst the infraorbital foramen was somewhat in front of the nasal opening in the skull. The postorbitals were wanting, but in one skull a strong fibrous band stretched from the orbital process of the zygomatic arch to the side of the frontal bone, and completed the ring of the orbit posteriorly. The ascending processes of the superior maxillæ, like the nasals, were received between the two diverging frontals.

The hard palate was widest immediately behind the last molar tooth ; it was concave anteriorly and mesially, though without much depth, and its outer edge behind the dentary arcade was scarcely raised above the general plane of the surface. In one male skull this edge extended 132 mm. from the socket of the 5th post-canine to the palato-pterygoid suture, and in the largest female 69 mm. The palatal surfaces of the premaxillæ were triangular, and the apex of each was received between the superior maxillæ ; an almost obliterated naso-palatine foramen was situated mesially between the premaxillæ. The palato-maxillary suture was almost transverse, and placed some distance behind the last molar tooth, though immediately behind the root of the malar process of the superior maxilla ; behind it the palate diminished considerably in breadth, and at its posterior border was doubly festooned, with a slight posterior process in the region of the mesial palatal suture. The vertical plate of the palate bone extended behind the posterior edge of the hard palate, and overlapped the outer surface of the pterygoid. The hamular process was distinct and curved backwards and outwards. In the older males the posterior border of the hard palate was in the same transverse plane as the lower border of the articulation between the malar and the squamoso-zygomatic, and a little in front therefore of the glenoid fossa; but in the female and younger skulls it was in a transverse plane, a little in front of this articulation.

The posterior edge of the nasal septum did not in either sex extend so far back as the posterior nares, and consisted of the posterior border of the vomer, which sloped downwards and forwards, and of an ascending vomerine crest from the palate bone, articulating with the vomer in front of the truncated border.

The alisphenoid canal was absent. The tympanic bulla was smooth and only slightly elevated; its general form was triangular, and prolonged into the greatly elongated wall of the external meatus; it was perforated at the postero-internal angle of the base by the canal for the internal carotid artery, which looked almost directly backwards and was quite distinct from the foramen lacerum posterius. When opened into, the tympanic cavity was seen to consist of a chamber as big as a walnut, with which both the external meatus and Eustachian tube communicated. At the posterior part of the roof and immediately above the orifice of the meatus was a subordinate chamber of the tympanum about the size of a hazel nut, and situated immediately to the outer side of the petrous element; it opened by a narrow fissure into the cranial cavity. As the tympanic ossicles have already been so fully described by Mr. Doran[1] and by Professor Flower,[2] and figured also by the former anatomist, it is unnecessary to redescribe them, as they correspond so closely with the accounts which they have given. I need only state that the stapes showed no trace of a division into crura. The optic foramina opened separately into the cranial cavity, and between them was a mesial plate of bone continuous with a prominent crista galli. The tentorium was partially ossified, although not so extensively as in some seals. In the young skull, the cap of which had been sawn off for the removal of the brain, the transverse diameter of the cranial cavity (148 mm.) was markedly greater than the antero-posterior (127 mm.).

The occipital condyles closely approximated in front, and in the males were separated by a narrow groove. In the females the condyles were more widely divergent than in the males. In one female where the process of maceration was carefully watched, a broad plate of unossified cartilage, continuous with the basis cranii, extended backwards along the inner border of each condyle for 29 mm. from the basi-occipital, so that the foramen magnum was greatly diminished in size, as compared with a fully macerated specimen; in two of the males the corresponding plate of cartilage had undergone a

[1] *Trans. Linn. Soc. Lond.* (Zool.), ser. 2, vol. i., 1876. [2] *Proc. Zool. Soc. Lond.*, January 4, 1881.

partial ossification. A pair of foramina opened on the outer surface of the occipital bone immediately behind the foramen magnum, and the canals continuous with them running vertically upwards in the substance of the supra-occipital, opened again on the surface below the occipital crest, the distance varying in different specimens; the canals and foramina probably transmitted veins, and may appropriately be named *supra-occipital*. The basi-occipital was not perforated, and in the older skulls was marked by a transverse ridge. A slight paroccipital process was present in the older males, but in the young male and the females it was just visible. The mastoid was scarcely differentiated as a process.

The lower jaw was much more massive in the males than females, due in part to the magnitude of the canine teeth and the size of the areas of attachment of the muscles of mastication. In none of the specimens had fusion at the symphysis taken place. The lower border of the body of the bone was slightly everted and terminated abruptly behind in one of the males, but not in the other or in the females. At the posterior border of the ascending ramus a *subcondyloid process* projected backwards a little below the neck of the bone. The condyle was transversely elongated, the coronoid process was low, and the sigmoid notch was shallow.

Spine.—The description of the bones of the neck, trunk, and limbs has been based upon the study of the skeleton of the well-grown male (*e*) from Betsy Cove, Kerguelen, though the skeletons of the younger specimens have been also examined. In no specimen were the plates ankylosed to the bodies, and the cartilaginous tips of the spinous, transverse, and mammillary processes were unossified.

The vertebral formula was C 7, D 15, L 5, S 3, Cd 10 = 40.

The *cervical* vertebræ, except the 7th, possessed a foramen at the root of the transverse process; in all except the axis this process was a massive bar of bone projecting downwards and outwards, but not flattened into a plate except in the atlas. Evidence of the presence of two tubercles at the end of this process was seen in all except the axis and the 7th. The spinous process was feeble, except in the axis, where it was massive. The articular processes were antero-posterior in direction, the anterior pair looked upwards and inwards, the posterior pair downwards and outwards. The bodies were elongated transversely. The *atlas* had plate-like transverse processes which projected outwards and very slightly downwards; the articular surfaces for the occipital condyles were deeply concave, and separated from each other by a distinct interval; the lamina on each side was perforated by a foramen for the vertebral artery. The articular surface for the odontoid was continuous with the posterior articular facets for the axis, and they were covered by a common plate of cartilage. The *axis* had a well-marked odontoid process and the bone showed the remains of the intervertebral disc between this process and the body of the axis. A broad plate of cartilage covered the inferior surface of the process, which was separated from the cartilage covering the anterior articular surfaces by a narrow groove on each side. The surface of the odontoid for the transverse ligament was covered by a much narrower plate of cartilage. The transverse process was very short and pointed.

The *dorsal* vertebræ had low spinous processes, those of the 2nd and 3rd being the most prominent. They projected slightly backwards. The transverse processes were thick and strong in the anterior and middle regions, but posteriorly they had almost disappeared. Notwithstanding the relative disappearance of the transverse processes in the last five dorsal vertebræ, each possessed a large articular surface for a rib in the region where the transverse should have been, so that throughout the series the vertebræ possessed both an articular surface or surfaces on the side of the body for the head of a rib and one for the tubercle. The last five dorsal vertebræ had only a single facet on each side of the body, which was placed at its anterior part. Anapophyses were very faintly marked in the 11th to the 14th vertebræ. Metapophyses were no more than very slightly indicated in any. Only the more anterior and posterior dorsal vertebræ were keeled on the ventral surface of the body.

Each *lumbar* vertebra had a transverse process directed downwards, forwards, and outwards. The spine was strong but low. The mammillary processes were short and rounded and directed forwards and outwards. The anterior articular processes were slightly concave and directed upwards and inwards, the posterior convex and directed downwards and outwards. The bodies were elongated antero-posteriorly and faintly keeled on the ventral surface.

The *sacral* vertebræ were apparently three in number. The 1st was massive, 7·2 cm. in antero-posterior diameter, and 16·5 cm. in transverse diameter at the base. Its lateral articulation for the ilium was ear-shaped below, and rough above for the great sacro-iliac ligament. This bone diminished rapidly in transverse diameter from the base to the posterior surface. Its neural arch was complete in the larger animal, but the laminæ had not met in the young female. The 2nd sacral vertebra was 6·6 cm. in antero-posterior, and 9·7 in its greatest transverse diameter. Its neural arch was complete in both pelves. At first I thought that it had a slight articulation laterally with the ilium, but a fresh examination leads me to say that it did not quite reach it. In addition to the articulation between the bodies it articulated in front with the 1st sacral by a pair of truncated processes springing from the pedicles, and situated ventrally to the proper anterior articular processes, and behind it articulated with the 3rd sacral by a corresponding pair of processes. The inferior and superior sacral foramina were situated ventrally and dorsally to these processes. The 3rd sacral vertebra was smaller than the 2nd, and had in both pelves a complete neural arch. The epiphyses between the bodies of the 1st and 2nd and the 2nd and 3rd sacral vertebræ had fused with each other, but had not ankylosed to the bodies of the vertebræ to which they belonged.

I have referred ten vertebræ to the *caudal* region. The first caudal had a neural arch, the next one had a neural groove, the laminæ not being united; the rest consisted only of elongated bodies, diminishing in size to the end of the tail, the last being only 1·4 cm. in length.

Ribs.—There were fifteen pairs of ribs, nine of which articulated with the sides of the sternum. The head of the 1st rib articulated with the side of the body of only the 1st dorsal vertebra, but the heads of the ribs from the 2nd to the 11th, both inclusive, articulated with the sides of the bodies of two vertebræ. The heads of the four most posterior ribs articulated each with the body of only a single vertebra. The 1st to the 11th ribs, both inclusive, possessed each a well-defined neck, with a distinct interval between the head and the tubercle; but in the last four ribs the neck was stunted and the head and tubercle were more closely approximated, so that in the last rib they were separated by an interval of only 8 mm. In a straight line the osseous part of the 1st rib measured 145 mm., and the bony shaft gradually increased in size to the 8th rib, which was 390 mm. in length, from which again the ribs diminished to the 15th, which was 232 mm. long. The ribs as a rule were curved; their shafts were thick and with three surfaces, external, anterior and posterior. The two last ribs were almost straight. The massive costal cartilages of the sternal ribs were either longer than, or closely approximated in length to, the osseous division of their respective costal arches. The cartilages of the asternal ribs were attenuated at their inner ends. In this animal the ligamentum conjugale costarum originally described by Professors Mayer[1] and Cleland[2] was seen to great advantage. As in the seal which Professor Cleland dissected, it consisted of a strong ligamentous band attached on each side to a depression situated immediately below the cartilage covering the undivided articular surface of the head of each of the ribs which articulated with the bodies of two vertebræ. It entered the spinal canal in the plane of the intervertebral disc, immediately above which it was situated, and its inferior surface as well as the superior surface of the disc was smooth and polished, and was covered by a synovial membrane, continuous with that of the costo-vertebral joint on each side. There can be no doubt therefore that this ligament plays upon the upper surface of the disc in the respiratory movements of the ribs. It was kept in its place by the superior common ligament which covered it.

Sternum.—This bone, formed of nine segments, was 960 mm. long. The 1st or præsternal segment was 85 mm. in length, and consisted of a præsternal cartilage, broader posteriorly than anteriorly, where it terminated in a pointed apex, so that it had somewhat of a triangular form. It extended forwards to the neck for 63 mm. in front of the 1st pair of costal cartilages. The 2nd to the 8th segments were plates of bone, the first, second and third of which were longer than broad, whilst the length and breadth of the remainder were almost equal. These segments articulated with each other by movable

[1] *Müller's Archiv f. Anat. u. Physiol.*, vol. i. p. 273, 1834.

[2] *Edinburgh New Philosophical Journal*, vol. viii., April 1859. See also J. B. Sutton, *Journ. of Anat. and Phys.*, vol. xviii. p. 225, 1884, and Ligaments, their Nature and Morphology, London, 1887.

joints, and the margin of the segment next the joint was formed of unossified cartilage. The 9th or xiphisternal segment was situated behind the last pair of sternal ribs; it was 290 mm. long, and whilst its anterior third was ossified, the remainder consisted of cartilage, which widened at its free end into a leaf-like expansion. The first seven pairs of costal cartilages articulated with the side of the sternum at the junction of its segments with each other, the 8th pair was jointed to the side of the 8th segment and the 9th pair at the junction of the 8th and xiphisternal segments. The 8th and 9th costal cartilages also articulated with each other close to the sternum. The maximum sterno-vertebral diameter of the cavity of the thorax was 430 mm. and the greatest transverse diameter of the cavity was 370 mm.

Anterior Extremity.—The *scapula* did not have so well-marked a falciform shape as is usual in the seals. The dorsum was divided into two fossæ; the postspinous was deeply grooved immediately below and parallel to the spine, and its vertical diameter was about three times more than its greatest antero-posterior diameter. The præspinous fossa was almost triangular in shape, and its vertical diameter was about twice as great as the antero-posterior. The area of the præspinous was somewhat greater than that of the postspinous fossa. The spine had no great prominence, and was without an acromion. The coracoid was stunted, and in the younger skeletons was not fused with the body of the scapula. The scapula was prolonged by a triangular suprascapular cartilage, and its extreme breadth or vertical diameter, including this cartilage, was 34·5 cm., whilst the length or antero-posterior diameter was 19·5 cm. The subscapular and præspinous fossæ were smooth and only slightly concave.

The *humerus* was 26 cm. long, and had a strong deltoid ridge with a bicipital groove internal to it. The upper and lower epiphyses were not fused with the shaft; that of the internal condyle was quite distinct from the radio-ulnar articular epiphysis, and that for the head was separate from that for the inner tuberosity. There was no supra-condyloid foramen and the shaft of the bone was not much twisted.

The *radius*, 24 cm. long, was rounded above and had the usual cup-shaped head, and was flattened in its lower half as is usual in seals. The anterior border of the shaft was strongly ridged for the tendon of insertion of the pronator teres. The *ulna*, 28 cm. long, was expanded above at the olecranon and attenuated below. In both bones of the fore-arm the epiphyses were not united to the shafts. The radius was anterior to the ulna, and its cup was a more important factor in the elbow joint than the articular surface of the ulna. The radius articulated at its lower end with the ulna, scapholunar, and cuneiform; the ulna articulated with the radius, cuneiform, and pisiform.

Manus.—The *carpus* possessed seven bones. The *pisiform* was a mere nodule and articulated with both ulna and cuneiform. The *cuneiform* articulated with the ulna, radius, scapholunar, unciform, and 5th metacarpal. The *scapholunar* was large and articulated with radius, cuneiform, trapezium, trapezoid, os magnum, and unciform. The *trapezium* articulated with 1st and 2nd metacarpals, trapezoid, and scapholunar. The *trapezoid* articulated with the trapezium, 2nd metacarpal, scapholunar, and os magnum. The *os magnum* was one of the smallest bones of the carpus, and articulated with the 2nd, 3rd, and 4th metacarpals, the trapezoid, scapholunar, and cuneiform. The *unciform* was shut out from the inner border of the wrist by the approximation and articulation of the 5th metacarpal with the cuneiform; it articulated with the 4th and 5th metacarpals, the os magnum, scapholunar, and cuneiform. The carpal bones were roughened on their palmar and dorsal surfaces for the attachment of ligaments, but there was an absence of the ridges and processes which characterise the corresponding bones in the human carpus.

The *digits* were five in number, and both the entire digit and its metacarpal segment diminished in length from the pollex to the minimus. The three segments of the pollex were longer than the corresponding segments in any of the fingers. The so-called metacarpal of the thumb and the phalanges generally possessed three centres of ossification, one for the shaft and one each for a proximal and a distal epiphysis; the ungual phalanx, however, had only a proximal epiphysis. The metacarpals of the four fingers had only a distal epiphysis, and if a proximal epiphysis had ever been present, it had become fused with and indistinguishable from the shaft of the bone. The 1st metacarpal articulated with the trapezium; the 2nd with the trapezium, trapezoid, os magnum, and 3rd metacarpal; the 3rd with the os magnum and 2nd and 4th metacarpals; the 4th with the os magnum, cuneiform, and 3rd and 5th metacarpals; the 5th with the cuneiform, unciform, and 4th metacarpal.

Pelvis.—The pelvis consisted of the sacrum and two innominate bones. The sacrum has been described above. Each *os innominatum* articulated by the inner or sacro-pelvic surface of the ilium with the area on the 1st sacral vertebra, which was partly auricular and cartilaginous, and partly rough for the great sacro-iliac ligament. In the larger animal, a male, the length of the bone was 320 mm., in a smaller specimen, a female (*c*), 215 mm. The acetabulum, though relatively deep, had only a feeble brim, and the non-cartilaginous covered surface at the bottom was narrow and grooved. The ilium was short, 98 mm., and its crest was 135 mm. long. Its dorsal surface was more than twice as broad as the ventral surface. From the sacro-iliac joint the bone inclined almost transversely outwards to the iliac crest, which was only a little anterior to the transverse plane of the base of the sacrum. The os pubis, ischium, and obturator foramen were all elongated, as is characteristic of the seals, and the diameter from the pectineal tubercle to the pubic symphysis was 240 mm. The junction of the os pubis and ilium was marked by a large pectineal tubercle for the insertion of the psoas parvus. In the larger of the two pelves measured the ischium and os pubis were not fused with each other at the pubic symphysis, but in the smaller female specimen the fusion was complete. The ischial tuberosity was moderate. The epiphysial cartilages at the symphysial end of both pubis and ischium, at the iliac crest, the ischial tuberosity, and the pectineal tubercle were unossified, but the fusion of the three segments of the bone in the acetabulum was complete. The interval between the two pubic bones at the symphysis was of considerable width.

Posterior Extremity.—The *femur* was 173 mm. long, and was characteristically flattened, its greatest width at the condyloid end being 100 mm. The head was smooth and without a depression for the ligamentum teres. The trochanter major was well marked, but there was neither trochanter minor nor trochanter tertius. The anterior flattened surface of the shaft was divided by an oblique ridge, which separated the crureus and vastus externus, and extended from the neck downwards and outwards towards the outer condyle, and on the back of the shaft there was a faint linea aspera. The trochlear surface for the patella was shallow and not continuous with the articular surfaces of the condyles, from which it was separated by an intermediate rough area, to which was attached a broad, strong, ligamentous band connected with the lower end of the patella and the deep surface of the ligamentum patella. This band would separate the patello-femoral joint from the femoro-tibial joints and was doubtless morphologically the same as, though histologically different from, the ligamentum adiposum of the human knee-joint. The condylar articular surfaces were feebly convex and separated from each other by a roughened intercondylar fossa. The epiphyses in one of the larger femora were separable from the shaft, but in the other fusion had commenced.

The *patella* was 45 mm. in its long axis and 41 mm. transversely; its trochlear articular surface was feebly concave and not facetted. Its cutaneous surface was roughened. At its upper end it was 26 mm. thick, and at its lower end only 12 mm.

The *tibia* was 340 mm. long, and the *fibula* was 336 mm. They articulated with each other above and below, and the shafts were separated in the upper three-fourths by an interosseous interval of some width, but in the lower fourth they were closely approximated and united by an intermediate ligament. Each bone had a malleolar prolongation at the lower end, but that of the tibia was very short, and did not articulate with the inner surface of the astragalus. The tibia had a broad surface superiorly, smooth on each side for the femoral condyles, but rough between for the attachment of the semilunar cartilages and crucial ligaments. The shaft of the tibia was almost straight and possessed a ventral surface and ridge for the insertion of the gracilis, semitendinosus, and semimembranosus tendons. Above this ridge was the surface of attachment of the ligamentum patellæ, fibulad to which the shaft was grooved for the tibialis anticus. The posterior surface of the tibial shaft was grooved for the origin of the tibialis posticus, the tendon of which also grooved the back of the lower end of the bone. The fibula was a much more bulky bone than in the human leg, so as to give broader surfaces for the origin of muscles; two peroneal grooves marked the lower end of the shaft and the external malleolus. The epiphyses at both ends of each leg bone were not fused with the shafts.

Pes.—The *tarsus* contained seven bones. The *astragalus* was the largest bone of the foot, and articulated with the tibia by its superior surface, and with the fibula by its external lateral surface, and its fibular surface was almost as large as the tibial; also with the os calcis by its inferior surface, which possessed two facets separated by a deep groove for an interosseous ligament, and by its anterior surface or head with the scaphoid bone; it also had a posterior process which, though massive, did not project quite so far back as the calcanear process of the os calcis, and was not grooved posteriorly. The *os calcis* grooved for the peroneal tendons articulated with the astragalus and cuboid; its calcanear process was longer than, but not so massive as, the posterior process of the astragalus, and possessed at its free end a separate epiphysis. The *scaphoid* had the characteristic form of the bone and articulated with the astragalus, cuboid, and three cuneiforms. Its tubercle for the tibialis posticus was massive, and it had also a pointed plantar process. The *cuboid* had a plantar ridge and peroneal groove; it articulated with the 4th and 5th metatarsals, and by a very small surface with the 3rd, also with the calcaneum, scaphoid, and ecto-cuneiform. The three *cuneiforms* varied much in size, the ento- was the largest, the ecto- next in size, and the meso- so small as only to be seen on the dorsum of the foot. The ento- articulated with the 1st and 2nd metatarsals, the scaphoid, and meso-cuneiform. The meso- with the other cuneiforms, the scaphoid, and the 2nd metatarsal. The ecto- with the 2nd and 3rd metatarsals, the meso-cuneiform, cuboid, and scaphoid.

There were five *toes*. The hallux and minimus, notwithstanding the difference in the number of segments, were of almost equal length, although the hallux had slightly the advantage. The 2nd and 4th toes, almost of equal length, reached to about the level of the articulation of the terminal and penultimate phalanges of the hallux. The 3rd toe was the shortest and ended almost opposite the joint between the 2nd and 3rd phalanges of the 2nd toe. The segments of the hallux were longer than the corresponding segments in the other toes. The 2nd metatarsal was in close relation to the outer side of the 1st, and the tarsal end passed behind that of the 1st, so as to articulate with nearly one-half of its proximal end, the remainder being for the internal cuneiform; this arrangement gave to the tarsal end of the 2nd metatarsal a hook-like form; it articulated with all three cuneiforms and with the 1st and 3rd metatarsals. The 3rd metatarsal was the shortest and articulated at its proximal end with the ecto-cuneiform, slightly with the cuboid, and with the 2nd and 4th metatarsals. The 4th metatarsal was in close apposition with the 5th, and its tarsal end was hollowed on the outer side to allow the 5th metatarsal to be lodged in it; it articulated with the 3rd and 5th metatarsals and the cuboid. The 5th metatarsal, though shorter than that of the hallux, was if anything more massive; its tarsal end articulated with the 4th metatarsal and cuboid, and was somewhat elongated into a process on the outer side of the foot. The ossification of the metatarsals and phalanges was on the same plan as that of the metacarpals and phalanges in the manus. A fold of integument extended for some distance beyond the tip of each ungual phalanx.

The vertebral column was 2580 mm. in length in the largest of the Challenger skeletons (male *e*), measured with the intervertebral discs in place but shrivelled and dried, so that during life the spine would have been somewhat longer; the extreme length of the skull was 402 mm., giving 2982 mm. or 9 feet 9 inches from the front of the premaxilla to the end of the tail. This dimension was very much shorter than that of the male measured by Professor Flower (p. 5),[1] or that which Professor Peters has measured,[2] the length of the spine of which was 3700 mm., and of spine with skull 4200 mm. or 13 feet 9 inches. A spine with skull in the Museum at Cambridge, Mass., measured by Mr. J. A. Allen, and said to be an adult male, was 4340 mm. or 14 feet 3 inches long, and in the same animal the humerus was 335 mm., radius 310, femur 200, tibia 415 mm. in length. If these measurements are compared with those of the corresponding bones in the young male that I have described, it will be seen that they are very materially longer, so that in all probability the Challenger animal had not attained much more than about two-thirds of the growth of an adult male. Great differences in size exist between the adult male and female Elephant Seals. Captain Scammon, whose observations were made on the Californian Sea Elephant,[3] states that the male is frequently triple the bulk of the female—the oldest males average from 14 to 16 feet, whilst the largest he had ever seen measured was 22 feet. Two females which he measured were 9 and 10 feet respectively. Corresponding differences in magnitude may be seen in the skulls of the Southern Elephant Seal measured in Table I.

The length-breadth indices of the skulls measured in Table I., calculated on the relation of the condylo-premaxillary length to the interzygomatic width, were for the three large male skulls respectively 72·8, 70·9, and 68, for the well-grown male (*e*) 69·9, and for the large female (*f*) 74. Calculated on the relation of the condylo-premaxillary length to the width behind the external meatus the indices for the two Heard Island males were 58 and 61 respectively, for the well-grown male (*e*) 62·9, and for the large female (*f*) 66. The greater magnitude of the zygomatic index expresses the greater breadth of the skull in that region.

[1] Notwithstanding the dimensions of this animal the plates were not united to the bodies of the vertebræ, nor the epiphyses of the bones of the fore-arm and fore-leg to their respective shafts.

[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, 1875, p. 393.

[3] The Marine Mammals of the North-West Coast of North America. San Francisco, 1874.

Leptonychotes,[1] Gill.

Leptonychotes, Gill, Arrangement fam. Mam., 1872.

On the 9th January 1874, a seal, regarded as a Sea Leopard, and believed to be a female, was shot at Betsy Cove, Kerguelen. The skeleton was preserved and sent home. It is referred to in the Narrative of the Voyage of the Challenger (vol. i. p. 355), and on p. 373 it is stated that the sandy beach of Heard Island was strewn with bones of both the Elephant Seal and the Sea Leopard, those of the former being the more abundant.

Leptonychotes weddelli (Lesson) (Plate V.).

Otaria Weddellii, Lesson, Férussac's Bull. d. Sci. Nat., vol. vii., 1826, pp. 437, 438.
Leptonyx weddelli, Gray, Ann. and Mag. Nat. Hist., vol. x., 1836.

False Leopard Seal, or Weddell's Seal.

The comparison of the skull of the animal shot at Betsy Cove with the drawings and descriptions of the crania of the seals figured by Dr. Gray in the Zoology of the Voyage of the "Erebus" and "Terror,"[2] has satisfactorily shown that the specimen was not a true Sea Leopard, such as is included under the generic names *Stenorhynchus* (*Ogmorhinus*) and *Lobodon*, but that it was like the specimen of the seal from Santa Cruz, which was named by Dr. Gray after Captain Weddell. Short notes on the characters of the skull of Weddell's Seal have been given by Messrs. Allen and St. George Mivart in their monographs already referred to, but the skeleton generally has not yet been described.

Skeleton.—The animal was not an adult, for the vertebral plates were not united to their centra, and the epiphyses of the bones of the shafts of the limbs were not ankylosed.

Skull.—In drawing up the following description I have examined and compared the skull of Weddell's Seal from Betsy Cove with two well-grown crania of *Stenorhynchus* (*Ogmorhinus*) *leptonyx*, one of which was from Wellington Harbour, New Zealand,[3] but the locality from which the other and somewhat older specimen came is unknown.

In Table III. I have given the comparative measurements of these crania.

In none of the skulls was either of the basi-cranial synchondroses ossified, though the interval between the bones was scarcely more than would admit the edge of a knife.

The dental formula of *Stenorhynchus leptonyx* was—

$$\text{in. } \frac{2-2}{2-2} \quad \text{c. } \frac{1-1}{1-1} \quad \text{p.c. } \frac{5-5}{5-5},$$

and of Weddell's Seal,

$$\text{in. } \frac{2-2}{2-2} \quad \text{c. } \frac{1-1}{1-1} \quad \text{p.c. } \frac{6-5}{5-5}.$$

[1] As the generic name *Leptonyx*, given to Weddell's Seal by Gray, has also been applied to one of the Mustelidæ, to one if not two genera of Birds, and to a genus of Gastropodous Molluscs, I have preferred to adopt the generic name *Leptonychotes* employed by Gill and Allen.

[2] Vol. i., Mammalia, London, 1844-1875.

[3] This skull was presented to the Anatomical Museum of the University of Edinburgh by Sir James Hector, F.R.S.,

In Weddell's Seal the incisors were much smaller than in *Stenorhynchus*, but in both species they were rather recurved, and the laterals both above and below were larger than the centrals. In Weddell's Seal, however, as compared with *Stenorhynchus*, the upper lateral incisors were proportionally bigger than the central, whilst the lower lateral incisors were proportionally smaller than the central. The canines were also similarly formed in both species, but considerably larger in *Stenorhynchus*. The post-canines, however, showed important differences in the two species. In *Stenorhynchus* they had the characteristic three large cusps so frequently described; but in Weddell's Seal these teeth were very much smaller and with a single prominent cusp, which represented the central cusp of *Stenorhynchus*, though in the 3rd and 4th molars in both jaws a rudiment of a posterior cusp was just visible, and a sharp-edged ridge or cingulum ran around the inner side of the base. Except the first the post-canines were two-fanged. The difference in size may be gathered from a comparison of the length of the second upper post-canine,

Table III.—Crania of Leptonychotes and Stenorhynchus.

	Challenger. Weddell's Seal. mm.	Wellington Harbour. *Stenorhynchus leptonyx.* mm.	*Stenorhynchus leptonyx.* mm.
Extreme condylo-premaxillary length,	237	323	321
,, interzygomatic width,	142	161	176
,, width behind external meatus,	157	165	172
Greatest width of palate,	57	68	68
Width between outer side of base of upper canines,	42	57	55
,, ,, of lower canines,	26	46	42
Length of palate in line of mesial suture to central incisor,	87	114	...
Height of skull from basion to middle of occipital crest,	81	91	92
Smallest interfrontal width in plane of upper surface,	22	31	40
Length of nasals,	55	77	89
Greatest width of anterior nares,	29	31	33
Length of mandible,	147	232	241
Width between outer ends of condyles of mandible,	141	164	179

from the alveolar border to the tip of the cusp in both animals. In *Stenorhynchus* it was 15 mm., in Weddell's Seal only 6 mm. In the latter specimen the first and last post-canines both above and below, and on the left side above (where there were six post-canines) the penultimate tooth also, were considerably smaller than the three intermediate teeth, which were about equal in size, but in *Stenorhynchus* there was but little difference in the relative magnitude of the five post-canine teeth both above and below.

In all the crania the extreme length was in the condylo-premaxillary diameter, for the occipital crests, though present, were small. In one *Stenorhynchus leptonyx* measured in the table the interzygomatic width was less than the greatest width of the skull, but in the other the interzygomatic width slightly preponderated; in this animal the widest part of the zygomatic arch was at its hinder end, and the arch diminished in width when traced from behind forwards; in Weddell's Seal the width of the arch was a little greater at its mid-point than posteriorly. In *Stenorhynchus* the distance from the antorbital process to the most anterior surface of the cranial box as compared with the distance from the antorbital process to the orbital process of the molar was as 9 to 7; in Weddell's Seal the former diameter very slightly exceeded the latter. In both specimens of *Stenorhynchus* the total length of the skull both absolutely and relatively was greater than the breadth as compared with the same dimensions in Weddell's Seal. The skull was capacious in the parietal region, and comparatively flattened in all the crania, and became greatly constricted in the frontal region; this constriction was relatively longer in *Stenorhynchus* than in Weddell's Seal. In *Leptonychotes* the antero-inferior angle of the parietal articulated with the alisphenoid; in one *Stenorhynchus leptonyx* they were separated by an epipteric bone; in the other they directly articulated.

In all the crania the nasal bones were elongated and ankylosed together posteriorly and mesially. More than one-half of the length was received between the two divisions of the frontal, where they formed a triangular area, with the apex backwards, whilst the anterior part, lodged between the two superior maxillæ, was quadrilateral in form. The anterior edge of the mes-ethmoid was situated far back in the nasal chamber, and the spout-like vomer, which contained the septal cartilage, sloped downwards and forwards to the anterior nares. The ascending part of each premaxilla entered into the lateral boundary of the anterior nares, but in *Stenorhynchus leptonyx* it did not quite reach the nasal bone, whilst in Weddell's Seal it partially articulated with the anterior end of the outer edge of the nasal. The lateral boundaries of the anterior nares sloped obliquely downwards and forwards, so as to bring the floor of the opening close to the anterior end of the rostrum. The interval between the vomer and the side wall of the nose was occupied by a much subdivided maxillo-turbinal. In *Stenorhynchus* the antorbital process, though small, was distinctly marked, but in Weddell's Seal it was only a faint tubercle; in the former there was an indication of a postorbital process, which was not visible in Weddell's Seal. The antorbital process and infraorbital foramen in all these skulls were in almost the same transverse plane, and considerably behind the opening of the anterior nares. The ascending process of the superior maxilla was not received between the diverging frontals.

In all the specimens the hard palate was widest opposite the last molar, and its concavity was very slight. In *Stenorhynchus* it extended for 40 mm. from the last molar to the palato-pterygoid suture, and in Weddell's Seal for 36 mm., and its border was not raised above the general plane of the palate. The palatal surface of each premaxilla was triangular and the naso-palatine canal was large enough to admit a stilet. The palato-maxillary suture was transverse near the middle line and opposite the last molars, but then sloped backwards and outwards and terminated immediately behind the malar process of the superior maxilla. The posterior border of the hard palate was deeply emarginate, and the posterior border of the vomer was visible between the two diverging bones, though not to so great an extent in Weddell's Seal as in the other species. The angle of junction of the two palate bones in the mesial line of the hard palate was in the younger *Stenorhynchus* about opposite the last molar tooth, and in the older specimen further back and almost on a line with the posterior border of the zygomatic process of the superior maxilla. In Weddell's Seal again this angle was in a plane 11 mm. posterior to the same process. In both specimens of *Stenorhynchus* two small triquetral bones were situated at the antero-internal angle of the palato-maxillary suture, and in Dr. Gray's figure of the skull procured during the voyage of the "Erebus" and "Terror" a mesial triquetral bone is shown in the same region.

The alisphenoid canal was absent. The tympanic bulla was almost hemispherical and smooth in Weddell's Seal, and its antero-internal angle was truncated; in *Stenorhynchus* a keel-like ridge, not very elevated, was prolonged from the postero-external to the antero-internal angle, the latter of which was pointed. The carotid canal was separated from the foramen lacerum posterius in all three specimens by a distinct plate of bone as in the Elephant Seal. A deep fissure also separated the tympanic bulla from the mastoid part of the bone, and in it the stylo-mastoid foramen opened. The two optic foramina had a common opening into the cranial cavity in both *Leptonychotes* and *Stenorhynchus*. The hamular process was barely visible in *Stenorhynchus leptonyx*, but in Weddell's Seal it was present and directed outwards.

The occipital condyles converged and met anteriorly in one skull of *Stenorhynchus* but did not quite meet in the other, and in Weddell's Seal the cartilaginous covered surfaces of the two were continuous. In Weddell's Seal the basi-occipital was thin and perforated by a rounded hole, but in the other crania it was entire. A low par-occipital process was present in *Stenorhynchus*, but was scarcely visible in Weddell's Seal. In both specimens of *Stenorhynchus* the supra-occipital canals opened immediately within the posterior edge of the foramen magnum; in Weddell's Seal a single foramen only was present on the outer surface of the bone close to the foramen magnum.

The lower jaw in Weddell's Seal was proportionally more slender than in *Stenorhynchus*, which was in part due to the smaller size of the teeth, requiring a shallower alveolar border, and in part to the more limited surfaces for the attachment of the masticatory muscles. The body of the bone was straight and smooth, and with no eversion of the lower border. The mandible had scarcely any ascent behind to the condyle, and had no angle; the *subcondyloid process* was absent in *Stenorhynchus leptonyx*, but in Weddell's Seal it was a faint incurved tubercle. In Weddell's Seal the mandible was much more slender than the lower jaw of *Ommatophoca rossi*, or Ross's large-eyed seal, figured in pl. viii. of the Voyage of the "Erebus" and "Terror."

Spine.—Vertebral formula, C 7, D 15, L 5, S 2, Cd 11 = 40. As the animal was immature the vertebræ had not assumed their adult characters, and various of the processes were probably less strongly marked than would have been the case in a mature animal. As previously stated, the epiphysial plates were not ankylosed to the bodies.

In all the *cervical* vertebræ, except the 7th, a vertebrarterial foramen was present between the two roots of each transverse process, and in the atlas the neural arch was also perforated on each side. The transverse process of the atlas was a broad plate projecting almost transversely outwards; that of the axis was short and pointed; those of the 3rd, 4th, 5th, and 6th were more massive, and ended in two tubercles, that of the 7th was a single bar of bone springing from the neural arch. In the configuration of its transverse processes Weddell's Seal approximated closely to the Elephant Seal and differed materially from the corresponding processes in *Arctocephalus*, in which animal they were flattened into broad plates which projected almost vertically downwards, though in the case of the atlas they were elongated downwards and outwards. The axis was the only cervical vertebra with a prominent spine; its odontoid process was 19 mm. high, and fused with the body of the axis. The ventral surface of the bodies of the cervical vertebræ had a mesial keel.

The *dorsal* vertebræ articulated with fifteen pairs of ribs; the 1st with one and a half, the 11th, 12th, 13th, 14th and 15th with only a single rib on each side, the others with the halves of the heads of two ribs. When only a single rib articulated with the side of the body, it was near its anterior part. The transverse processes were prominent from the 1st to the 10th dorsal, behind which they diminished in size, and were scarcely to be recognised in the 14th and 15th dorsal vertebræ. The spines were feeble.

In the *lumbar* vertebræ the transverse processes were elongated, and projected forwards, outwards, and downwards. The spines were not very prominent. The body was keeled on its ventral surface.

The *sacrum* was represented apparently by only two vertebræ, though it is possible that the more anterior of the two caudal vertebræ which possessed a neural arch, might in a mature animal be ankylosed with the sacrum. Of the two vertebræ which I have regarded as sacral, the first was much the larger, its breadth at the base was 100 mm., and its antero-posterior diameter was 40 mm. It had a broad lateral articulation with the ilium, 47 mm. in its longer diameter, whilst the corresponding articulation of the second sacral was only 17 mm. in its longer diameter.

Each of the *caudal* vertebræ, except the two most anterior, consisted of an elongated body, without a neural arch, and they diminished in length from before backwards, the terminal vertebra being only 12 mm. long.

Ribs.—Of the fifteen pairs of ribs, ten articulated with the sides of the sternum. The capitular epiphysis was not in any bone ankylosed to the rest of the rib. The cartilaginous division of the rib was long in relation to the osseous part, and in the 1st rib it was as 87 mm. to 52 mm. The osseous parts of the ribs increased in length from the 1st to the 8th, then they were almost equal in length to the 13th, whilst the 14th and 15th again were shorter. The last two ribs had no tubercles, and in the 13th the tubercle was rudimentary.

Sternum.—This bone was narrow and elongated, 468 mm. long; it consisted of ten segments; all the bony segments were quadrilateral in shape, except the 8th, which was a flattened disc. The first bony segment was more elongated than the others. The margins of articulation of the bony segments consisted of unossified cartilages, and at least one pair of costal cartilages articulated with the side of the sternum where the segments were jointed together; but between the 8th and 9th bony segments both the 9th and 10th pairs of cartilages articulated with the bone. The most anterior or præsternal segment was a slender mesial cartilage of almost uniform transverse diameter throughout, and 70 mm. long; it projected forwards into the neck, and the 1st pair of costal cartilages was articulated at the junction of this præsternal cartilage with the 1st osseous segment. The last or xiphisternal segment was prolonged behind the last pair of sternal ribs; its most anterior half was an elongated bone 50 mm. long, which was continuous behind with a broad plate-like cartilaginous xiphisternum.

Anterior Extremity.—The *scapula* was falciform and 135 mm. in length. The præ- and post-spinous fossæ were almost of equal size. The upper two-thirds of the spine formed so low a ridge as scarcely to be recognisable, the lower third, which was 32 mm. long, projected for 17 mm. from the dorsum of the bone. There was no acromion and the coracoid was feeble.

The *humerus* had a prominent deltoid ridge, inner and outer tuberosities about equal in size, bicipital groove deep, no supra-condyloid foramen, capitellum and trochlea both distinct. It was 117 mm. long.

The *ulna* had a large olecranon; its shaft was traversed by a strong anterior ridge to which the internal lateral ligament of the elbow was attached; its lower end was somewhat rounded, and articulated with radius, cuneiform, and pisiform. It was 136 mm. long.

The *radius* had a cup-shaped head, below which was a feeble bicipital tuberosity. The shaft was rounded above and flattened out at the lower end, which articulated below with a large scapholunar bone, and at its inner border with the cuneiform and ulna. Its length was 126 mm.

The *manus* was pentadactylous. Owing to the coalescence of the scaphoid and lunare there were only seven carpal bones, which were rough both on the palmar and dorsal surfaces for the attachment of ligaments, and which were devoid of ridges and processes. The *scapholunar* articulated with radius, trapezium, trapezoid, os magnum, and unciform. The *cuneiform* articulated with radius, ulna, pisiform, unciform, and 5th metacarpal. The *pisiform* was small, and articulated both with the cuneiform and ulna. The *trapezium* articulated with scapholunar, trapezoid, 1st and 2nd metacarpals. The *trapezoid* articulated with scapholunar, trapezium, os magnum, and 2nd metacarpal. The *os magnum*, though small, articulated with the 2nd, 3rd, and 4th metacarpals, and with the unciform, scapholunar, and trapezoid. The *unciform* was small and did not reach the ulnar border of the wrist, so that the 5th metacarpal articulated with both it and the cuneiform; it also articulated with the scapholunar, os magnum, cuneiform, and 4th metacarpal. The skin on the last phalanx had not been removed, and was covered with yellow hairs both on the dorsal and palmar aspects. Each phalanx had an elongated dark-brown nail on its dorsum. The pollex was the longest digit, and they gradually diminished in length to the minimus. Each of the three segments of the pollex was longer than the corresponding segments in any of the other digits. Its first or so-called metacarpal segment had both a proximal and a distal epiphysis, and in this respect it corresponded with all the phalanges, except the terminal, which latter had only a proximal epiphysis. The metacarpals of the other digits had each a distal epiphysis but no proximal. A pair of small sesamoids was situated on the palmar aspect of each metacarpo-phalangeal joint.

Pelvis.—The *innominate bones* articulated with the 1st and slightly with the 2nd sacral vertebra, and also with each other through the interposition of a cartilage at the pubic symphysis. The ilium was 64 mm. long and its crest was truncated. Its ventral surface was narrow and gave but little room for the attachment of an iliacus muscle. The dorsal surface was four times the breadth of the ventral. From the sacro-iliac joint the ilium passed almost transversely outwards to the crest which, as in the Elephant Seal, was in nearly the same transverse plane as the base of the sacrum. A pectineal tubercle marked the place of junction of the ilium and os pubis. Although the ligamentum teres was absent a narrow and elongated noncartilaginous covered area, bounded by a definite line, was at the bottom of the acetabulum. The ischium, os pubis, and obturator foramen were all elongated. The diameter from the pectineal tubercle to the pubic symphysis was 131 mm. A sharp pectineal line extended from the tubercle to the pubic symphysis. An angular projection on the upper border of the ischium marked the position of the ischial tuber, and between it and the acetabulum, but nearer to the latter, was a ridge which probably represented the ischial spine.

Posterior Extremity.—The *femur*, 96 mm. long, was flattened, and with its epiphyses not ankylosed. The head was smooth and without any depression for a ligamentum teres. The great trochanter was large, and with a digital fossa. There was no small or third trochanter. The condyloid end possessed a shallow trochlear surface for a *patella*, which surface was not continuous with the articular areas on the condyles. The two condyles were separated from each other by an intercondyloid fossa, to which the crucial ligaments were attached.

The *patella* was 21 mm. long, and almost flat on both its articular and cutaneous surfaces. The upper end of the bone was very slightly thicker than the lower.

The *tibia* had a broad upper end with two smooth surfaces for articulation with the femoral condyles, and an intermediate rough part for the attachment of the crucial ligaments and semilunar cartilages. Its shaft had three surfaces above but was antero-posteriorly compressed below. The shaft had just below the condylar end a tubercle for the attachment of the great patellar tendon, and externally an articular surface for the fibula. About the middle of the ventral side of the shaft was a rough ridge for the attachment of the gracilis tendon. The lower end of the tibia was prolonged into a short malleolus, and articulated both with the fibula and the upper surface of the astragalus; it was grooved in front for the tendons of the tibialis anticus and long extensor of the great toe; whilst behind there was also a groove for the tendon of the tibialis posticus. Its length was 201 mm.

The *fibula*, although about equal in length to the tibia, had only half its bulk. Its upper end was relatively broad; the lower end was prolonged into a malleolus, and articulated with the tibia, the outer surface of the astragalus, and by the posterior part of its tip with a small area on the os calcis external to the astragalo-calcaneal articulation. The epiphyses were not ankylosed to the shafts of the two bones of the leg. The interval between their shafts was wide in the middle.

The *pes* was pentadactylous and with dark yellowish-brown hair at the tips of the toes both on the dorsal and plantar surfaces; a small dark-brown nail, concealed amidst the hair, was present on the dorsal aspect of the terminal phalanx of each toe. The hallux and minimus, about equal in length, were much the longest digits, about 280 mm., they were rounded at the tip and the integument extended about 30 mm. beyond the terminal phalanx. Digits 2 and 4, about equal to each other, though 2 was a little longer, reached a little beyond the line of articulation of the 2nd and 3rd phalanges of the thumb. Digit 3 was the shortest, and ended on a line with the articulation of the 2nd and 3rd phalanges of digit 2. Each of the three segments of the hallux was longer than the corresponding segment in the other digits. The phalanges diminished in length from the 1st to the 3rd. The 3rd metatarsal was the shortest. The 2nd metatarsal was equal in length to the 5th, and resembled in shape the corresponding bone in the Elephant Seal; it articulated behind with the three cuneiforms, and the 1st and 3rd metatarsals. The 4th metatarsal was concave on the external lateral surface at its proximal end where it articulated with the 5th metatarsal. The first or so-called metatarsal segment of the hallux had both a proximal and a distal epiphysis, a character which it shared along with all the phalanges except the terminal, which latter had only a proximal epiphysis. The metatarsal bone of each of the four outer toes had only a distal epiphysis. A pair of sesamoid bones was situated on the plantar surface of each metatarso-phalangeal joint.

The tarsalia were seven in number. The *astragalus* was a larger bone than the os calcis. Its posterior process reached behind the corresponding process of the os calcis, and formed the most projecting part of the heel; it was grooved for the tendon of probably the plantaris muscle. Its head passed in front of the same bone, and articulated with the scaphoid and cuboid. Its inferior surface articulated with the os calcis, and its superior and external lateral surface with the two bones of the leg.

The *os calcis* was attenuated behind into a calcanear process, and articulated with the astragalus and fibula on its superior, and the cuboid on its anterior surface. The *cuboid* possessed both a plantar tubercle and a deep peroneal groove, and articulated with the os calcis, astragalus, scaphoid, ecto-cuneiform, and 4th and 5th metatarsals. The *scaphoid* was shaped not unlike the human bone, and articulated with the astragalus, cuboid, and three cuneiforms. Of the three *cuneiform* bones the ento- was much the largest, and the meso- was so small as not to be visible on the plantar surface. The ecto-cuneiform had a peroneal groove on its plantar surface, and it articulated with the scaphoid, meso-cuneiform, cuboid, and 2nd and 3rd metatarsals. The meso-cuneiform was only seen on the dorsum of the foot, and the ento-cuneiform passed so far in front of it that the 2nd metatarsal had to be prolonged both backwards and inwards in order to reach it; it articulated with the other cuneiforms, the scaphoid, and the 2nd metatarsal. The ento-cuneiform articulated with the meso-cuneiform, scaphoid, and 1st and 2nd metatarsals.

The vertebral column of *Leptonychotes* measured, with the discs dried and in position, 1540 mm. or 5 feet, and as the skull was 237 mm. long, the length from the premaxillary bone to the tip of the tail was 1777 mm. or 5 feet 9 inches. As the ossification of the skeleton was so imperfect it is obvious that this seal in its adult condition must grow to be a much longer animal than was the specimen above described.

The length-breadth indices of the skulls measured in Table III., calculated on the relation of the condylo-premaxillary length to the interzygomatic width, were for Weddell's Seal 59·9, and for the crania of *Stenorhynchus leptonyx* 49·8 and 54·8 respectively, but calculated on the width behind the external meatus this index was 66 for Weddell's Seal and 51 and 53·5 for *Stenorhynchus leptonyx*. These figures show at a glance how much wider in relation to the length the skull of Weddell's Seal is than the other two crania.

Otaria, Péron.

Otaria, Péron, Voyage aux Terres Australes, ii., 1816.

Under the generic name *Otaria* I include only those Eared Seals which possess a long and deeply concave palate, truncated posteriorly, and extending back as far as, or nearly as far as, the hamular processes of the pterygoids. One large adult skull, which possessed this character of palate, was collected by the expedition. It was from an animal shot at Port Stevens, West Falkland Islands, and was presented to Sir C. Wyville Thomson by Mr. E. T. Smith. The skin of another specimen, a young male, containing the skull, was presented by Mr. Dean, of Stanley, Falkland Islands. In the Narrative of the Voyage it is stated that along the coast of these islands many bones of seals and whales were scattered.

Otaria jubata (Forster).

Phoca jubata, Forster, 1755, and Schreber, Säugethiere, iii.

Lion Seal.

External Characters.—The young specimen of the Sea Lion obtained at Stanley was probably from fifteen to twenty days old, as the skull which it contained is almost the same size as one in the Royal College of Surgeons of England, which is said to be of that age. The skin had been preserved in salt and was in good condition. It is unnecessary for me to give a detailed description of the skin, as the external characters of the Sea Lion have been so admirably described and figured by Dr. James Murie in his well-known memoir on this animal.[1] It may suffice if I state that from the muzzle to the tip of the tail the length was 36 inches, and 41 inches to the tip of the pes, when the hind foot was drawn backwards. The pinna of the ear was pointed at the tip and 16 mm. long. The hair on the back was dark brown, almost indeed black, but the hair on the belly was somewhat lighter, and with a slight reddish shade in the brown, and there was no under fur. The dorsum of both manus and pes was haired as low down as the nails, but the skin of the palm and sole was hairless and much wrinkled.

Skull.—The skull of the young male closely resembled both in size and appearance the specimen figured by Dr. Murie in pl. lxxvii. figs. 12, 13. The skull of the adult was like that figured by him in the same plate, figs. 20, 21. It also was a male and of full age, for the basi-cranial synchondroses were both ossified, and the teeth were worn. This skull was accompanied by the hyoid apparatus and the atlas vertebra. After the excellent description of the skull of *Otaria jubata* in both sexes and at different ages which has been given by Dr. Murie, it might seem unnecessary again to describe the skull of this animal; but as one of the objects which I have in view in this Report is to make a comparison between the skulls of different genera of seals so as clearly to bring out

[1] *Trans. Zool. Soc. Lond.*, vol. viii. part ix.

their differential characters, I have drawn up a short account of these specimens on the same lines as with the other genera described. I have also compared these Falkland Island crania with the adult male skull of a Sea Lion brought by Dr. R. O. Cunningham, from Laredo Bay, Magellan Strait,[1] with another adult collected at Maldonado, River Plate, by the same naturalist, and with a third adult obtained in guano on the Chincha Islands, off the coast of Peru, all of which specimens are in the Anatomical Museum of the University of Edinburgh. The last-named skull was at one time in the collection of Dr. M'Bain, and was described by him[2] as probably an example of the seal named by von Tschudi and Peters, *Otaria ulloæ*.

The principal dimensions of the crania are given in the following table :—

Table IV.—Crania of Otaria.

	Juv. Stanley, Falkland Islands. mm.	*Adult.* West Falkland Island. mm.	*Adult.* Laredo Bay, Magellan Strait. mm.	*Adult.* Maldonado, River Plate. mm.	*Adult.* Chincha Islands. mm.
Extreme condylo-premaxillary length,	161	365	365	255	252
From basion to optic foramen,	92	148	151	121	107
Extreme interzygomatic width,	97	235	226	154	...
Extreme width, immediately behind external meatus,	90	217	210	125	...
Greatest width of palate,	34	71	62	47	43
Width between outer side of base of upper canines,	33	116	106	...	49
Width between outer side of base of lower canines,	26	91	...	...	...
Length of palate in line of mesial suture to central incisor,	78	...	227	148	142
Height of skull from basion to middle of occipital crest,	66	155	139	90	...
Smallest interfrontal width (at root of crest),	47	20	25	28	17
Length of nasals,	30	70	...	49	39
Greatest width of anterior nares,	24	41	49	34	27
Greatest width at postorbital processes,	54	145	116	85	52
Length of mandible,	100	279	...	...	...
Width between outer ends of condyles of mandible,	91	213	...	...	...

From the above table it will be seen that the adult crania from West Falkland Island and Laredo Bay were in all their dimensions considerably larger than the Maldonado and Chincha Islands specimens, and as all four crania had the basi-cranial synchondroses closed, the question arises—Are the smaller skulls a different species from the larger, or are they the females and the larger specimens the males of the same species? In addition to these differences in size the two larger crania, more especially the West Falkland specimen, possessed lofty occipital, sagittal, and interfrontal crests, the latter of which was grooved

[1] Natural History of the Strait of Magellan, Edinburgh, 1871. [2] *Journ. of Anat. and Phys.*, vol. iii. p. 113, 1869.

on its summit antero-posteriorly; also from each parietal, where it formed the anterior wall of the cranial box, a strong tubercle projected forwards. In the two smaller adult skulls the sagittal and occipital crests were very feeble, and the interfrontal was scarcely marked, and although the frontal bone at the anterior wall of the cranial box bulged forwards, it was not elevated into a tubercular process.

In the young Falkland Island skull, the crests were undeveloped, the summit of the cranium was smooth and the frontal region was only slightly constricted behind the postorbital processes, and its absolute width was about twice as great as the large male crania. The length of the brain-cavity, measured from the basion to the optic foramen, is given in Table IV., so that its proportional length to that of the entire cranium may be estimated, and in the young skull the antero-posterior diameter of the cranial box was more than one-half that of the entire skull, so that the more anterior part of the skull grows in its progress to adult life at a much greater rate proportionally than the brain-cavity.

The dentition in all the specimens was as follows:—incisors $\frac{3-3}{2-2}$, canines $\frac{1-1}{1-1}$, post-canines $\frac{6-6}{5-5}=36$. The individual teeth in the adults possessed the characters which have so frequently been described in *Otaria*, so that I need not dwell upon them.

The teeth in the young male were so much smaller than the adult that they were apparently the milk series. In the upper jaw only two incisors on each side, each with an anterior and a posterior cusp, had cut the gum; $in._3$ being still concealed. Very small canines had erupted, and the points of the 1st and 2nd post-canines could be seen. In the lower jaw the incisors, canines, 1st and 4th post-canines had cut the gum.

As compared with the Elephant Seal, the zygomatic arches were much flatter, and the greatest width was towards the posterior end. The zygomatic and temporal fossæ were not so capacious relatively to the size of the skull, but the frontal region in *Otaria* was much more constricted immediately behind the orbits. In the two adult male skulls the distance from the anterior surface of the cranial box (the tubercular process not being included) to the antorbital process was about twice as great as the orbital diameter from the antorbital process to the orbital process of the malar. In the smaller adult from the Chincha Islands the orbital diameter was three-fourths that of the entire distance, and in the Maldonado skull two-thirds. In the young male from the Falkland Islands the two diameters were almost equal. It follows, therefore, that whilst in the young animal the back of the orbit is in close relation to the front of the cranial box, in the adult male it is separated from it by a wide interval, which marks the position of the temporal muscle and acquires its magnitude in relation to the use of that muscle in the masticatory process. The zygomatic process of the temporal did not curve upwards so abruptly as in the Elephant Seal, and did not reach the tip of the orbital process of the malar, which was much more stunted than in the Elephant Seal.

The nasal bones were relatively short and not ankylosed except in the Maldonado skull;

they diverged from each other posteriorly so as to admit between them in the middle line an anterior or nasal prolongation of the frontal bone. The anterior border of the mes-ethmoid was vertical, but did not quite reach the anterior nares. The anterior end of the spout-like vomer terminated a little in front of the anterior border of the nasals. The horizontal part of the premaxilla was relatively short, and gave origin to a nasal tubercle close to the floor of the anterior nares; in one of the larger skulls the depth of the bone from the anterior nares to the alveolar border was 45 mm., in one of the smaller only 18 mm. The ascending part of the premaxilla mounted upwards and formed the lateral boundary of the nares, and by its upper end articulated with somewhat more than the anterior half of the outer border of the nasal bone. The superior maxilla articulated with the rest of the outer border of the nasal, and completely shut out the frontal from this border. A large, much divided maxillo-turbinal occupied the interval between the mes-ethmoid and the outer wall of the nose, but it did not come quite so far forwards as in the Elephant Seal. The plane of the anterior nares sloped downwards and forwards from the nasal bones to the premaxilla, and the opening was well in front of both the antorbital process and infraorbital foramen. Although the large males possessed massive canines, yet the anterior end of the superior maxillæ with their canines did not lie so near to the transverse plane of the incisor teeth as in the Elephant Seal.

The postorbital processes were transverse in direction, much larger than the antorbital in all the crania, but in the two large crania the antorbitals were several times larger than in the smaller skulls. From Table IV. it will be seen that the skulls differed greatly in width in this region, and this difference in relation to their almost equal length was especially marked in the Maldonado and Chincha Island specimens. In the West Falkland adult a strong fibrous band passed from the postorbital process to the zygoma, and completed the orbital ring posteriorly.

The hard palate had the characteristically elongated form of the genus. In the larger skulls the concavity was much deeper in proportion to the size of the specimens, and the borders of the palate behind the molar teeth converged more closely together than in the smaller crania. The distance from the last molar tooth to the posterior edge of the hard palate was 101 mm. in the large West Falkland Island skull. The greatest palatal width of the larger skulls was either between the canines or the more anterior post-canine teeth, and in the smaller skulls immediately behind the last molar. The premaxillæ were not so distinctly triangular as in the Elephant Seal, and each contained a well-defined naso-palatine foramen. The most anterior part of the palato-maxillary suture was triangular, and either just behind or opposite the last molar tooth. The palatal surface of the palate bone formed nearly one-half of the length of the hard palate, but in one of the larger crania the proportion varied on the two sides owing to these bones not being symmetrical. The dentary border of the superior maxilla, although continued behind the last molar, yet did not nearly reach the length of the posterior border of the hard palate. In the young Falkland Island male the hard palate differed in some respects from the adult; it had scarcely any concavity in its posterior part, but anteriorly it was somewhat hollowed out; the anterior part of the palato-maxillary suture was opposite the penultimate molars; the length of the palatal surface of the palate bone was equal to the length from the palato-maxillary suture to the incisive canal; the widest part of the hard palate was immediately behind the last molars. The posterior edge of the hard palate and the posterior nares in the two large skulls were in the same transverse plane as the anterior border of the glenoid fossa, but in the smaller adults they were a little anterior to that plane, and more so in the young skull from Stanley. The hamular processes were curved and projected downwards, inwards, and then outwards.

The great elongation of the palate in *Otaria jubata* is therefore due to the remarkable antero-posterior diameter of the palatal plate of the palate bone, which completely concealed both the sphenoidal articulation and the posterior border of the vomer, the latter of which was falciform, and did not articulate with the palate, but passed forwards to reach the vomerine crest of the superior maxilla. As the hard palate was covered by the mucous membrane when the skull reached me, I took the opportunity of examining it when softened prior to its removal. This membrane possessed numerous short papillæ, which, in the part of the palate situated between the molar teeth, were arranged in seven low ridges, which were not quite transverse, but with a slight inclination backwards. Between and in front of these rows similar dwarf papillæ were scattered over the mucous surface, but behind the last molars the membrane was smooth.

All the crania possessed alisphenoid canals and mastoid processes. In all, the tympanic bulla had a process projecting vertically downwards from the inferior surface. In the larger adults it was thick and truncated, in the smaller adults it formed a sharp ridge; in the young male, although the ridge did not project so much as in the smaller adults, it was quite as thick. The tympanic cavity was opened into in the Maldonado specimen, and consisted of a large chamber, dilated below, which suddenly narrowed as it ascended to the outer side of the petrous-temporal. The carotid canal opened within the boundary of the jugular foramen. The occipital condyles were not continuous anteriorly in the adults but separated by a definite interval, and their inner borders in front lay in a plane running almost directly from before backwards; in the young skull, however, the condyles were continued into each other in front, and the cartilage was prolonged from one to the other. No supra-occipital foramen was visible either at the foramen magnum or below the occipital crest. The inferior surface of the basi-occipital had in the four adult crania an elevated ridge running antero-posteriorly, and there was no mesial perforation in any of the skulls. The carotid canal opened immediately within the boundary of the jugular foramen. The par-occipitals were stunted.

The skulls from the Falkland Islands were the only specimens which possessed a lower jaw. The angle was marked by a ridge-like tubercle which projected backwards. A strong, quadrangular, inflected subcondyloid process sprang from the posterior border of the ascending ramus; it was separated by a notch from the ridge-like angle, and by a still deeper notch from the neck and condyle. The coronoid was broad, thin, and formed an obtuse angle. The body was massive, with its lower border everted, and closely corresponded in its characters to the description given by Dr. Murie. The mandible in the young skull showed on a smaller scale the same character as the adult.

The differences between the larger and smaller adult crania, in addition to that of size, may be summarised as follows:—In the smaller skulls the occipital and sagittal crests were feeble; no parietal tubercle; the antorbital processes much smaller; the interfrontal diameter relatively larger; the front of the premaxilla was both absolutely and relatively less deep, and its nasal tubercle was scarcely marked; the breadth of the palate was greater behind the molars; the tympanic bulla was prolonged downwards into a sharp ridge instead of a thick, truncated process; the length of the brain-cavity in the smaller crania, especially the Maldonado specimen, was, in proportion to that of the entire skull, greater than in the larger specimens; and the antero-posterior diameter of the orbit bore a larger proportion to the distance between the front of the cranial box and the antorbital process. These differences cannot be ascribed to age, for the smaller skulls were as perfectly ossified as the larger crania. As nothing is known of the sex of the animals from which the smaller crania were derived, it cannot absolutely be stated that the differences were sexual only, though without doubt, for the most part, they were such as are mainly occasioned by a more vigorous ossification in the one skull than in the other, as we are in the habit of recognising in male crania when compared with female. That important sexual differences do exist in the crania of the Sea Lions has already been pointed out by Sir Richard Owen,[1] Mr. J. A. Allen,[2] and Dr. J. Murie,[3] and both Drs. Gray[4] and Murie have dwelt on the changes in form which the skull undergoes in passing from the young stage to that of adult life and old age, and the specimens now before me show that the characters of the two smaller adults in many respects approximated to those of the young male Falkland Island cranium.

The opinion of zoologists has greatly fluctuated regarding the number of species which should be referred to the genus *Otaria*, even when that genus is restricted according to the definition given on p. 29. A perusal of the numerous papers on the Eared Seals by the late Dr. J. E. Gray will show how frequently he changed his views on this subject. In a similar manner the late Professor Peters of Berlin from time to time either added to or subtracted from the number of species. It is unnecessary to give a resumé of their various changes of opinion, as this has already been done by Mr. J. A.

[1] Catalogue, Royal College of Surgeons.
[2] *Bull. Mus. Comp. Zoöl.*, Cambridge, U.S., vol. ii. 1870–1871; and History of North American Pinnipeds, 1880.
[3] *Proc. Zool. Soc. Lond.*, 1869; *Trans. Zool. Soc. Lond.*, vol. viii.
[4] *Proc. Zool. Soc. Lond.*, 1859; and Catalogue of Seals and Whales.

Allen in his important monograph above referred to. It may suffice to state that Dr. Gray, in his latest writings[1] on this subject, spoke of four species, viz., *Otaria jubata*, *Otaria minor*, *Otaria ulloæ*, and *Otaria pygmæa*; whilst Dr. Peters, in his last published paper,[2] recognised only one species, viz., the *Otaria jubata* of Forster. Peters regarded the *Otaria leonina* of Fr. Cuvier, and the *Otaria ulloæ* of Tschudi, merely as "Localrassen," whilst he made no mention of the *Otaria godeffroyi* which he had described in May 1866[3] as a distinct species, so that he doubtless ultimately considered it also as only a variety of *Otaria jubata*. The geographical distribution of *Otaria jubata* is said by Peters to extend around the southern half of South America, from Rio de la Plata on the east to Callao and the Chincha Islands on the west. Mr. Allen also favours the view that *Otaria jubata* is the only species, and in addition to its habitat on the South American continent, assigns it to the Galapagos Islands in the Pacific, from specimens collected by the Hassler Expedition, whilst the crania collected by the Challenger, and others previously procured, have established it to be a denizen of the Falkland Islands.

If it be correct to regard the genus *Otaria* as consisting only of the species *jubata*, then it will follow that all the crania which I have described in this section, notwithstanding their great difference in size, and to some extent in proportion, are to be considered as of this species, and the small adult skulls would then be females, whilst the larger crania would without doubt be males. Dr. Murie, in his monograph on the Sea Lion, has given the following dimensions of crania which he has measured. In an adult female the skull was 11 inches long (280 mm.), and 5·8 inches broad (148 mm.); an old male was 12·8 inches long (325 mm.), and 7·5 inches broad (190 mm.), and a very old male 14·3 inches long (363 mm.), and 9·4 inches broad (239 mm.). Mr. Allen records the mean length of eight male skulls at 350 mm., and the mean breadth 223 mm., whilst the mean length of four females was 261 mm., and the mean breadth 143 mm. These proportions closely approximate to the measurements of the adult male and female crania which I have given in Table IV. Mr. Allen also states that there is a wonderful disparity in size between the sexes in *Otaria jubata*, the weight of the adult males being generally three to five times that of the adult females.

The length-breadth indices of the two large male skulls, calculated on the interzygomatic breadth, were respectively 64·3 and 61·9, and on the width behind the external meatus 59·4 and 57·5. The corresponding indices in the smaller adult from Maldonado were 60·3 and 49, and in the young skull 60·2 and 55·9. The difference between the interzygomatic width and the width behind the external meatus was most strongly marked in the Maldonado cranium.[4]

[1] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. xiii. p. 325; and Hand Atlas of Seals.

[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, August 9, 1877, p. 506.

[3] *Op. cit.*, May 17, 1866, p. 266.

[4] I have not thought it necessary to figure the skull of *Otaria jubata*, as Dr. Murie's memoir on this animal is so completely illustrated.

Arctocephalus, F. Cuvier.

Arctocéphales, F. Cuvier, Mém. du Muséum, xi., 1824.

In the Narrative of the Voyage it is stated that Fur-Seals frequented Nightingale Island, one of the Tristan da Cunha group; the Crozet Islands; Kerguelen Island; Juan Fernandez; the Messier Channel; and Elizabeth Island in the Strait of Magellan. Specimens of Eared Seals, which did not possess the elongated concave palate so characteristic of the genus *Otaria* in the sense defined on p. 29, were procured from the Kerguelen group of islands; in Messier Channel on the west coast of South America, and from Juan Fernandez. They consisted of the following specimens from Kerguelen:—Two carcases of young Fur-Seals without the skin, procured from the "Emma Jane" at Fullers Harbour, January 1874; two skeletons of Fur-Seals also at Fullers Harbour, which were distinguished from each other as No. 1 and No. 2 (No. 2 having been killed on Swaine Island). From the Messier Channel were obtained the skin and skeleton of a male and the skin and skeleton of a female, also two skeletons of males shot on rocks in January 1876. The specimen from Juan Fernandez was a skin containing the skeleton of a very young animal.

Arctocephalus gazella, Peters (Pl. VI.).

Arctocephalus gazella, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, June 10, 1875, p. 393.

Kerguelen Island Fur-Seal.

This species of Fur-Seal was described by the late Professor W. Peters from two specimens procured for the Berlin Museum by the German exploring ship "Gazelle," which visited Kerguelen Island shortly after the departure of the Challenger in 1874. The larger of these two specimens was the skin of a male, but without the cranium, whilst the smaller skin contained the head and trunk of a female, not quite adult.

Subsequently to his first description of this species, Peters ascertained[1] that only the female specimen had been obtained from Kerguelen; whilst the male skin was either from St. Paul or Amsterdam Island, and he named it *Arctocephalus elegans*.

The Fur-Seals collected by the Challenger at Kerguelen Island I have referred to *Arctocephalus gazella*. At the request of the late Sir C. Wyville Thomson, I forwarded, in November 1877, the skull of one of the larger specimens (No. 2) procured by the Challenger to Professor Peters for examination. In returning the specimen to me in April 1878, Professor Peters wrote that it was the male of *Arctocephalus gazella*, of which he had previously seen only the skull of a female. The male, he said, showed "all the peculiarities of the species, which consist, amongst others, in the extreme smallness of the tympanic bones, a part which is of so great an importance as it is peculiar for each species."

[1] *Idem*, May 18, 1876, p. 315.

Skeleton.—Neither of the two skeletons from Fullers Harbour had reached adult life, as the epiphyses of the long bones and the plates of the vertebral bodies were not ankylosed to their respective bones.

Skull.—In each of the larger crania the occipito-sphenoid synchondrosis was ankylosed, but the joint between the two divisions of the sphenoid was yet open.

The principal dimensions of the crania are given in Table V.:—

Table V.—Crania of Kerguelen Island Fur-Seal.

	No. 1.	No. 2.
	mm.	mm.
Extreme condylo-premaxillary length,	212	211
From basion to optic foramen,	85	79
Extreme interzygomatic width,	131	120
Extreme width immediately behind external meatus,	120	109
Greatest width of palate,	39	35
Width between outer sides of base of upper canines,	45	42
Width between outer sides of base of upper lateral incisors,	24	25
Width between outer sides of base of lower canines,	30	32
Length of palate to incisor teeth,	92	91
From basion to middle of occipital crest,	77	69
Smallest interfrontal width in plane of upper surface,	33	30
Length of nasals,	29	...
Greatest width of anterior nares,	22	28
Vertical diameter of mes-ethmoid at anterior nares,	...	...
From antero-inferior angle of mes-ethmoid to central incisor,	...	...
Greatest length of mandible,	142	133
Greatest width at condyles of lower jaw,	124	93

Although the ossification of these two crania was so far advanced, yet they possessed no sagittal or interfrontal crest, and there was only the faintest indication of a crest in the occipital region. On the supposition that these crania were males, as was surmised by Professor Peters from an examination of the smaller of the two specimens, it would appear that in this species of *Arctocephalus* the development of cranial crests scarcely if at all occurs.

The dentition was the same in both skulls, and the formula was as follows:—incisors $\frac{3-3}{2-2}$, canines $\frac{1-1}{1-1}$, post-canines $\frac{6-6}{5-5}=36$. The first and second upper incisors possessed the customary anterior and posterior cusps. Both the upper and lower canines had only a single large cusp. The greatest interval between the post-canines was between the 4th and 5th and the 5th and 6th, the interval between the last named being the widest. The 6th post-canine was the smallest, and both it and the 5th in the upper jaw had two diverging fangs; the remaining upper post-canines had only a single fang. The 5th lower post-canine was two-fanged; the remainder one-fanged.

The zygomatic arches were widest behind, and the arch was somewhat flattened. The malar bone formed a larger proportion of the arch than in *Otaria*. The antero-posterior diameter of the orbital cavity, from the antorbital process to the ascending process of the malar was in No. 2 $\frac{9}{11}$ths and in No. 1 $\frac{10}{11}$ths of the distance from the cranial box to the antorbital process. The orbital process of the malar was pointed, and the zygomatic process of the temporal only reached its base, and did not therefore turn up behind it.

The nasal bones were separate, and received posteriorly a mesial process of the frontal between them. The anterior border of the mes-ethmoid did not extend quite as far as the anterior border of the nasals. The anterior end of the vomer reached to 22 mm. of the tip of the premaxilla. The horizontal part of the premaxillæ was short, so that the anterior nares came close to the anterior end of the skull, and the premaxillæ projected so far in front of the superior maxillæ that the upper canines were well behind the incisor teeth. The ascending process of the premaxilla formed the lateral boundary of the anterior nares and articulated with a little more than the anterior half of the outer border of the nasal. The superior maxilla articulated with the nasal behind the premaxilla, but a small part of the frontal also joined the outer border of the nasal behind the superior maxilla. The maxillo-turbinals did not quite reach the anterior nares, the plane of which sloped obliquely downwards and forwards to the incisive region, well in front of both the antorbital process and the relatively large infraorbital canal. The post-orbital processes were transverse and distinctly larger than the antorbital. As the left process was broken off in each skull the width in this region could not be taken.

The hard palate was only slightly concave. Its posterior edge was transverse at and on each side of the mesial suture; it was so far in front of the glenoid fossa as to be in the same transverse plane as the orbital process of the malar bone; and the interval from the posterior edge to the last molar tooth was only 20 mm. The most anterior part of the palato-maxillary suture was opposite the 4th pair of post-canines, which were distinct, and curved backwards, downwards, and outwards, and the posterior border of the hard palate was 29 mm. in front of the hamular pterygoids. The palatal plates of the palate bones did not contribute so much to the formation of the hard palate as the corresponding plates of the superior maxillæ, the dentary border of which latter bones extended almost as far back as the posterior edge of the hard palate. The palatal surface of each premaxilla was quadrilateral in shape, and each contained a large naso-palatine canal. The posterior edge of the vomer sloped very obliquely forwards, and was not seen at the posterior nares, which openings were not nearly so far back as in *Otaria*, and permitted the junction between the pre- and post-sphenoids to be seen.

Both the crania had alisphenoid canals and mastoid processes. The tympanic bulla was almost flattened and marked by only a low ridge. The occipital condyles were separated by a wide interval in front, and their inner borders anteriorly were almost parallel to an antero-posterior plane. The basi-occipital was not perforated mesially. Each skull had a single supra-occipital foramen immediately within the outer edge of the foramen magnum. The carotid canal opened independently of the jugular foramen. The par-occipitals were very slight.

The lower jaw, although much less massive than in *Otaria*, yet had a general resemblance in form ; the subcondyloid process from the posterior border of the ascending ramus was distinct and inflected, and the coronoid process was relatively large. It also had a tubercle which marked the angle, which was feeble as compared with *Otaria*.

Arctocephalus australis (Zimmermann) (Pls. VI., VII.).

Phoca australis, Zimmermann, Geogr. Geschichte, iii., 1783.

South American Fur-Seal.

The specimens from the Messier Channel have furnished me with material for studying both the external characters and the osteology of the Fur-Seal which frequents the southern part of South America.

External Characters.—The external characters were examined in the skins of both the male and female specimens. The principal dimensions were as follows :—

Table VI.—Dimensions of South American Fur-Seal.

	Male.		Female.	
	ft.	in.	ft.	in.
From snout to tip of tail in straight line, ...	4	11	3	10½
From snout to tip of longest digit of pes, ...	5	10½	4	7½
Length of free part of tail, ...		3¾		2½
Length of pectoral limb, ...	1	4	1	2
Greatest breadth of that limb, ...		6½		5½
Length of hind limb from root of tail, ...	1	5¼	1	2
Greatest breadth of that limb, ...		5		4½
From root of pectoral limb to angle of mouth, ...	2	0	1	6

The skin possessed two kinds of hairs, long and short. On the back of the neck and chest the long over-hairs were from one to two inches long, the shaft of the hair being black but tipped with grey or yellowish-grey so as to give a grizzled character. In the lumbar, sacral, and caudal regions the black over-hairs were not more than an inch long, and their tips were grey. On the under surface of the remarkably elongated neck the over-hairs resembled in colour those on the back of the neck, but were not quite so long. On the sides of the body they were like those in the lumbar region, but on the belly they were blackish-brown, and without grey tips. The dorsal surface of both manus and pes was covered up to the nails with black hairs not tipped with grey, but beyond the nails and on the inferior surface of both manus and pes the hairs were absent and the skin was black and beautifully marked with ridges and furrows. The short under-hairs formed the proper fur of the animal and constituted a thick undergrowth, concealed by the long over-hairs, and only exposed when they were parted asunder. The fur was of a brownish or reddish-brown colour.

In the manus rudimentary nails were present on the dorsum of the terminal phalanx of each digit, but that on the minimus was so small as to be detected with difficulty. The pollex was the longest digit and from it they diminished in length to the minimus. The digits were all so closely enclosed in a common fold of skin that any widening of the manus by the muscular efforts of the animal seemed impossible. The skin extended, however, for some two inches beyond the terminal phalanx, being thickened in line with the digits, but thinner and webbed between them. At the free posterior border of the manus it was faintly indented and the position of each digit was marked by a slight projecting fold of integument.

The pes had on the dorsal surface of each of the 2nd, 3rd, and 4th digits a strong curved greyish-coloured nail; on both the hallux and minimus the nail was feeble and scarcely projected beyond the fold of skin at the nail-root. The toes varied but little in length, digits 3 and 2 being slightly the longest, and the minimus being a trifle shorter than the hallux. The hallux was the broadest digit, and next to it the minimus. The toes were connected together by an intermediate web, haired on the dorsum but not on the plantar surface, so that the animal could widen or diminish the transverse diameter of the pes. This web, together with five thickened folds of skin, one corresponding to each toe, was prolonged from 105 to 110 mm. beyond the nails and phalanges. The thickened folds reached the free end of the foot, but the thinner web did not go so far, so that the integument of the terminal border of the foot was deeply indented.

The snout was short and the tip of the nose was black and without hairs. From the upper lip about twenty bristles, arranged in six rows, projected backwards and outwards. As a rule they were white, though some of the smaller were greyish-black. A pair of white bristles projected from the skin immediately above each eye. The external ear was in the male situated 3 inches behind the outer canthus of the eye; it was $1\frac{1}{2}$ inch long in the male and $1\frac{3}{4}$ in the female. It was pointed at the tip, and whilst its dorsum was haired the opposite surface was hairless, hollowed out into a concha and directed forwards and outwards.

In the male the abdominal opening for the penis was 8 inches in front of the vent. The female had two pairs of elongated nipples. The hinder or abdominal pair were $8\frac{1}{2}$ inches in front of the vent, whilst the anterior or thoracic pair were 6 inches in front of the abdominal and only a little behind the transverse plane of the posterior edge of the pectoral fin.

Skeleton.—The four skeletons consisted of one female and three males. The female (No. 2) skeleton was fully ossified. One male (No. 3) was fully ossified; a second (No. 1) had the epiphyses completely fused with the shafts of the long bones only at one extremity, at the opposite a groove of demarcation was still visible; the third (No. 4) again was a much younger animal, and the epiphyses at both ends of the long bones were separable from the shafts.

Skull.—Along with the specimens of *Arctocephalus australis* from the Messier Channel I have examined two skulls from Tuesday Bay, Desolation Island, Strait of Magellan, which were collected by Dr. R. O. Cunningham when acting as naturalist on H.M.S. "Nassau."[1] In all the crania from the Messier Channel, the basi-occipito-sphenoid joint was ossified, and in one specimen only (No. 4) was the intra-sphenoidal joint unossified. The Desolation Island specimens were aged crania and in all probability males.[2] The dimensions of all these skulls are recorded in Table VII.

Table VII.—Crania of South American Fur-Seal.

	♂. No. 1.	♂. No. 3	♂. No. 4.	♀. No. 2.	♂. Desolation Island.	♂. Desolation Island.
	mm.	mm.	mm.	mm.	mm.	mm.
Extreme condylo-premaxillary length,	231	233	206	202	241	245
From front of premaxilla to occipital crest,	225	228	195	179	228	236
From basion to optic foramen,	83	94	86	94	97	103
Extreme interzygomatic width,	...	148	118	116	...	145
Extreme width immediately behind external meatus,	129	138	104	107	142	125
Greatest width of palate,	38	...	31	26	33	33
Width between outer sides of base of upper canines,	52	55	...	34	50	...
Width between outer sides of base of lateral incisors,	26	25	24	19	29	...
Width between outer sides of base of lower canines,	37	35	28	20	...	...
Length of palate to incisor teeth,	101	...	86	85	106	108
From basion to middle of occipital crest,	79	87	77	67	82	83
Smallest interfrontal width in plane of upper surface,	31	...	29	25	25	...
Length of nasals,	36	...	30	30	...	...
Greatest width of anterior nares,	27	...	24	26	31	...
Vertical diameter of mes-ethmoid at anterior nares,	...	...	...	...	28	...
From antero-inferior angle of mes-ethmoid to central incisor,	...	...	...	...	52	...
Greatest width at postorbital processes,	56	...	42	37	...	...
Greatest length of mandible,	162	...	133	139	...	...
Greatest width at condyles of lower jaw,	119	...	111	105	...	...

The Desolation Island skulls and Nos. 1 and 3 from the Messier Channel possessed occipital crests and sagittal crests extending more or less forward into the frontal region, the greatest elevation of which was 10 mm. In No. 4, a younger male from the Messier Channel, and in the adult female, these crests were scarcely developed at all.

[1] These skulls were presented by Dr. Cunningham to the Anatomical Museum of the University of Edinburgh. See his work already cited on p. 30 for an account of the seals in this locality.

[2] Some years ago I left these skulls from Desolation Island, for examination, with the late Dr. J. E. Gray, who made some notes on them in the *Ann. and Mag. Nat. Hist.*, vol. iv. ser. 4, p. 264, 1869. He referred them to the species which he had described as "*Euotaria nigrescens*, the usual Fur-Seal of the Falkland Islands and other parts of the coast of South-West America," the same animal as is described in the text as *Arctocephalus australis*.

The dental formula in all the crania of *Arctocephalus australis* was as follows:—

$$\text{incisors } \frac{3-3}{2-2}, \text{ canines } \frac{1-1}{1-1}, \text{ post-canines } \frac{6-6}{5-5} = 36.$$

In the younger male the left upper canine had not erupted. The two last upper post-canines were two-fanged, the 5th lower post-canine was also two-fanged. The 6th upper post-canine, though smaller than the 5th, yet did not differ much from it in size. In addition to the cingulum and large cusp the lower post-canines possessed a faint anterior cusp, and the last two also a faint posterior cusp, but in the upper post-canines, whilst the rudimentary anterior cusp was present, it was the exception to find a rudimentary posterior cusp, though the last one or two frequently had one.

The zygomatic arches had generally the same form as in *Arctocephalus gazella*. The proportion of the antero-posterior diameter of the orbit to the distance from the cranial box to the antorbital process was in two adult males about $\frac{3}{4}$ths, in the young male about $\frac{5}{6}$ths, and in the adult female about $\frac{12}{13}$ths. The orbital process of the malar was pointed, and the zygomatic process of the temporal only reached its base.

In one Desolation Island skull the nasal bones were ankylosed with each other and with the frontal; in the remaining crania they were separated behind and received between them a mesial prolongation of the frontal. The anterior edge of the mesethmoid did not extend as far forwards as the anterior border of the nasals. The premaxilla articulated by its ascending process with the anterior half of the outer side of the nasal. The superior maxilla articulated with the same bone immediately behind the premaxilla, but in one specimen allowed a slender process of the frontal to be intercalated between it and the nasal, whilst the superior maxilla itself superiorly and posteriorly was received into a recess in the anterior border of the frontal. The upper surface of the horizontal part of the premaxilla was deeply grooved, and the ridges bounding this groove laterally met in front to form a *premaxillary tubercle*, stronger than in *Arctocephalus gazella*, which projected forwards in front of the plane of the incisor teeth. The postorbital processes were stronger than the antorbital and in the male skulls were bent backwards at the tip. The anterior nares sloped downwards and forwards to the premaxillæ and were well in front of both the antorbital process and the relatively large infraorbital foramen.

The hard palate was only slightly concave. Its posterior margin in most of the specimens was truncated, but in two it was slightly emarginate. This margin was in a line almost midway between the glenoid fossa and the posterior border of the malar process of the superior maxilla, and almost opposite the orbital process of the malar bone; in the adult males it was from 25 to 30 mm. behind the last molar tooth, and about the same distance in front of the hamular pterygoids. The hamular processes were distinct and curved backwards, downwards, and outwards. In the female skull a strong fibrous membrane had been preserved, prolonging the palate as far back as the hamular pterygoids, and it is probable that in all seals in which the hard palate is not itself continued as far back, a similar membranous prolongation exists. The most anterior part of the palato-maxillary suture was in one specimen opposite the 4th pair of post-canines, and in another opposite the last molar; a pair of small ossicles was situated in the middle of this suture. The palate bones formed a smaller proportion of the hard palate than the superior maxilla. The premaxillæ had well-marked naso-palatine canals and in one specimen a pair of ossicles was situated behind the maxillo-premaxillary suture. The posterior edge of the vomer resembled that of *Arctocephalus gazella*, and the articulation of the præ- and post-sphenoids was visible.

In the female and young male the tympanic bullæ were swollen and marked by an anterior and a posterior low ridge. In the adult males these ridges were stronger and the posterior one projected downwards as a definite tubercle. Alisphenoid canals and mastoid processes were present. The occipital condyles generally resembled those of *Arctocephalus gazella*. The supra-occipital foramen was not visible. The carotid canal opened independently of the jugular foramen. The basi-occipital was not perforated mesially, and the paroccipitals were only distinct in the male skulls.

The lower jaw of *Arctocephalus australis* in its general form resembled that of *Arctocephalus gazella*, but it was, especially in the adult males, more massive, and the hollowing out of the ramus in the region of the masseter muscle was much deeper.

The hyoid consisted of a transversely elongated basi-hyal, which was articulated at each extremity, both with a thyro-hyal and a kerato-hyal. The kerato-hyal though not so long was thicker than the thyro-hyal. Both the epi-hyal and stylo-hyal were ossified and jointed together, so that nine distinct bones formed the hyoid apparatus.

I do not consider it necessary to give a separate description of the spine and the other bones of the trunk and of the limbs of the Kerguelen Island and South American Fur-Seals, as they are in most respects so much alike that one description will, in a great measure, suffice for both, and such differences as occur can easily be included in it. As one of the Messier Channel specimens was a fully ossified male, the leading description has been written from *Arctocephalus australis*.

Spine.—The vertebral formula was C 7, D 15, L 5, S 3, Cd 11 = 41.

The *cervicals* had, as a rule, a foramen at the root of each transverse process. The 7th cervical was, however, peculiar, for in the adult male from the Messier Channel each of its transverse processes was perforated by a small foramen, but in the other three skeletons from the same place there was no foramen. In both skeletons of *Arctocephalus gazella* the right transverse process was perforated but not the left. In the atlas the transverse process was broad, plate-like and elongated downwards and outwards; in the axis it was much shorter and styloid; in the 3rd cervical the inferior lamella was flattened out into a plate which increased in magnitude in the other cervical vertebræ down to the 6th; in the 7th this lamella was absent except in those specimens in which the transverse process was perforated, when it was a thin, horizontal plate of bone. The spine of the atlas was rudimentary: in the axis it was massive; in the 3rd cervical it was short and it gradually increased in length to the 7th cervical. A strong process, distinct from the transverse process, projected backwards for nearly half an inch from the pedicle of the 7th cervical immediately below the articular process, and indications of a similar process were seen in both the 6th and 5th. The bodies of the cervicals were mesially keeled on the ventral surface, and in the 7th the keel was elongated into a plate-like hypapophysis, which was very projecting in the adult Messier Channel male.

The *dorsal* vertebræ had relatively short transverse processes, which were the longest in the more anterior dorsals, but diminished in length in the posterior dorsals so as to be scarcely recognisable in the 14th and 15th. Anapophyses were present in all the dorsals; in the more posterior they were elongated and styloid, in the middle and more anterior they were stunted and tubercular, and in series with the strong backward-projecting process from the pedicle of the 7th cervical. Metapophyses projecting forwards from the anterior articular processes were especially seen in the middle and posterior dorsals. The spines projected backwards; they were elongated and strong in the anterior vertebræ, but gradually diminished in size from before backwards. The bodies of the more anterior and more posterior dorsal vertebræ were keeled on the ventral surface.

The *lumbar* vertebræ had transverse processes which projected downwards, outwards, and forwards; in the 1st lumbar they were very short, but they increased in length to the 4th. The spines were short and hatchet-shaped. Anapophyses had almost entirely disappeared; metapophyses were present in all of these vertebræ. The ventral surface of the bodies was keeled.

Sacrum.—In the adult male from the Messier Channel the 1st and 2nd sacral vertebræ were completely fused together, the laminæ of the 2nd were fused with those of the 3rd, but the spines were not, and between their bodies the intervertebral disc was partially present. The 3rd sacral vertebra was fused with the 1st caudal by the pair of processes situated below the articular processes. The greatest breadth of the base of the 1st sacral vertebra was 48 mm. and the length of its body was 32 mm. The 2nd and 3rd were smaller bones, especially in breadth; they were all fully ossified In *Arctocephalus gazella* fusion of the sacral vertebræ had not taken place.

The *caudal* vertebræ diminished in size from the 1st to the 11th. The 1st, 2nd, and 3rd possessed laminæ and spines, the 4th had a neural groove, but the rest consisted only of the bodies, and the two terminal segments of the tail were only 6 and 4 mm. long respectively.

Ribs.—There were fifteen pairs of ribs, of which nine articulated with the sides of the sternum. The head of the 1st rib articulated only with the body of the 1st dorsal vertebra, but from the 2nd rib backwards to the 12th, both inclusive, the head articulated with the bodies of two vertebræ. The three most posterior ribs again articulated, each only with a single vertebra. The osseous part of the 1st rib was about the same length as its costal cartilage, but in the other ribs the bony part considerably exceeded the cartilaginous. The 10th and succeeding pairs had more slender cartilages than those which were anterior to them. In *Arctocephalus gazella* the arrangement was the same, but the bones were more slender.

Sternum.—This bone consisted of eight segments, capable of being separated from each other. The 1st was 125 mm. long, and 29 mm. in its widest part; it was formed of bone in its whole length, and consisted apparently of the præsternal segment fused with the most anterior segment of the meso-sternum, for it projected forwards to the neck, and the 1st pair of ribs was articulated to it 90 mm. behind its anterior end. It was an elongated bar of bone, and possessed three surfaces and a ventral keel. The cartilages of the 2nd to the 7th ribs, both inclusive, were articulated at the junctions of the segments of the meso-sternum. The 8th pair of cartilages were articulated to the sides of the 7th segment, and the 9th pair at the junction of the 7th and xiphisternal segments. The segments of the meso-sternum were all elongated, and the 7th was expanded in the plane of articulation of the 8th costal cartilages. The xiphisternum projected behind the 9th pair of costal cartilages, it was bone in its more anterior two-thirds, but the posterior third was a leaf-like plate of cartilage. The sternum of *Arctocephalus gazella* closely resembled *Arctocephalus australis*.

Anterior Extremity.—The *scapula* in the Messier Channel adult male measured 205 mm. from glenoid fossa to vertebral border, and 253 mm. from the pointed posterior to the rounded anterior angle. The spine was more distinct than in *Macrorhinus* and *Leptonychotes*, especially than in the latter, and it ended below in a very feeble acromion. The præspinous fossa was more than twice as large as the postspinous, and was imperfectly divided into two almost equal areas by a ridge almost parallel to the spine, and situated about halfway between the spine and the rounded anterior angle. A strong ridge behind the spine, which was much more projecting than in *Macrorhinus* and *Leptonychotes*, was for the origin of the third and fourth heads of the triceps muscle. The axillary border was falciform and the coracoid process was very feeble. The ventral surface was concave, but marked by ridges for the tendons of origin of the subscapularis. In *Arctocephalus gazella* and the younger animals from the Messier Channel a portion of the suprascapular cartilage was still unossified.

The *humerus* had an extreme length of 185 mm. The deltoid ridge was strong and rough, with its outer border everted, and terminated above in a strong external tuberosity, which was separated from the inner tuberosity by a deep bicipital groove. The outer condyloid ridge projected much more than the inner, but the inner condyloid eminence was more prominent than the outer. The capitellum and trochlea formed a continuous articular surface, and both the radial and olecranoid fossæ were shallow. The musculo-spiral groove was not very strongly marked, but the shaft was concave vertically on the outer side of the deltoid ridge, which was not the case in *Macrorhinus*. In *Arctocephalus gazella* the humerus was 156 mm. long. The epiphysis of the head was conjoined with that of the greater tuberosity, but that for the lesser tuberosity was distinct. The epiphysis for the inner condyle was distinct from that for the radio-ulnar articular surface. Neither species possessed a supracondyloid foramen.

The *radius* and *ulna* had the characteristic general shape and relative position customary in the seals. The radius had a strong ridge on its anterior border for the pronator teres, its lower end was grooved on the dorsal aspect for the extensor tendons, and immediately below the neck was a low bicipital tuberosity. The olecranon and upper half of the shaft of the ulna were distinctly grooved both on the dorsal and palmar surfaces; that on the dorsal surface was divided into two unequal parts by a longitudinal ridge which commenced in a tubercle at the free edge of the olecranon. Another tubercle was situated at the anterior end of the same border of the olecranon, and a third at the posterior end. To these parts the triceps and dorsi-epitrochlear muscles were attached. The interosseous interval was narrow. The radius articulated at its lower end with the ulna, scapholunar, and cuneiform; the ulna with the radius, cuneiform, and pisiform. The radius in the adult male was 182 mm. long, the ulna 224 mm. In *Arctocephalus gazella* they were similar in shape but smaller; the radius was 152 mm., the ulna 191 mm. long, and the epiphyses were not ankylosed.

Manus.—There were seven carpal bones. The *scapholunar* was large and transversely elongated; it articulated with the radius, cuneiform, and the four bones of the distal row. The *cuneiform* was elongated in the dorsi-palmar diameter and articulated with the radius, ulna, pisiform, scapholunar, unciform, and 5th metacarpal. The *pisiform* was elongated for 21 mm., and projected inwards from the lower end of the ulna, with which and the cuneiform it articulated. The *trapezium*, though much smaller than the scapholunar, was next to it in size; it articulated with it and with the trapezoid and 1st and 2nd metacarpals. The *trapezoid* was wedged in between the trapezium and magnum, and articulated with them and with the scapholunar and 2nd metacarpal. The *os magnum* was a comparatively small bone: it articulated with the 3rd metacarpal, trapezoid, unciform, and scapholunar. The *unciform*, as in the other seals described, did not reach the inner border of the carpus, owing to the articulation of the 5th metacarpal with the cuneiform; it articulated with the 4th and 5th metacarpal, cuneiform, scapholunar, and magnum. All the carpalia were rough on the palmar and dorsal surfaces for the attachment of ligaments, and only the scapholunar had a process, and that a low one, projecting from the inner side of its palmar surface.

There were five *digits*, which diminished in length from the pollex to the minimus. The three segments of the pollex measured collectively 241 mm., they were not only longer than the corresponding bones of the other digits but they were broader and stronger. The metacarpal of the pollex, 110 mm. long, was flattened at its carpal end, and articulated with the trapezium and second metacarpal. The 2nd metacarpal articulated with the 1st and 3rd, and with the trapezium and trapezoid. The 3rd metacarpal articulated with the 2nd and 4th and with the os magnum. The 4th metacarpal articulated with the 3rd and 5th and with the unciform. The 5th metacarpal was only 56 mm. long, and was flattened, unlike the metacarpals of the other fingers; it articulated with the 4th metacarpal, the unciform, and cuneiform. The metacarpal bone and phalanges of the minimus collectively measured 117 mm. The nails were rudimentary, and the terminal phalanges ended abruptly and without an ungual process. The skin, longitudinally wrinkled and without hairs, was prolonged beyond the terminal phalanx, and in the pollex this cutaneous fold was 100 mm. long and 45 mm. broad.

In *Arctocephalus gazella* the carpalia corresponded in number, shape, and arrangement to the bones in *Arctocephalus australis*, but they were smaller. The bones of the digits were also similar, but on a somewhat smaller scale. In both species the 2nd phalanx of the minimus though wider was scarcely so long as the terminal phalanx. Both in *Arctocephalus gazella* and the younger specimens of the Messier Channel *Arctocephalus*, it was seen that the ossification of the phalanges and metacarpal bones was on the same plan as in *Macrorhinus* and *Leptonychotes*. In *Arctocephalus gazella* the length of the pollex and minimus was 178 and 89 mm. respectively.

Pelvis.—This division of the skeleton consisted of the three sacral vertebræ and the two innominate bones. The length of the *os innominatum* was 210 mm., that of the ilium 85 mm., and of the ischio-pubic part 125 mm. The ilium was more elongated than is usual in the seals; its dorsal surface was three times broader than the ventral, which was 11 mm. broad, and was bounded externally by a rough surface for the origin of the rectus; the inner surface was as usual articular for the side of the sacrum, but the crest of the bone instead of being in almost the same transverse plane as the base of the sacrum, as in *Macrorhinus* and *Leptonychotes*, projected forwards, so that it was 31 mm. in front of the base of the sacrum. Between the crest and the base of the sacrum the inner surface of the ilium was marked for the origin of a muscle, probably the multifidus spinæ. The acetabulum had a complete covering of cartilage immediately within the brim, but at the bottom of the cup was a narrow rough depression which opened at the back of the brim in a small cotyloid notch or foramen. The margin of the brim was complete in bone, as the cotyloid notch was bridged by a bony bar which almost converted the notch into a foramen for the passage of the vessels and nerves into the joint. The os pubis and ischium were slender bars of bone, and the symphysis was limited to the junction of the two pubic bones. The junction of the os pubis and ilium was marked by a very prominent pectineal tubercle, and the pectineal line was sharp. The ischium had neither definite tuberosity nor spine, and the obturator foramen was elongated.

Posterior Extremity.—The extreme length of the *femur* in the adult male from the Messier Channel (No. 3) was 112 mm. The head was smooth and without a fossa for the ligamentum teres; the neck was stunted, the great trochanter was well marked, and with a shallow digital fossa for the obturator muscle; the small trochanter was a distinct tubercle, of no great size; there was a faint posterior intertrochanteric line, a very feeble anterior intertrochanteric line, but no trochanter tertius. The shaft was broadened laterally, though not so much as in *Leptonychotes* and *Macrorhinus;* its inner lateral border was almost straight, its outer lateral border slightly concave, differing therefore from the other two genera, in which, more especially in *Leptonychotes*, these borders were markedly concave; though the posterior surface was flat the anterior was slightly convex. A rough ridge passed down the inner border of the bone towards the posterior surface, which apparently represented a linea aspera. The external tuberosity was more prominent than the internal, and they were both grooved; the outer groove being for the tendon of the popliteus. The patellar articular surface was not hollowed from side to side, and was convex from above downwards; it was so large as to occupy almost the whole of the front of the lower end of the femur, whilst in *Macrorhinus* and *Leptonychotes* it occupied only about the middle third of that part of the bone. This surface was prolonged downwards and backwards so as to be continuous with the internal condylar articular surface, but was separated from the external condylar surface by a narrow groove; the condylar surfaces were situated on the back of the lower end of the bone, and were separated from each other by an intercondylar fossa. The inner condylar surface was concave from side to side, whilst the outer was convex. In *Arctocephalus gazella* the femur was only 93 mm. long, and much more slender than in the Messier Channel seal, and this indeed was a character which distinguished all the bones of the hind limb; the trochanter minor was absent even in the most fully ossified of the two skeletons, in which the head was united to the neck of the bone. The patellar articular surface was continuous with the inner condylar articular surface, but was separated from the outer by a narrow groove, to which the adipose ligament was attached as well as to the intercondylar fossa. The outer border of the shaft of the femur was more concave in *Arctocephalus gazella* than in *Arctocephalus australis.*

The *patella* was 28 mm. long, and in both species of *Arctocephalus* had an articular surface transversely elongated and slightly concave from above downwards; its cutaneous surface was elongated superiorly into a strong tubercle, whilst lower down the bone was flattened, so that whilst the upper end of the bone was 18 mm. in antero-posterior thickness, the lower end was only 10 mm.

The *tibia* was 235 mm. long in the Messier Channel adult male. Its superior surface was divided into two articular facets with a rough groove between them, and the outer facet was wider than the inner. The ligamentum patellæ was attached to the front of the bone immediately below the condylar surface. The shaft of the tibia was divided into three surfaces in its upper part, but in the lower half the ventral and outer surfaces were not so sharply differentiated from each other. The lower end of the inner and posterior surfaces of the tibia had two longitudinal grooves, the inner for the tibialis posticus being both wider and deeper than the outer for the flexor longus hallucis. On its inner side a short malleolus projected downwards. The tibia articulated below with the fibula and the upper surface of the astragalus. The tibia differed from that of *Leptonychotes* in having a much less transverse diameter at the condylar end, in not possessing a definite ridge on the shaft for the gracilis, in not being so distinctly grooved at the lower end in front for the tibialis anticus, and in being more deeply grooved behind for the tibialis posticus and flexor longus hallucis.

The *fibula* was a slender bone, 213 mm. long. Its upper end was fused with the outer tuberosity of the tibia. The shaft was three-sided all the way down. A short malleolus projected from the lower end which articulated by movable joints both with the tibia and the external lateral surface of the astragalus, and was grooved externally for the peronei; it did not articulate with the os calcis, and the malleolus generally was much less bulky than in *Leptonychotes*. In *Arctocephalus gazella* the tibia was 180 mm. and the fibula 163 mm. long, and the epiphyses were not ankylosed.

Pes.—The tarsus contained eight bones. The *astragalus* possessed a trochlear surface superiorly, which articulated with the lower end of the tibia; internally it did not articulate with the tibia, and externally it had a broad surface for the external malleolus of the fibula, which looked forwards as well as outwards, but was not however relatively so large as in *Macrorhinus* and *Leptonychotes*; anteriorly it had a convex head for the scaphoid, immediately external to which was a narrow articular surface for the cuboid; inferiorly its articular surface was divided into two parts, separated by an interosseous ligament, for the os calcis; the posterior surface was narrow and grooved, and not prolonged into a calcanear process. The extreme length of the astragalus was 40 mm.

The *os calcis* was elongated behind into a strong calcanear process, which was grooved posteriorly for the tendon of the plantaris. Its outer surface was also marked by the peronei tendons, the position of which was expressed by a strong tubercle and by two grooves; superiorly it articulated with the astragalus, and anteriorly with the cuboid. The extreme length of the os calcis was 54 mm.

The *cuboid* had both a plantar ridge and a peroneal groove. It articulated behind with the os calcis, internally with the scaphoid and external cuneiform, anteriorly with the 4th and 5th metatarsals.

The *scaphoid* had the usual shape of the bone, but without a tubercle; it articulated behind with the astragalus, externally with the cuboid, internally with the ento-scaphoid bone, anteriorly by three very distinct facets with the cuneiforms.

Of the *cuneiforms* the ento- was as usual the largest and the meso- the smallest. The ento-cuneiform articulated behind with the scaphoid, internally with the eighth tarsal bone, anteriorly with the 1st metatarsal, externally with the 2nd metatarsal and the ecto-cuneiform. The meso-cuneiform was visible both on the dorsal and plantar surfaces of the foot; it articulated laterally with the other cuneiforms, behind with the scaphoid, in front with the 2nd metatarsal. The ecto-cuneiform was also visible on both surfaces of the foot; externally it articulated with the cuboid, internally with the meso-cuneiform and 2nd metatarsal, behind with the scaphoid, and anteriorly with the 3rd and very slightly with the 4th metatarsals.

The *eighth* bone of the tarsus, or *entoscaphoid*, was in the adult *Arctocephalus australis* 21 mm. long by 14 mm. broad, situated internally, and articulating by distinct facets with the inner surfaces of both the scaphoid and ento-cuneiform bones towards the plantar aspect. It was present in the other skeletons from the Messier Channel, and in both the skeletons of *Arctocephalus gazella*. Obviously therefore it is a constant bone in this genus.[1] This additional bone represents, I believe, the tubercle of the scaphoid which has remained as a separate ossicle. Occasionally in man the tubercle of the scaphoid ossifies as a distinct ossicle in connection with the tendon of the tibialis posticus, to which it seems to have the relation of a sesamoid bone, and some years ago I described in an adult a specimen of this kind.[2] Karl Bardeleben has also stated[3] that in the human embryo at the second month there is a special cartilage, corresponding to the tuberosity of the scaphoid, which he regards as homologous with the scaphoid bone of the carpus. In a youth of 15 years he had once seen it as a separate ossicle.

The toes were of almost equal length as regards their skeleton, but the integument was prolonged in a variable extent from 105 to 110 mm. beyond the terminal phalanx. Each toe had an elongated convex nail on the dorsum of the last phalanx, but the integument was not haired. The three segments of the hallux measured collectively 237 mm. Each was longer than the corresponding segments in the other digits. The 1st metatarsal articulated by much the greater part of its proximal end with the ento-cuneiform and very slightly with the 2nd metatarsal; it was the longest and the most

[1] Dr. Murie says that *Otaria jubata* possesses the normal number of tarsal bones, and he figures the seven tarsalia. In a skeleton of the Grey Sea Lion of Australia, *Eumetopias cinereus*, I found the eighth tarsal bone occupying a position similar to what I have described in *Arctocephalus*, and articulating with both scaphoid and ento-cuneiform. In a young *Arctocephalus gazella* dissected by Dr. Miller, the entoscaphoid was still cartilaginous, and received a large part of the tendon of the tibialis posticus. In *Macrorhinus* there was no separate entoscaphoid, and the tendon of the tibialis posticus was inserted into a thick plate of cartilage continuous with the scaphoid bone in the region of the tubercle. In both a young and adult *Phoca vitulina* dissected by Dr. Miller, the tendon of the tibialis posticus was inserted into the tubercle of the scaphoid, but a strong slip passed distally from that tendon to end in an ossicle which in the adult was 13 mm. long and 8 mm. broad. This ossicle was situated internally to the ento-cuneiform, but had not a definite faceted articulation either with that bone or with the scaphoid as was seen in *Arctocephalus*. In a young Walrus, the ossicle was represented by a cartilaginous nodule intimately connected with the tendon of the tibialis posticus, and having a distinct facet for articulation with the ento-cuneiform.

[2] *Journ. of Anat. and Phys.*, October 1882, vol. xvii. p. 82.

[3] *Journ. of Anat. and Phys.*, July 1885, vol. xix. p. 510.

massive of all the bones of the toes. The 2nd metatarsal articulated with the 1st and 3rd and with the three cuneiforms; it was bent a little inwards, much less than in the Elephant Seal, in order to pass slightly behind the 1st metatarsal. The 3rd metatarsal articulated with the 2nd and 4th and with the ecto-cuneiform; it was the shortest of the metatarsals. The 4th metatarsal articulated with the 3rd and 5th and with the ecto-cuneiform and the cuboid, it was not hollowed out on the outer side of the shaft as in *Macrorhinus* and *Leptonychotes*. The 5th metatarsal was next in length to the first, but much less broad; it possessed at its tarsal end a peroneal tubercle and articulated with the 4th metatarsal and the cuboid. The terminal phalanx of the 2nd, 3rd, and 4th toes was prolonged into a pointed ungual process on which the nail rested, but the corresponding phalanx of the 1st and 5th digits had no such process, and the nails were smaller than in the other toes. A pair of sesamoids was situated on the plantar surface of each metatarso-phalangeal joint. In the adult male all the epiphyses were fused with the diaphyses, but in the young male the epiphyses were seen to have a similar arrangement to those described in the metatarsals and phalanges of the Elephant and Weddell's Seals.

The tarsalia in *Arctocephalus gazella* corresponded in number, form, and arrangement to those of *Arctocephalus australis*. The bones of the digits were also similar, but more slender, and the epiphyses as in the young male of the other species were not ankylosed.

Nearly twenty years ago the late Professor Allen Thomson described[1] the ossification of the digits in the common seal, *Phoca vitulina*. In the manus he said that the 1st metacarpal bone and all the digital phalanges, except the terminal phalanx, each possessed only a proximal epiphysis, whilst in the four other metacarpal bones there were only distal epiphyses. In the pes again, the 1st metatarsal bone had both a proximal and a distal epiphysis like the phalanges generally, except that the terminal phalanx had only a proximal epiphysis; the four other metatarsals had each only a distal epiphysis. In the year 1869, the late Mr. A. B. Stirling prepared and mounted, in the Anatomical Museum of the University of Edinburgh, specimens to illustrate this method of ossification of these bones. The description which has been given in this Report of the manus and pes of *Macrorhinus*, *Leptonychotes*, and *Arctocephalus*, shows that in them the bones of the digits of the manus do not ossify in the same manner as in the manus of *Phoca vitulina*, but that in all these three genera the digits both of the manus and pes ossify after the same plan, which corresponds with that seen in the pes of the common seal.

The length of the spine of the adult male Fur-Seal from Messier Channel was 1490 mm., the dried intervertebral discs being included, and that of the skull of the same animal was 233 mm., giving a total length of 1723 mm. or 5 ft. 6 in. The length of the spine of the adult female, including the dried intervertebral discs but exclusive of the six terminal caudal vertebræ which were missing, was 1100 mm., and the length of

[1] *Journ. of Anat. and Phys.*, November 1868, p. 140.

the skull was 202 mm.; if 90 mm. be allowed for the missing vertebræ then the combined length of skull and spine would be 1392 mm. or 4 ft. 6 in. The length of the spine, including the dried intervertebral discs, of the larger Kerguelen Island Fur-Seal was 1110 mm., that of the skull was 212 mm., giving a total length of 1322 mm. or 4 ft. 3 in. Mr. H. E. Elliott in his account of the Northern Fur-Seal of the Pribylov Islands (*Callorhinus ursinus*) states[1] that the male, when fully mature and fat, weighs on an average from 400 to 500 pounds, while the female gives a mean of from 80 to 85 pounds. Mr. Allen gives the length of the skeleton, including the skull of an adult male *ursinus*, as 2040 mm. (6 ft. 7 in.); and of another as 1840 mm. (6 ft. ½ in.); whilst one adult female measured 1370 mm. (4 ft. 5 in.); and another 1215 mm. (3 ft. 10 in.).

It would appear therefore that the Northern Fur-Seal, especially the male, is a somewhat longer and probably more bulky animal than the Fur-Seal which frequents the southern half of the South American continent.

The length-breadth indices of five male skulls of *Arctocephalus australis*, calculated on the width behind the external meatus, were respectively 55·8, 59, 50, 58·9, and 51, and of the female 52·9; but at the interzygomatic width the indices for three males were respectively 63·5, 57, and 59, and for the female 57·4. The length-breadth indices of the skulls from Kerguelen Island, calculated on the width behind the external meatus, were respectively 56·6 and 51·6, and on the interzygomatic width 61·7 and 56·8 respectively.

Arctocephalus, sp. incerta.

Fur-Seal from Juan Fernandez.

This specimen from its size was obviously a very young pup. It was given alive to Sir Wyville Thomson at Juan Fernandez, but died after being a few days on board ship. The animal was preserved in strong spirit. Its principal dimensions are as follows :—

Table VIII.—Fur-Seal from Juan Fernandez.

	Ft.	In.
From snout to tip of tail,	1	7¼
From snout to longest digit of pes,	1	10
Length of free part of tail,		1¼
Length of pectoral limb,		6¾
Greatest breadth of that limb,		2¼
Length of hind limb from root of tail,		5½
Greatest breadth of that limb,		1½
From root of pectoral limb to angle of mouth,		7½

[1] The Seal Islands of Alaska, a memoir issued by the Department of the Interior, Washington, 1881; and in his book, An Arctic Province, Alaska and the Seal Islands, London, 1886.

The skin of the body was covered with soft jet-black hairs, which were present also on the dorsum both of the manus and pes. The shape and general character of the manus closely corresponded to the South American Fur-Seal. The pes also had generally the same character, but the nails were in relation to the size of the foot stronger than in that seal, especially the nails on the hallux and minimus. Some of the bristles in the upper lip were dark brown, others black. The external ear was 1 inch long, pointed at the tip, and with black hairs on the dorsum.

Mr. Elliott says that the pup of *Callorhinus ursinus* at birth, and for three months after, is of a jet-black colour both in the hair and flippers, save a tiny white patch at the back of each forearm; that it weighs at birth from 3 to 4 pounds, and is 12 to 14 inches long. The jet-black colour of the hair in the fœtus and at the time of birth seems to be a character of the Fur-Seal. In *Phoca vitulina* it has been observed that the intra-uterine hair is yellowish-white and woolly, and it is shed either *in utero* or immediately after birth.[1] Some years ago I showed that the intra-uterine hair of the fœtus of *Halichœrus grypus*[2] was yellowish-fawn colour and streaked with dark grey bands and spots, but that it was neither woolly nor fur-like. The fœtal hair is shed within about a month after the animal is born.

The skull was 130 mm. long, 73 mm. in its zygomatic diameter, and 81 mm. at the widest part of the cranial box. The orbits were immediately in front of the anterior part of the cranial box, so that the orbital process of the malar was close to the anterior wall of the cranium, and the zygomatic part of the temporal did not turn up behind the orbital process of the malar. The frontal bone passed between the hinder ends of the nasals. The ascending process of the premaxilla articulated with the anterior third of the outer border of the nasal. The anterior and postorbital processes were small. The anterior nares opened well in front of the antorbital process and infraorbital foramen. The basi-occipital was not perforated. The occipital condyles were not continuous with each other, and alisphenoid canals were present. Each tympanic bulla had a low antero-posterior ridge.

The hard palate was emarginate posteriorly and ended in line with about the middle of the zygomatic arch and the orbital process of the frontal bone. The posterior edge of the vomer sloped very obliquely forwards and was not seen at the posterior nares, though the joint between the præ- and post-sphenoids was well behind the posterior edge of the palate. The skull showed the following dentition, and the teeth which had erupted or were just appearing were:—incisors $\frac{3-3}{2-2}$, canines $\frac{1-1}{1-1}$, post-canines $\frac{5-5}{4-4}=32$. The canines and post-canines were small and unifanged. In the lower jaw the coronoid process was expanded and there was a distinct quadrilateral and inflected subcondyloid tubercle.

[1] Wright, *Förhandl. vid de Skandin. Naturforsk. i Stockholm*, 1842 (1843), abstract in *Müller's Archiv f. Anat. u. Phys.*, 1844.

[2] Memoir on the Placentation of the Seals, *Trans. Roy. Soc. Edin.*, June 1875, vol. xxvii.

Some years ago Dr. Philippi of Santiago obtained specimens of a Fur-Seal from Juan Fernandez, which Professor Peters examined and named *Arctocephalus philippii*.[1] He regarded it as the same as the seal which had been named *Arctocephalus* (*Otaria*) *argentatus*. It is not unlikely that the pup which I have described is the young of this animal, though whether it should be regarded as a distinct species, or as of the same species as *Arctocephalus australis*, is a matter which perhaps can scarcely as yet be said to be definitely decided.

[1] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, November 9, 1871; June 10, 1875; August 9, 1877.

PART II.

CLASSIFICATION OF THE PINNIPEDIA.

In the course of the study of the species of Seals described in the preceding part of this Report, I have been led to examine and compare, so far as the material at my disposal would admit, the skeletons of other species of Seals, belonging both to the Earless and Eared families, and also that of the Walrus. This examination and comparison have enabled me to recognise several anatomical characters, which either have had too little attention paid to them, or have been altogether overlooked, and which are of undoubted value in assisting one to discriminate between the different genera and species. I propose in this part of the Report to give a classification of the Pinnipedia, and to introduce into it, along with the characters usually recognised, those additional ones which seem to me to be of value in taxonomy.

Starting from the usually accepted position that the Pinnipedia are a suborder of the Carnivora, which suborder is divided into three families, Phocidæ, Trichechidæ or Odobænidæ, and Otariidæ or Arctocephalidæ,[1] I shall first state briefly the distinguishing characters of these families, and then subdivide them into their subfamilies, genera, and species.

PHOCIDÆ.

Without pinna of ear and scrotum; postorbital processes either wanting or rudimentary; no alisphenoid canal; mastoid moderate and not entirely discontinuous from the tympanic bulla; nasal bones elongated backwards between the two halves of the frontal. Inner wall of orbit complete or almost complete. Hard palate the widest opposite or a little behind the last pair of molars and almost in line with the hinder

[1] See as authorities on the subdivision of the Pinnipedia, H. N. Turner, *Proc. Zool. Soc. Lond.*, 1848; Gill, *Proc. Essex Inst.*, vol. v., 1866, and Families of Mammalia, 1872; J. E. Gray, Cat. Seals and Whales, 1866 and Supplement; W. H. Flower, *Proc. Zool. Soc. Lond.*, January 14, 1869, and article Mammalia in Ency. Brit., 9th Ed.; J. A. Allen, North American Pinnipeds, 1880; and St. George Mivart, *Proc. Zool. Soc. Lond.*, May 19, 1885.

edge of the maxillary root of the zygoma, from which spot the palate diminishes in transverse diameter both forwards and backwards; posterior border either truncated or emarginate. Articulation of vomer with floor of the nose variable in position. Carotid canal distinct from and antero-external to the foramen lacerum posterius. Occipital condyles converging anteriorly, their articular surfaces frequently continuous; basioccipital flattened and usually perforated mesially. Anterior nares far from terminal. Malar variable in its length. Neck short. Hind limbs directed backwards, not used in land locomotion. Front limbs smaller than posterior, digits armed with strong terminal claws. Palms and soles hairy. Dentition—incisors variable, canines $\frac{1-1}{1-1}$, post-canines $\frac{5-5}{5-5}$. Mammæ 2 or 4. Scapula with præ- and postspinous fossæ almost equal in area. Humerus with or without supra-condyloid foramen. Ilium with crest much everted and in transverse plane of base of sacrum. Femur with small trochanter absent or rudimentary. Astragalus with a long calcanear process.

TRICHECHIDÆ.

Without pinna of ear and scrotum; postorbital processes either wanting or rudimentary; alisphenoid canal large; mastoid massive but not entirely discontinuous from the tympanic bulla; posterior border of nasal articulating with anterior border of frontal almost in the transverse plane of skull. Inner wall of orbit complete, but that of zygomatic fossa defective. Lateral borders of hard palate almost parallel to each other behind, though somewhat converging anteriorly; posterior border truncated. Vomer articulating with floor of nose well in front of hinder border of palate. Carotid canal distinct from and in front of foramen lacerum posterius. Basi-occipital mesially keeled and not perforated. Anterior nares terminal. Malar short. Neck longer than in Phocidæ. Palms and soles hairless; manus and pes can be turned forwards and used for land locomotion. Upper canines 1 – 1, elongated into great tusks. Mammæ 4. Scapula with præspinous much larger than postspinous fossa. Humerus without a supra-condyloid foramen. Ilium with crest everted and in front of base of sacrum. Femur with rudimentary small trochanter. Astragalus without a calcanear process.

OTARIIDÆ.

With pinna of ear and scrotum; postorbital processes distinct; alisphenoid canal present; mastoid quite discontinuous from tympanic bulla and prominent; tympanic bullæ only slightly swollen; anterior mesial process of frontal passing between the diverging posterior ends of the nasals. Inner wall of the orbit very defective, so that vomer can be seen through the opening. Hard palate either truncated or emarginate. Malar very elongated and reaching back almost to glenoid fossa. Vomer articulating on floor of nose only with crests of superior maxillæ. Carotid canal opens either within boundary of foramen lacerum posterius or immediately anterior to it. Basi-occipital mesially keeled and seldom perforated. Anterior nares not quite terminal. Neck of considerable length. Palms and soles hairless, used in land locomotion, and manus and pes capable of being turned forwards. Three middle digits of pes short and feeble compared with pollex and minimus, and with well-developed nails. Outer upper incisor caniniform; inner upper incisors with anterior and posterior cusps. Permanent dentition—in. $\frac{3-3}{2-2}$, c. $\frac{1-1}{1-1}$, p. c. $\frac{5-5}{5-5}$ or $\frac{6-6}{5-5}=34$ or 36. Mammæ 4. Scapula with præspinous very much larger than postspinous fossa. Humerus without a supracondyloid foramen. Ilium with crest slightly everted and well in front of base of sacrum. Femur with small trochanter usually present. Astragalus without a calcanear process.

PHOCIDÆ.

The family Phocidæ has been divided into the following subfamilies—Phocinæ, Ogmorhininæ, and Cystophorinæ.[1]

PHOCINÆ.

Anterior nares oblique and in front of infraorbital foramen; beak but little prolonged in front of opening; no postorbital process; interorbital and interzygomatic parts of frontal greatly compressed laterally; horizontal part of premaxilla thin; widest part of hard palate behind molar teeth, and in line with hinder edge of maxillary root of zygoma, from which spot the palate diminishes in transverse diameter both forwards and backwards. Zygomatic process of maxilla not much prolonged back below malar. Inner wall of orbit entire or almost entire. Tympanic bullæ swollen. Pterygoids vertical in direction. Dentition—in. $\frac{3-3}{2-2}$, c. $\frac{1-1}{1-1}$, p. c. $\frac{5-5}{5-5}=34$. Mandible with both a subcondyloid process and an angle. Nails strong in all the digits. Toes of hind foot almost equal in length. Humerus with supracondyloid foramen.

This subfamily contains the genera *Phoca* and *Halichœrus*.

[1] For a number of years I have lost no opportunities of collecting specimens of the crania of the Seals of the North Atlantic for the Anatomical Museum of the University of Edinburgh, and from the courtesy of several gentlemen, more especially the late Mr. Charles Edward Smith, Dr. A. J. M. Bentley, Dr. James Foulis, Captain M'Donald, the Rev. Dr. Joass, Dr. W. Stewart Campbell, Dr. W. Livesay, and Mr. Charles A. Anderson, the collection is now very complete.

Phoca.

Callocéphale, F. Cuvier, Mém. du Muséum, t. xi. p. 182, 1824.

Infraorbital foramen opens into anterior part of floor of orbit, which slopes backwards to become continuous with the thin posterior border of zygomatic root of maxilla. Anterior nares not high, post-canines with more than a single cusp on the crown, mostly three-cuspidate; fangs two-rooted except in the first post-canine.

Phoca vitulina, Linnæus. Common Harbour Seal.[1] North Atlantic Ocean.

Phoca vitulina, Linn., Syst. Nat., ed. x. p. 38.
Callocephalus vitulinus, Gray, Brit. Mus. Catal., p. 20, 1866.

Nasal bones elongated and attenuated between frontals, not ankylosed together; premaxilla forming side of anterior nares but usually not quite reaching the nasal; neither antorbital nor postorbital processes; occipital ridge fairly marked; sagittal ridge indicated; no ridge along line of sagittal suture. Hard palate with posterior border acutely cleft, the sides of cleft forming with line drawn between hamular-pterygoids almost an equilateral triangle; the apex of the cleft a little behind the posterior edge of the maxillary root of the zygomatic arch and considerably in front of the hamular-pterygoids; posterior border of vomer visible in cleft and articulating with vomerine crest ascending from the upper surface of the anterior part of the horizontal plate of the palate bone. Zygomatic arches bulging, and their greatest width, which is about the middle, considerably exceeding the greatest cranial width. Post-canines set closely together and obliquely, so that the posterior part of the tooth in front is external to the anterior part of the tooth immediately succeeding. Subcondyloid process of posterior border of ramus of mandible short, inverted, distinct from the tubercle at the angle of the bone; lower border of horizontal ramus scarcely inverted; coronoid moderate.

Phoca grœnlandica, Fabricius. Harp Seal. North Atlantic[2] and Arctic Oceans.

Phoca grœnlandica, Fabricius in Müller, Zool. Dan. Prodr., p. viii., 1776, and Fauna groenlandica, p. 11, 1780.

Nasal bones elongated and attenuated between frontals, not ankylosed together. Premaxilla forming side of anterior nares and articulating with about one-third of outer border of nasal but not reaching its tip. Anterior nares oblique, but the lateral borders more concave near the nasal bones than in *Phoca vitulina*, *Phoca hispida*, and *Phoca*

[1] In writing the descriptions of the characters of the skulls of the several species of Seals I have as far as possible selected those of adult males.

[2] In November 1874 I recorded (*Journ. Anat. and Phys.*, vol. ix. p. 163) the capture of a Seal on the coast of Lancashire, which was identified by Mr. T. Gough and myself as *Phoca grœnlandica*.

barbata. Occipital crests well marked, no sagittal crest, ridges at upper border of temporal fossa distinct. No definite ridge along line of sagittal suture. Hard palate with posterior border truncated and immediately in front both of the hamular-pterygoids and the malo-zygomatic articulations. Posterior edge of vomer immediately above this border and at once articulating with vomerine crest of palate bones; vertical diameter of vomer short, that of posterior nares contracted, and about one-half the transverse diameter. Tympanic bulla somewhat more swollen, the apex is more truncated and the outer part of its under surface is rougher than in *Phoca vitulina;* it is also prolonged outwards into a much thicker wall for the external auditory meatus, the aperture of which looks forwards. Greatest width of zygoma about middle of arch and inter-zygomatic width exceeding greatest cranial width. Post-canine teeth not set closely together, nor oblique. Subcondyloid process of mandible broadly triangular, inverted, distinct from the tubercle at the angle; lower border of body more incurved than in *Phoca vitulina,* so that the transverse diameter between the angles is much less in *Phoca grœnlandica* than in *Phoca vitulina;* coronoid long and pointed.

Phoca hispida, Schreber. Ringed-Seal or Floe-Rat. North Atlantic and Arctic Oceans.

Phoca hispida, Schreber, Die Säugthiere, iii. p. 312, pl. lxxxvi., 1778.
,, *fœtida,* Fabricius in Müller, Zool. Dan. Prodr., p. viii., 1776, and Fauna groenlandica, p. 13, 1780.
,, *annellata,* Nilsson, Skand. Faun., i. p. 362, 1820.

The smallest species of the genus.

Interorbital part of frontal more constricted than in any other seal. Occipital crests feeble, no sagittal crest, ridge at upper border of temporal fossa distinct; no definite ridge along line of sagittal suture. Nasal bones elongated and attenuated between frontal, not ankylosed together. Premaxilla articulating with about anterior fourth of outer border of nasal. Hard palate cleft at posterior border though not so deep as in *Phoca vitulina,* the base of the triangle between the hamulars being wider than the sides; posterior border of vomer scarcely visible in cleft, and running very obliquely forwards for some distance before articulating with vomerine crest of palate bone. Transverse diameter of orbit more capacious than in *Phoca vitulina* and *Phoca grœnlandica.* Tympanic bulla and external meatus closely resembling *Phoca vitulina.* Foramen lacerum posterius very capacious, basi-occipital perforated mesially so that basi-occipital is largely unossified. Post-canines not crowded and not obliquely set, frequently quadricuspidate, the second cusp being the largest. Subcondyloid process of mandible not triangular, but elongated into a vertical ridge, somewhat inverted and forming the posterior border of the bone, but separated by a notch from the tubercle at the angle; lower border of body incurved opposite the last molar tooth, behind which incurved part this border of the bone sweeps backwards and outwards in a graceful curve; coronoid long and pointed.

Some years ago, after an examination of the bones of the Seals which up to that time had been found in brick clay in several localities in Scotland, I came to the

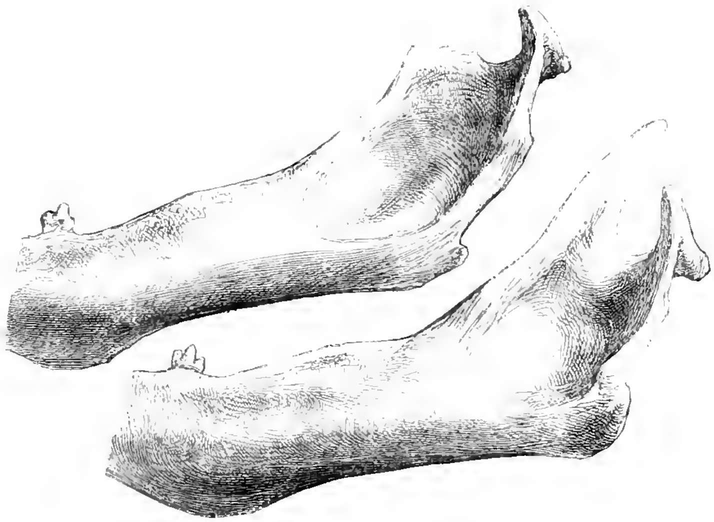


FIG. 1.—The ramus and part of the body of the mandible, in the upper figure from a fossil Seal found in brick clay at Montrose, in the lower figure from an adult *Phoca hispida*.

conclusion[1] that they belonged to *Phoca hispida*, and as the lower jaw is a very characteristic bone, I figured it both in a recent and fossil specimen, and for convenience of reference now reproduce the figure.

Phoca barbata, Fabricius. Bearded Seal. North Atlantic and Arctic Oceans.

Phoca barbata, Fabricius in Müller, Zool. Dan. Prodr., p. viii., 1776, and Fauna groenlandica, p. 15, 1780.
Erignathus barbatus, Gill, Proc. Essex Inst., vol. v., 1866.

The largest species of the genus.

Interorbital part of frontal bone less constricted than in the other species. Occipital crests present, no sagittal crest, ridge at upper border of temporal fossa distinct; a strong, curved ridge along line of sagittal suture, with a deep groove between the ridge and the root of the zygoma. Nasals elongated backwards, but not so attenuated as in preceding species, and not ankylosed together. Premaxilla articulating with tip and for a short distance only with outer border of nasal. Superior maxilla having a much

[1] I described and figured the characters of the lower jaw in *Phoca hispida* in my paper On Fossil Seals found in Scotland, *Journ. of Anat. and Phys.*, vol. iv. p. 268, May 1870. The figures are reproduced in the text.

larger articulation with nasal proportionally than in the other species. Antorbital processes are faint tubercles. Zygomatic arches comparatively flattened, their greatest transverse diameter at posterior part of arch, and the transverse diameter of cranium behind external meatus greater than interzygomatic diameter. Malar bone short, only about equal in length to the same bone in *Phoca hispida*. Hard palate truncated behind and reaching close to the hamulars; posterior border of vomer almost entirely concealed and extending very obliquely forwards to join the vomerine crest of the superior maxilla. Tympanic bulla not so swollen as in the other species and somewhat rougher on inferior surface. Foramen lacerum posterius small, basi-occipital not perforated mesially, par-occipitals distinct. The floor of the orbit not so oblique as in the other species of *Phoca*, but approximating more nearly to the vertical. Post-canines with distinct intervals between, and not very strongly implanted. Subcondyloid process of mandible large, triangular, deeply incurved, and continued by a ridge into the tubercle at the angle of the jaw; lower border of body a little incurved and concave in its general outline. Coronoid process shorter and less pointed than in the other species, and the sigmoid notch more shallow.

A comparison of the cranial characters of *Phoca barbata* with those of the three other species of the genus *Phoca*, shows that it differs more from them than they do from each other. These differences are especially seen in the lower jaw as just stated, in the flattening of the zygomatic arches, so that the cranial breadth is greater than the interzygomatic diameter, in the more vertical direction of the floor of the orbit, and in the very pronounced ridge along the line of the squamous suture. It has been pointed out by previous writers (Gill, Allen) that *Phoca barbata* differs from the other species of *Phoca* in having a broader muzzle, in the middle digit of the manus being the longest instead of the digits slightly decreasing in length from 1st to 5th, and in possessing four and not two mammæ, and on these differences Gill has established for it the genus *Erignathus*. To these external differences may now be added those cranial differences which I have just described, so that from the point of view of those zoologists who are in favour of the multiplication of genera, additional data are given for separating it from the genus *Phoca* and calling it *Erignathus barbatus*.

I have not seen any specimens of the Seals which have been named *Phoca caspica*, *Phoca siberica*, and *Phoca equestris* (*Histriophoca fasciata*).

Halichœrus, Nilsson.

Infraorbital foramen does not open into anterior part of floor of orbit but below it, for the floor of orbit does not form a continuous slope with the posterior border of the zygomatic root of maxilla, but is separated from it by a deep vertical surface. Anterior nares high and capacious. Post-canines each with a large, conical, simple cusp;

secondary cusps not present in upper post-canines except occasionally in 4th and 5th; in lower post-canines secondary cusps not unfrequently present. Teeth single-fanged except the last lower and last two upper post-canines.[1]

Halichœrus grypus (Fabricius). Grey Seal. North Atlantic Ocean.

Phoca grypus, Fabr., Skr. Nat. Selsk., i. p. 167, pl. xiii. fig. 4, 1790.
Halichœrus griseus, Nilsson, Skand. Faun., i. p. 377, 1820.
Phoca gryphus, Fischer, Syn. Mamm., p. 239, 1829.

The only species.[2]

Interorbital constriction of frontal somewhat swollen about the middle. Occipital and sagittal crests present and not unfrequently a squamous ridge. Nasals wider than in *Phoca* and not ankylosed together. Premaxilla not expanding at its upper end and with only a limited articulation to outer border of nasal, not reaching its tip; the two premaxillæ curve outwards from side of nasal, so that the widest part of anterior nares is in the upper third and the opening generally is very capacious. Zygomatic arches bulging, widest part of arch in the middle and much wider than the widest part of the cranium. Hard palate with rounded arch at posterior border, the crown of the arch considerably in front of both the hamulars and the malo-zygomatic joints; posterior border of vomer visible in concavity of arch, but soon joining vomerine crest of palate. Horizontal part of premaxilla thicker than in *Phoca* and with distinct tubercle. Tympanic bulla swollen, generally smooth, but with a ridge in outer half, which is prolonged into thick wall of external auditory meatus. Foramen lacerum posterius moderate. Basi-occipital usually not perforated mesially. Par-occipital short. Mandible with a stunted, vertically elongated, subcondyloid process, scarcely inverted and quite distinct from the tubercle at the angle; lower border of body thickened and scarcely inverted; masseteric fossa very deep, coronoid broadly triangular.

[1] Nehring (*Sitzb. der Gesellsch. naturf. Freunde zu Berlin*, October 17, 1882) gives an account of *Halichœrus grypus*, and refers to variations in the skull due to age and sex as well as individual modifications. He points out that the roots may vary in number in the hinder post-canine teeth, and that the accessory cusps are variable in the lower post-canines. He also states both from his own observations and those of Professor Gerstaecker that an accessory 6th upper molar not unfrequently occurs. Gerstaecker has seen it eight times in thirty-four crania, five times on one side only, thrice on both sides. I may also refer to the skull of a young *Halichœrus grypus* which I described in the *Journ. of Anat. and Phys.*, vol. vii. p. 273, 1873, in which no teeth were developed except the canines.

[2] This Seal is often regarded, in so far as its distribution in Scotland is concerned, as restricted to the west coast, but, in addition to specimens from that side of the island, I have placed crania in the Anatomical Museum of the University from animals killed at the mouth of the Tay, off Montrose, at Golspie in Sutherlandshire, and from the Shetland Islands.

Ogmorhininæ.

Anterior nares in front of the infraorbital foramina; beak moderately prolonged in front of opening. Either a postorbital process or a mere rudiment of one; premaxilla may or may not articulate with nasal. Horizontal part of premaxilla moderate. Floor of orbit sloping back to become continuous with the thin posterior border of zygomatic root of maxilla; infraorbital foramen opening into floor. Greatest width of palate behind last molar and almost on line with posterior border of zygomatic root of maxilla. Zygomatic process of maxilla prolonged back for some distance below malar. Inner wall of orbit defective. Basi-occipital sometimes perforated mesially. Pterygoids horizontal or almost horizontal in direction and with slit or foramen between upper border and base of skull. Dentition—in. $\frac{2-2}{2-2}$, c. $\frac{1-1}{1-1}$, p. c. $\frac{5-5}{5-5}$, $=32$. Post-canines two-rooted except the first. First and fifth toes of hind foot longer than the rest.

This subfamily contains the genera *Ogmorhinus*, *Leptonychotes*, *Ommatophoca*,[1] and *Monachus*.

Ogmorhinus.[2]

Sténorhinque, F. Cuvier, Mém. du Muséum, t. xi. p. 190, 1824.
Ogmorhinus, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, p. 393, footnote, 1875.

Premaxilla does not reach the nasal. Cranial width may or may not be greater than the interzygomatic width; nasals ankylosing together early. Anterior nares oblique. Hard palate emarginate posteriorly, transverse part of palato-maxillary suture opposite penultimate post-canine; posterior border of vomer distinctly visible in palatal cleft, and articulating only slightly with vomerine crest of palate. Postorbital process rudimentary or absent. Basi-occipital not perforated, par-occipital process present. Wall of auditory meatus short, foramen opens outwards; groove between tympanic and mastoid temporal.

[1] Dr. J. E. Gray has given, in vol. i. of the Zoology of the Voyage of the "Erebus" and "Terror," figures of the palatal aspect and the profile of the skull of the following seals:—*Stenorhynchus leptonyx* and *Lobodon carcinophaga*, *Leptonyx weddelli*, *Ommatophoca rossi*, *Macrorhinus leoninus*, *Eumetopias hookeri*, *Otaria jubata*, and the palate and teeth of *Arctocephalus lobatus*.

[2] I wish to express my obligations to Mr. William E. Hoyle of the Challenger Commission for having revised and verified the references to the names given to the various species of Seals described in the text. In the course of this revision, which was not made until after Part I. of the Report had been sent to press, he pointed out to me that the names *Stenorhynchus* and *Macrorhinus* have both been applied to different animals. The name *Stenorhynchus* was given to a Brachyurous Crustacean so far back as 1818 (Lamarck, Hist. Nat. des Anim. sans Vert.), and is regularly in use at the present time (see Report by E. J. Miers on the Brachyura, part xlix., Zool. Chall. Exp., vol. xvii.). Taking as a precedent Gill's name *Leptonychotes*, as a modification of *Leptonyx*, it would have been better to have modified *Stenorhynchus* into *Stenorhynchotes*, and thus to obtain a generic name which, whilst distinctive, would have been a less departure from the name most commonly in use than the generic term *Ogmorhinus* proposed in 1875 by Peters. *Macrorhinus* was used in 1825 by Latreille (Fam. Nat. du Règne Animal), to designate a genus of Coleoptera, whilst F. Cuvier in the previous year had applied to the Elephant Seal the name "Macrorhine." Thus the name as applied to the Elephant Seal has the priority, and it rests with the entomologists to change the name of the Beetle.

Ogmorhinus leptonyx (de Blainville). Leopard Seal. Southern Ocean.

Phoca leptonyx, Blv., Journ. de Phys., t. xci. p. 298, 1820.
Stenorhynchus leptonyx, F. Cuvier, Dict. d. Sci. Nat., t. xxxix. p. 549.
,, ,, Gray, Zool. Voy. "Erebus" and "Terror," p. 16, 1875.

Tympanic triangular, with pointed apex placed antero-internally, not much swollen, with ridge running from base to apex. Superior maxilla with extensive articulation with side of nasal. Hard palate deeply emarginate posteriorly, pterygoids not much everted. Hamular processes rudimentary. Post-canines large, with three pointed cusps, the middle being the largest and somewhat recurved at tip, the tips of the others being inclined towards the middle cusp; all the post-canines almost equal in size. Mandible with only a thickening in the border of the bone to represent the subcondyloid process and with no angle; symphysis moderate, lower border of body scarcely incurved. Skull elongated.

Ogmorhinus carcinophagus (Hombron and Jacquinot). The Crab-eating or Saw-toothed Seal. Southern and Antarctic Oceans.

Phoca carcinophaga, Hombron and Jacquinot, Voy. Pole Sud, Atlas, Mamm., pls. x., XA., 1842–1853.
Lobodon carcinophaga, Gray, Zool. Voy. "Erebus" and "Terror," p. 5, 1844.
Stenorhynchus serridens, Owen, Ann. and Mag. Nat. Hist., vol. xii. p. 331, 1843.

Tympanic not so pointed at apex as in preceding species, swollen and without so definite a ridge from base to apex. Superior maxilla with limited articulation with side of nasal. Hard palate moderately concave posteriorly, posterior border of vomer scarcely seen in the concavity. Hamular processes elongated. Post-canines much longer than in *Ogmorhinus leptonyx*; one cusp recurved and especially elongated and somewhat bulbous at the apex, with a small cusp anteriorly and one, two, or three behind it. Mandible with a distinct angle and rudimentary subcondyloid process; symphysis greatly elongated, lower border of body incurved. Skull not so elongated as in preceding species.

Leptonychotes, Gill.

Premaxilla reaching the side of the nasal. Cranial width greater than the inter-zygomatic width, nasals ankylosing together early and the interfrontal part laterally much constricted; anterior nares oblique, superior maxilla with a moderate articulation with the nasal. Hard palate emarginate, posterior border of vomer visible in cleft and articulating with vomerine crest at anterior part of palate bone. No postorbital process;

hamular process and pterygoid everted, basi-occipital perforated mesially. Tympanic bulla not ridged and with antero-internal angle truncated. Mandible more slender than in *Ogmorhinus*. Humerus without a supracondyloid foramen.

Leptonychotes weddelli (Lesson). Weddell's Seal. Southern Ocean.

Otaria Weddellii, Less., Férussac, Bull. Sci. Nat., t. vii. p. 438, 1826.
Leptonyx Weddellii, Gray, Zool. Voy. "Erebus" and "Terror," p. 7, 1844.
Leptonychotes weddelli, Gill, Proc. Essex Inst., vol. v., 1866.

Post-canines small, with one moderately prominent cusp, though in the 3rd and 4th a rudiment of a posterior cusp is also visible; the last post-canine distinctly smaller than the rest. Mandible with a faint, incurved tubercle to represent the subcondyloid process and with no angle; symphysis moderate, the halves of body widely diverging.

Ommatophoca, Gray.

Nasals ankylosed together, greatly elongated and reaching to the back of the constricted part of the skull; premaxilla does not reach the nasal; anterior nares almost in the vertical plane and slightly in front of infraorbital foramina. Orbits very large and the interzygomatic width greater than the cranial; the lower border of zygoma reaches below the plane of the dentary border of superior maxilla. Malars greatly elongated. Marked protuberance on squamous temporal above and behind root of zygoma. Hard palate slightly emarginate, the apex of the cleft a little behind the posterior border of the maxillary root of the zygoma; palatal plate of palate bone much smaller than that of superior maxilla. Vomer visible in palatal cleft. Tympanic bulla not greatly swollen, triangular and ridged on inferior surface, prolonged outwards into a strong process which forms the floor of the external meatus, and may extend considerably beyond it as a thick truncated process. Basi-occipital not perforated. Pterygoids everted. Nails rudimentary on front and absent on hind feet.

Ommatophoca rossi, Gray. Ross's Seal. Antarctic Ocean.

Ommatophoca Rossii, Gray, Zool. Voy. "Erebus" and "Terror," p. 8, pls. vii., viii., 1844.

Teeth small; post-canines three-cusped, the central cusp the longest and recurved. Mandible with a moderate angle and low subcondyloid process; coronoid short but pointed, sigmoid notch shallow, symphysis moderate, lower border of body slightly incurved.

The genus *Ommatophoca* is, so far as we know, represented only by a single species living in the Antarctic seas, two skulls of which are in the Natural History department of the British Museum.[1] The crania have characters which distinguish them from the other genera of the same family and which approach in some degree to the characters of *Cystophora*, so that *Ommatophoca* is a well-marked genus. It approximates to *Cystophora* in the vertical direction of the anterior nares, in their relation to the infraorbital foramina, and in the shortness of the ascending part of the premaxilla, so that a definite part of the anterior nares is bounded by the superior maxilla. In the great width of the orbits and of the skull in the interzygomatic region they also approach each other. On the other hand the nasals are much longer in *Ommatophoca* than in *Cystophora*, and the superior maxillæ articulate with their outer border as far as the tip, and do not leave the anterior part of this border free; the palate plates of the palate bones are much shorter in *Ommatophoca* than in *Cystophora*, and they differ from each other in the number of lower incisors and in the shape of the crowns of the post-canine teeth.

Monachus, Fleming.[2]

Premaxilla articulating with side of nasal; anterior nares oblique and a short distance in front of the infraorbital foramina; no postorbital process. Nasals not greatly elongated. Inner wall of orbit defective; zygomata expanded and the width greater than cranial width. Hard palate slightly emarginate, the posterior border considerably behind maxillary root of zygoma and some distance in front of the hamulars, which are rudimentary, and well in front of the anterior border of the glenoid fossæ; the posterior border of vomer just visible in palatal cleft, and arching forwards to join vomerine crest about junction of superior maxilla and palate. Pterygoids everted and running almost horizontally forwards, with large foramen between the upper border and the basis cranii; the interpterygoid width considerable. Tympanic bulla swollen, scarcely ridged, apex truncated; basi-occipital perforated mesially; mastoid low; par-occipital prominent; occipital condyles confluent. Dentition—in. $\frac{2-2}{2-2}$, c. $\frac{1-1}{1-1}$, p. c. $\frac{5-5}{5-5}=32$.

[1] The description of *Ommatophoca* and *Monachus* has been written from the crania in this Museum, and I am indebted to Professor W. H. Flower, C.B., for permission to examine these and other crania of the Seals in the national collection.

[2] The generic name *Monachus* was suggested by Dr. Fleming in 1822. In a footnote to his Philosophy of Zoology, vol. i. p. 187, he says, "Some Seals as *Phoca monachus* are said to have four incisors in each jaw. Such will probably be constituted into a new genus under the title *Monachus*." In 1827, F. Cuvier used the name *Pelagios* (*Mém. Mus. Hist. Nat.*, t. xi. p. 196), and in 1829 (Dict. d. Sci. Nat., t. lix.) *Pelagius*, but Fleming's name has obtained general use for this Mediterranean Seal.

Monachus monachus (Hermann). Monk Seal. Mediterranean Sea.

Phoca monachus, Hermann, Abhandl. d. k. Akad. d. Wiss. Berlin, vol. iv. p. 501, 1779.
Phoca albiventer, Boddaert, Elenchus Animal., p. 170, 1785.
Pelagios monachus, F. Cuvier, Mém. Mus. Hist. Nat., t. xi. p. 196, 1824.
Monachus albiventer, Gray, Brit. Mus. Catal., p. 19, 1866.

Post-canines moderately large, very oblique, and set close together; two rooted in the upper jaw, except the first, mostly three-cusped, with the central cusp large, the anterior and posterior small, and with a prominent cingulum; the last upper post-canine set transversely. Mandible with angle and subcondyloid process not very strong and apparently continuous with each other; coronoid broad, not pointed, lower border of body not incurved.

CYSTOPHORINÆ.

Anterior nares in a vertical or almost vertical plane, and the upper part of the opening in the plane of the infraorbital foramina; beak considerably prolonged in front of the opening; premaxilla not articulating with nasal, horizontal part thick and with a tubercle. Greatest width of palate behind last molar, almost in line with posterior edge of maxillary root of zygoma and the transverse part of palato-maxillary suture. Basi-occipital not perforated mesially. Zygomata very bulging, the widest part of the arch in the middle and wider than the cranium. Posterior end of malar almost reaching glenoid fossa. Zygomatic root of maxilla not passing far back below malar. Inner wall of orbit defective. Pterygoids almost vertical in direction.

Dentition—in. $\frac{2-2}{1-1}$, c. $\frac{1-1}{1-1}$, p. c. $\frac{5-5}{5-5}=30$.

This subfamily contains the genera *Cystophora* and *Macrorhinus*.

Cystophora, Nilsson.

Ascending part of premaxilla short and not reaching the nasal, so that the upper half or third of anterior nares is bounded by superior maxilla, the outline of which is concave. Tympanic bulla very swollen, the inner two-thirds smooth, and separated by a strong oblique ridge from the outer third which is roughened and continuous with the wall of a short external auditory meatus, the aperture of which opens directly outwards. A distinct depression in superior maxilla below infraorbital foramen. The orbital orifice of the infraorbital foramen opens in the lower part of the slope formed by the anterior part of the floor of the orbit, and below this foramen the bone passes almost vertically downwards to the posterior edge of the maxillary root of the zygoma. Mastoid part of temporal relatively prominent. Posterior border of vomer short and articulating with vomerine crest of palate in the plane of the posterior nares. Crowns of post-canines plaited rather than lobed, last upper molar with two fangs. Adult males with inflatable narial sac. First and fifth toes of hind foot longer than the rest, nails rudimentary or absent.

Cystophora cristata (Erxleben). Crested Seal.[1] North Atlantic and Arctic Oceans.

Phoca cristata, Erxl., Syst. Reg. Anim. p. 590, 1777.
Cystophora cristata, Gray, Zool. Voy. "Erebus" and "Terror," p. 4, 1844; and Brit. Mus. Catal., p. 41, 1866.

Occipital crests strong, two sagittal crests formed apparently of the upper border of the temporal ridges; slight ridge along line of sagittal suture. Nasals elongated, not attenuated, expanding into a somewhat lobate form at the tip; outer border of nasal articulating only with frontal and superior maxilla, but the most anterior part of this border is free. Anterior nares capacious, the upper third being the widest part, mesethmoids and maxillo-turbinals reaching the opening. Antorbitals strong, post-orbitals indicated by a tubercle. Hard palate truncated at posterior border reaching close to hamulars and a little in front of the anterior border of the glenoid fossa. Zygomatic of temporal curving upwards to reach the tip of orbital process of malar. A distinct groove between tympanic bulla and mastoid temporal; slight par-occipital processes. Mandible with a longitudinal, incurved, subcondyloid ridge separated by a notch from the incurved angle of the bone; lower border of body incurved; coronoid elongated.

Macrorhinus.

Macrorhine, F. Cuvier, Mém. Mus. Hist. Nat., xi. p. 200, 1824.

Premaxilla with only a horizontal part, lateral boundaries of anterior nares formed exclusively of superior maxillæ, the outline of the nares concave. Tympanic bulla not much swollen in adult male, but relatively flattened and roughened, its outer part being prolonged into an expanded tympanic plate, which forms the wall of a remarkably elongated external meatus, the aperture of which opens outwards. Depression in superior maxilla below infraorbital foramen not very definite. The orbital orifice of the infraorbital foramen opens below the slope formed by the anterior part of the floor of the orbit, which slope is separated by a considerable interval from the posterior edge of the zygomatic root of the maxilla. Mastoid temporal scarcely distinguishable as a process. Posterior border of vomer articulating with vomerine crest of palate in front of truncated border. Mandible with a distinct subcondyloid process, not incurved or greatly elongated, and separated by distinct notch from angle; lower border of body everted, and with a wide arch between the two lateral halves; coronoid not elongated. Adult males with a proboscis. Humerus without a supracondyloid foramen.

[1] A specimen of this Seal was caught at St. Andrews in 1872. R. Walker, *Scottish Naturalist*, November 1872.

Macrorhinus leoninus (Linnæus). Elephant Seal. Southern and Antarctic Oceans.

> *Phoca leonina*, Linn., Syst. Nat., ed. x. p. 37, 1758.
> *Phoca elephantina*, Molina, Saggio sul Stor. Nat. del Chili, p. 280, 1782.
> *Morunga elephantina*, Gray, Zool. Voy. "Erebus" and "Terror," p. 8, pls. ix., x., 1844.
> *Macrorhinus anguirostris*, Gill, Proc. Essex Inst., vol. v. p. 13, 1866.

This animal has been described in so much detail in Part I of this Report that it is not necessary for me to repeat its characters here.

Dr. Gill, Mr. Allen, and other American zoologists have regarded the Californian Sea Elephant as distinct from the southern species, and have named it *Macrorhinus anguirostris*. Dr. Gill's description[1] was based on the examination of the skull of a female from Lower California, and the name *Macrorhinus anguirostris* was conferred owing to its narrowed and produced snout, as compared with that of a skull from the South Seas, figured by Dr. Gray in the Zoology of the "Erebus" and "Terror," which was at one time regarded as an adult female, but which is now known to be a male not full grown. If this character of the snout be the only difference between them, and Mr. Allen has stated that the Northern and Southern Sea Elephants differ very little in size, colour, and other external features, it cannot have much if any value as a mark of specific difference, for from my comparison of the male and female crania of the Southern Elephant Seal (Part I.) it will be seen that the male is much broader than the female in the prenasal region, owing to the greater size of the incisor and canine teeth.

The differences between the skulls of *Cystophora cristata* and *Macrorhinus leoninus* are seen to most advantage in the region of the premaxillary bones and anterior nares, in the shape of the tympanic bulla and the relative length of the external auditory meatus, in the position of the orbital orifice of the infraorbital canal, the relative size of the mastoid temporal, the place of articulation of the vomer with the palate bone, and the configuration of the lower jaw. When taken collectively these differences are, I think, sufficient to justify the separation of the genus *Macrorhinus* from *Cystophora*.

TRICHECHIDÆ.

The family Trichechidæ contains only a single genus amongst existing mammals, although two fossil genera have been described, *Alactherium* and *Trichechodon*. The existing genus is usually called *Trichechus*, but the old Linnæan term *Odobænus* has recently been revived for it by some zoologists, and Allen has consequently named the family Odobænidæ.[2]

[1] *Proc. Essex Inst.*, vol. v. p. 13, 1866; and *Proc. Chicago Acad. Sci.*, vol. i. p. 33, 1866.

[2] I may refer to Mr. Allen's valuable History of the North American Pinnipeds for a full discussion of the question of the generic term which should be given to the Walrus.

Trichechus (*Odobænus*), Linnæus.

Horizontal part of premaxilla very short and thick, and with a strong tubercle; ascending part articulating with nasal. Superior maxilla swollen in front, and with large alveoli for lodgment of canine tusks; these alveoli are in the transverse plane of the front of the face. Anterior nares relatively small, vertical in direction, and with scarcely any premaxilla in front of the opening. Occipital crests distinct and meeting mesially. No sagittal crest. Crests on frontal and temporal bones marking limit of temporal muscle. A slight ridge along line of squamous suture. Interorbital and interzygomatic region of frontal not very constricted. Hard palate truncated immediately in front of strongly projecting hamulars and in line with anterior border of glenoid fossæ; transverse part of palato-maxillary suture well behind the posterior edge of maxillary root of zygoma; vomer entirely concealed by hard palate, its posterior border articulates with vomerine crest of palate considerably in front of the truncated border. Zygomatic arch not bulging, its greatest width is at the zygomatic process of the temporal, and the interzygomatic part of the skull is much below the greatest width of the cranium; zygomatic process of temporal short and not nearly reaching the orbital process of the malar. Orbits relatively small; infraorbital foramen large and opening below the floor of the orbit. Tympanic bulla not swollen, but uniformly roughened on inferior surface and continuous with the short thick wall of the external auditory meatus, the mouth of which looks directly outwards. Foramen lacerum posterius relatively small. Paroccipitals not detached processes. Basi-occipital not perforated mesially. Occipital condyles converging anteriorly and sometimes continuous. Condyloid foramen immediately in front of condyle.

$$\text{Permanent dentition—in. } \frac{1-1}{0-0},\ \text{c. } \frac{1-1}{1-1},\ \text{p. c. } \frac{3-3}{3-3} = 18.$$

$$\text{Milk dentition—in. } \frac{3-3}{3-3},\ \text{c. } \frac{1-1}{1-1},\ \text{p. c. } \frac{5-5}{4-4} = 34.$$

The last and penultimate upper molars and the last lower molar often rudimentary or absent. Mandible with a massive, incurved, subcondyloid tubercle separated by a notch from the feeble angle; condyle with scarcely any neck, coronoid short and broad, sigmoid notch very shallow, lower border of body everted and with a wide arch; symphysis ankylosed. Pineal body remarkably developed.

Trichechus (*Odobænus*) *rosmarus*, Linnæus. Morse, Walrus, or Sea Horse. North Atlantic and Pacific Oceans.

Odobænus rosmarus, Linn., Syst. Nat., ed. i., 1735.
Phoca rosmarus, Linn., Syst. Nat., ed. x. p. 38, 1758.
Trichechus rosmarus, Auctorum.
Odobænus rosmarus, Steenstrup, Öfversigt k. Vetensk. Akad. Förhandl., Bd. xvi. p. 441, 1859; Zeitschr. f. gesammt. Naturw., xv. p. 275, 1860.
" " Malmgren, Öfversigt k. Vetensk.-Akad. Förhandl., 1863 (1864) (quoted by Allen).

The above description of the skull of the genus *Trichechus* has been written from the comparison of the crania of a number of specimens in the Anatomical Museum of the University of Edinburgh, which are all believed to be from the North Atlantic Walrus, so that they may be regarded as comprising both its specific and generic characters. On the supposition entertained by the majority of naturalists that the Walruses of both the North Atlantic and North Pacific are of the same species, they would, I doubt not, also coincide with the last-named animal, but as I have not had the opportunity of examining the skull of a specimen known to be from the North Pacific I cannot speak with absolute certainty. Mr. J. A. Allen has indeed attempted to show that specific differences separate the Walruses of these two oceans from each other, and, reviving an old name given by Illiger, he has distinguished the North Pacific animal by the name of *Odobænus* (*Trichechus*) *obesus*. In thus subdividing the genus he is also supported by Mr. H. E. Elliott.

In making this division Mr. Allen attaches great importance to a difference in the relative development of the frontal and occipital regions in the two animals. In the Atlantic species, he says, the narrow facial breadth is in striking contrast with the great occipital breadth, whereas in the Pacific species the two regions are more equally developed. The interorbital constriction is both relatively and absolutely much narrower in the Pacific animal; the tusks are longer and thicker, generally more convergent and less incurved in the Pacific, whilst in the Atlantic animal they are divergent and strongly incurved. In the Pacific species the front profile is nearly vertical, and the anterior edge of the nasals is very little posterior to the front border of the base of the tusk, and the orbits are more anterior; in the Atlantic animal the front profile is very oblique, the muzzle is smaller and the nasals scarcely pass beyond a vertical line drawn from the hinder border of the base of the tusk.

With regard to these characters I would point out that the increase in frontal breadth of the North Pacific animal, which makes it approximately equal to the occipital breadth, would necessarily be occasioned by an increase in thickness of the canine tusks, and the consequently greater development of the superior maxillary bones for their lodgment, and as it is stated that in the Pacific animal the tusks are thicker than in the Atlantic specimen, it is possible that these differences, as described by Allen, are not specific, but are simply due to certain specimens having thicker tusks than others. With regard to the length, thickness, and curvatures of the tusks, I find considerable differences in the series of crania in the Anatomical Museum of the University. As a general rule they diverge from each other so as to be two, three, or even four inches further apart at the tip than at the root, but in one very fine specimen with long and relatively thin tusks projecting 15 inches beyond the alveolus, the distance between their tips was a trifle less than that between their roots; it may be a question therefore if this character is more than individual or perhaps sexual. As to the front profile and the relation of the transverse plane of the anterior border of the nasals to the base of the tusk, I find that in my specimens this plane sometimes corresponds with the posterior border, at others it extends up to or indeed a little in front of the middle of the base of the tusk, so that it is obviously a variable feature.

Mr. Allen also refers, though without attaching so much importance as with the other characters, to a difference in the intermaxillaries in these animals. Usually, he says, in the Pacific Walrus the intermaxillæ extend posteriorly for two-thirds the length of the nasal, whilst in the Atlantic animal these bones do not enter into the dorsum of the skull, but end at the anterior border of the nasals. In those of my specimens, in which these bones had not yet ankylosed with their neighbours, I noticed considerable variation; in four each premaxilla articulated with the anterior two-thirds of the outer border of the nasal, in two each premaxilla reached the anterior border of the nasal and then seemed to terminate, but an elongated sutural bone was intercalated on each side between the superior maxilla and about the middle third of the outer edge of the nasal; in one the left premaxilla articulated with the anterior two-thirds, whilst the right bone only reached the tip of the nasal, but beyond it was a sutural bone similar to that above described. This intercalated bone obviously represents the detached upper end of the premaxilla. It is obvious that a bone presenting such variations in arrangement in the skull of the Walrus as does the premaxilla cannot have much importance attached to it for purposes of classification.

As regards the external features of difference Mr. Allen states that the two animals are similar in size and probably in general contour, though the facial outline is modified by the differences in the skull already considered, but the mystacial bristles are shorter in the Pacific than in the Atlantic Walrus.

On the whole I think it is doubtful whether these animals should be regarded as specifically distinct; I would rather consider them as varieties of one species.

OTARIIDÆ.

In no family of mammals, probably, have more diversities of opinion been expressed by zoologists, both with respect to the number of species in the family and their arrangement in genera and subfamilies, than in the Otariidæ. These divergences are to be seen both in the descriptions of different authors and in those of the same author at different times. It is, therefore, a matter of much difficulty to construct a classification of the Eared Seals which will prove satisfactory and conclusive, and it is doubtful whether the specimens in our museums are yet sufficiently numerous to give definite data of the variations in the skull engendered by age and sex, so that we may avoid confounding the sexual and age modifications with those that have a generic or specific value.

Dr. Gray in his latest writings[1] made in all eighteen species of Eared Seals, which he arranged in nine genera. Professor Peters in his latest monograph[2] recognised only thirteen species, which he classed in three genera, as follows:—

Otaria.	*Arctocephalus.*
sp. *jubata.*	sp. *pusillus.*
	falklandicus.
Eumetopias.	*brevipes.*
sp. *stelleri.*	*elegans.*
gillespii (misspelt *gilliespii*).	*forsteri.*
cinerea.	*gazella.*
hookeri.	*philippii.*
	ursinus.

Mr. Allen in his History of the North American Pinnipeds divides the Otariidæ into the subfamilies Trichophocaceæ and Ouliphocaceæ. In the Trichophocaceæ, which are distinguished by a harsh pelage without under-fur, he places the genera *Otaria*, sp. *jubata; Phocarctos*, sp. *hookeri; Eumetopias*, sp. *stelleri;* and *Zalophus*, spp. *californianus* and *lobatus.* In the Ouliphocaceæ, which are distinguished by a soft pelage with abundant under-fur, are the genera *Callorhinus*, sp. *ursinus;* and *Arctocephalus*, spp. *australis* (*falklandicus*), *antarcticus* (*pusillus*), and *forsteri.* This division, which is essentially based on differences in the character of the pelage, corresponds to the older and more popular nomenclature of Hair-Seals or Sea Lions, and Fur-Seals or Sea Bears. Dr. Burmeister arranges[3] the Hair-Seals into the genera *Otaria*, sp. *jubata*, *Eumetopias*, spp. *stelleri* and *californianus*, and *Phocarctos*, spp. *cinereus* and *hookeri;* and the Fur-Seals into the genera *Arctophoca*, spp. *falclandica* (*australis*), *cinerea*, and *forsteri*, and *Arctocephalus*, spp. *ursinus*, *philippii*, *gazella*, and *pusillus.* Professor Flower again[4] includes all the Eared Seals in the single genus *Otaria*, and he regards the different Sea

[1] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. xiii.; Hand List of Seals, 1874.

[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, August 9, 1877.

[3] Die Seehunde der argentinischen Küsten, Buenos Aires, 1883.

[4] Catalogue of Vertebrated Animals in Museum of Royal College of Surgeons, pt. ii., 1884; and Article Mammalia, Ency. Brit., 9th ed.

Lions and Sea Bears as merely species of that genus. A similar view would also appear to be entertained by Dr. St. George Mivart.[1]

The position which Mr. Allen, Dr. Burmeister, and to some extent Professor Peters, have taken up, that a sharp line of demarcation separates the pelage of the Sea Lions and Sea Bears, owing to the absence of an under-fur in the former and its presence in the latter, is apparently not quite free from doubt or absolutely to be accepted. Professor Peters, indeed, admits that both in young and aged Fur-Seals the fur is very sparse. In the young Fur-Seal from Juan Fernandez described on p. 51 there was no differentiation of the hair into over-hair and under-hair or fur. Dr. Murie states[2] that beneath the hair of the Sea Lion, *Otaria jubata*, which is short, firm and thick in the pile, there is a reddish underwool, very sparsely scattered and which sensibly diminishes with age. Mr. J. W. Clark[3] also points out that in a specimen which he examined of the Grey Sea Lion (*Arctocephalus cinereus*), from New South Wales, whilst the hair was short, stiff, and bristly, a red and sparse under-fur was present. Dr. Gray, in the Supplement to his Catalogue of Seals and Whales,[4] dwells at some length on the variability displayed in the length and abundance of the under-fur, which, indeed, he says may be present or absent in accordance with the season at which the animals are observed. But with reference to his remarks it should be stated that he does not always differentiate, with sufficient precision, the Hair-Seals from the Fur-Seals. For he places the Sea Lion of the North Pacific (*Eumetopias stelleri*) amongst the Fur-Seals, whilst it is without doubt a Hair-Seal.[5] If the presence in some Eared Seals of an under-fur and its absence in others were absolute, then undoubtedly it would furnish a divisional character of much value. It is, however, without question, that in the Fur-Seals the thick coat of under-fur constitutes a most important structural feature.

There is also, I think, sufficient evidence to show that in the cranial construction of the different species of Eared Seals differences do exist of such a kind as to support the view which so many zoologists have entertained that they possess a generic value, though whether these differences are so important as to justify the breaking up of the group into six or more genera, is, I think, very doubtful. The great Sea Lion of the southern hemisphere differs, however, in so many particulars from the Fur-Seals of the same seas, that it may fairly be separated from them by a distinct generic name, and to it, therefore, along with Peters and Allen, I restrict the name *Otaria*, although, in adopting this separation, it must be admitted that the passage from the Sea Lion of South America to the Fur-Seals is graded by such forms as Steller's Seal, the Californian Sea Lion, and the Hair-Seal from the Auckland Islands.

[1] *Proc. Zool. Soc. Lond.*, May 19, 1885.
[2] *Proc. Zool. Soc. Lond.*, January 28, 1869.
[3] *Proc. Zool. Soc. Lond.*, March 18, 1884.
[4] London, 1871, p. 9; also in *Ann. and Mag. Nat. Hist.*, vol. iv. p. 264, 1869.
[5] See Elliott's elaborate description of this Seal in his work on Alaska already cited.

On consideration of the whole question, therefore, I am not disposed to split up the family Otariidæ to the extent which has been done by Gray, Allen, and Burmeister, or even by Peters in his earlier memoirs; but to accept for the present at least the view which Peters, unfortunately with too great brevity in the specification of the generic characters, had adopted in his last monograph,[1] and to arrange the species under the generic terms *Otaria*, *Eumetopias*, *Arctocephalus*.

Otaria, Péron.

Otaria, Péron, Voy. aux terres austr., ii. p. 37, 1816.

Professor Peters defines this genus as follows:—"Ears short (15–20 mm. long); hair stiff and without under-fur. Bony palate elongated up to, or almost up to the hamular pterygoids." In addition, I may state that the palate reaches almost as far back as the transverse plane of the anterior borders of the glenoid fossæ and is truncated; borders of palate are elevated so that its surface is concave; in the male deeply so and with the hamulars converging so as closely to approximate. Posterior nares contracted. Vomer entirely concealed by palate, and not articulating with the floor of the nose until it reaches the vomerine crest of the superior maxilla. Infraorbital foramen opens in floor of orbit immediately above posterior border of maxillary root of zygoma. Premaxilla articulates with outer border of nasal.

Dentition—post-canines $\frac{6-6}{5-5}$.

Otaria jubata (Forster). Southern Sea Lion. South Atlantic and Pacific.

Phoca jubata, Forster, Descript. anim., p. 66, 1775.
" " Schreber, Die Säugthiere, iii. p. 300, pl. lxxxiiiB, 1778.
Otaria leonina, Gray, Brit. Mus. Catal., p. 59, 1866.

The skull has been described with so much detail in Part I., in the male, female, and young, that it is unnecessary to repeat the characters here. Last upper molar immediately behind posterior border of the zygomatic root of the maxilla. Mandible with a very massive quadrequilateral subcondyloid process inflected strongly inwards; angle with tubercle distinct from subcondyloid process, lower border of body everted. Muzzle broad in male. I may repeat that only one species has been referred in this Report to the genus *Otaria*.[2]

[1] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, August 9, 1877.

[2] It should be stated that Burmeister, so far back as 1868 (*Zeitschr. d. gessamt. Naturwiss.*, Bd. xxxi. p. 294), expressed the opinion that the *Otaria godeffroyi* of Peters is the same animal as the *Otaria jubata* of Forster, and that the *Otaria ulloæ* of Tschudi and Peters is the female of *Otaria jubata*.

Eumetopias, Gill.

Eumetopias, Gill, Proc. Essex Inst., vol. v., 1866.

This genus was established by Gill, and Steller's Sea Lion is by some zoologists the only species which is included in it. Peters, however, has placed in this genus Steller's Sea Lion, the Californian Sea Lion, the species *Eumetopias cinereus* from the Australian Seas and the species *Eumetopias hookeri* from the Auckland Islands. The characters as laid down by Peters are as follows:—"Ears longer than in *Otaria*, but with similar hair; posterior border of the hard palate far removed from the hamular processes."

Eumetopias stelleri (Lesson). Steller's Seal or Sea Lion. North Pacific.

Otaria stelleri, Less., Dict. Class. Hist. Nat., t. xiii. p. 420, 1828.
,, ,, Gray, Brit. Mus. Catal., p. 10, 1866.
Eumetopias stelleri, Allen and Bryant, Bull. Mus. Comp. Zoöl., vol. ii. p. 46, 1871.

Vertex sinuous or ~-shaped in outline from behind outwards.

Premaxilla articulates with about anterior third of outer border of nasal. Anterior nares well in front of infraorbital foramina. Postorbitals very large and quadrilateral. Inner wall of orbit very defective. Sagittal crest moderate in male, feeble in female. Skull relatively broad at frontal constriction. Hard palate truncated, not reaching further back than about the level of the middle of the zygomata, and well in front of the hamulars; the borders of the palate scarcely elevated and its surface almost plane. Vomer with its posterior border completely concealed and reaching the vomerine crest of the superior maxillæ. Hamulars strong and curved outwards. Tympanic not swollen or definitely triangular, relatively small and roughened, and with one or two ridges projecting vertically from it; the bony wall of the external meatus is short; mastoid massive. Post-canines $\frac{5-5}{5-5}$, the last upper is double rooted and is situated distinctly behind the maxillary root of the zygoma and the transverse part of the palato-maxillary suture; between the last and the penultimate tooth is a considerable gap which gives the impression that a tooth had at one time been developed in it, though Mr. Allen states that no evidence has as yet been seen of the presence of a tooth in this gap. Mandible with angle not very prominent; subcondyloid process massive, vertically elongated, but not projecting so much inwards as in *Otaria jubata*; lower border of body neither inverted nor everted. The skull originally described by Dr. Gray as *Arctocephalus monteriensis* is now regarded as a specimen of Steller's Sea Lion. A most interesting account of the habits and characters of this seal has been given by Mr. H. E. Elliott in his work on Alaska already frequently referred to, in which he points out that in this species also the adult male is about twice the weight and bulk of the adult female, and Mr. Allen states that the average length of ten old male skulls is 375 mm., their breadth 221 mm.; whilst the mean length of two old female skulls is 296 mm., and their mean breadth 157 mm. In the examination, therefore, of the adult skulls of the Sea Lions, both northern and southern, differences in size are of no value as indicative of specific characters, but are only of sexual importance.

Eumetopias californianus (Lesson). Californian Sea Lion.

Otaria californiana, Lesson, Dict. Class d'Hist. Nat., xiii. p. 420, 1828.
,, *Gillespii*, M'Bain, Proc. Roy. Phys. Soc. Edin., vol. i. p. 422, 1858.
Arctocephalus gilliespii, Gray, Brit. Mus. Catal., p. 55, 1866 (*errore*).
Zalophus gillespii, Gill, Proc. Essex Inst., vol. v. p. 13, 1866.

The late Dr. James M'Bain, R.N., of Edinburgh, was the first naturalist to describe the skull of this animal[1] from a specimen obtained from the Gulf of California, which was given to him by his friend Dr. Gillespie. I purchased this skull after Dr. M'Bain's death for the Anatomical Museum of the University of Edinburgh. This animal is generally recognised as distinct both from its southern neighbour, *Otaria jubata*, and from the northern or Steller's Sea Lion, though whether a special genus *Zalophus* should be established for it, or it should be regarded as only a distinct species of *Otaria*, or of *Eumetopias*, is still a moot point amongst zoologists. Although Dr. M'Bain's description embraces many of the characters of the cranium, and particularly the prominent sagittal crest on the vertex of the skull, yet I may refer to several additional points and measurements.

TABLE IX.—SKULL OF EUMETOPIAS CALIFORNIANUS.

	mm.
Extreme condylo-premaxillary length,	292
From front of premaxilla to occipital crest,	268
From basion to optic foramen,	116
From optic foramen to premaxillary tubercle,	159
Extreme interzygomatic width,	168
Extreme width immediately behind external meatus,	150
Greatest width of palate,	47
Width between outer sides of base of upper canines,	56
Width between outer sides of base of upper lateral incisors,	33
Width between outer sides of base of lower canines,	42
Length of palate to incisor teeth,	128
Height from basion to middle of occipital crest,	102
Smallest interfrontal width in plane of upper surface,	25
Length of nasals,	51
Greatest width of anterior nares,	31
Greatest width at postorbital processes,	68
Greatest length of mandible,	214
Greatest width at condyles of lower jaw,	152
Greatest height of sagittal crest,	30

[1] *Proc. Roy. Phys. Soc. Edin.*, vol. i. p. 422, 1858.

This specimen is evidently an adult male. The suture between the premaxilla and maxilla has disappeared, though there is an indication that the premaxilla had articulated with about the anterior third of the outer border of the nasal. The basicranial synchondroses are obliterated. The muzzle is markedly more contracted than in *Otaria jubata*, and the anterior nares are more oblique in direction than in *Arctocephalus*. In its general form, however, the skull has many points of resemblance with *Arctocephalus*. The mastoids are irregular and very prominent. The tympanic bulla is roughened and a strong process projects vertically downwards from it, immediately external to the carotid canal; this canal opens into the anterior part of the foramen jugulare.

Palate is neither elongated nor truncated as in *Otaria*, but slightly emarginate and converging behind last molar; its posterior border is well in front of the slender hamular pterygoids, and about opposite the middle of the zygomatic arch; borders of palate scarcely elevated, so that its surface is almost flat, and its widest part is opposite the last post-canine. Posterior border of vomer is concealed by palate, but its superior or sphenoidal articulation is in part seen in the emarginate border of the palate; vomer not articulating with floor of nose until it reaches vomerine crest of maxilla. Infraorbital foramen opens into floor of orbit distinctly in front of posterior border of zygomatic root of maxilla. Postorbitals triangular, and recurved at the apex. Sagittal crest in the male very high and thin, reaching forwards to the postorbital processes.

The length-breadth index of this cranium, calculated on the interzygomatic width, is 57·5, and on the width behind the external meatus is 51·0.

Dentition—post-canines $\frac{5-5}{5-5}$, relatively large, closely approximated, the most posterior being below the zygomatic root of the maxilla and in line with or a little in front of its posterior border. Mandible with a quadrilateral subcondyloid process much longer than broad, and inflected inwards; angle marked by a slight tubercle; lower border of body neither inverted nor everted. Muzzle narrow. The *Phocarctos elongatus* of Dr. Gray is probably this species.

Eumetopias hookeri (Gray). The Auckland Island Hair-Seal.

> *Arctocephalus Hookeri*, Gray, Zool. Voy. "Erebus" and "Terror," p. 4, pls. xiv., xv., 1844.
> *Otaria Hookeri*, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, May 17, 1866, p. 269, 1867.

Mr. J. W. Clark has definitely established the presence of a large species of Eared Hair-Seal on the Auckland Islands,[1] and an examination of the crania has satisfied him that they correspond exactly with the skulls brought home by Sir J. C. Ross's Antarctic expedition, which Dr. Gray named *Arctocephalus hookeri*. The skull of this Seal is

[1] *Proc. Zool. Soc. Lond.*, November 18, 1873, with two characteristic figures of the skull, which is also figured in Dr. Gray's Zoology of the Voyage of the "Erebus" and "Terror," pl. xv.

distinguished by its great length in relation to the breadth both of the cranial box and in the zygomatic region. Premaxilla articulating with about anterior half of outer border of nasal. Tympanic with peg-like process from the back of its inferior surface; mastoids not very prominent. Palate almost truncated, ending behind about opposite the middle of the zygomatic arch, and well in front of the hamular pterygoids, its surface hollowed out in front, but flattened behind, and with its margins converging so that the posterior nares are constricted. Post-canines $\frac{6-6}{5-5}$; the last upper distinctly behind both the maxillary root of the zygoma and the transverse part of the palato-maxillary suture; upper post-canines with one large cusp and either without a secondary cusp or with only one, except in the last two, the crowns of which are bicuspidate or tricuspidate and the fangs double rooted; the lower post-canines have not unfrequently an anterior secondary cusp and the last and penultimate teeth may have three cusps. Mandible elongated, massive, and almost of the same vertical height in the whole length of the body. The presence of an additional upper post-canine in this species as compared with Steller's Seal and the Californian Sea Lion has induced some naturalists to place it in a separate genus, as *Phocarctos hookeri*.[1]

I measured one of the type skulls in the British Museum, which was 268 mm. in extreme condylo-premaxillary length and 120 mm. in greatest width immediately behind the external meatus; from the front of the cranial box to the posterior border of the base of the postorbital process was 31 mm., and from the same border to the premaxillary tubercle was 139 mm. Another specimen from Campbell Island, New Zealand, was 293 mm. long, 145 mm. wide in its greatest interzygomatic diameter, and 126 mm. wide immediately behind the external meatus; from the front of the cranial box to the posterior border of the base of the postorbital process was 40 mm., and from the same border to the premaxillary tubercle 144 mm. The length-breadth indices of these skulls calculated on the width behind the external meatus were 44·7 and 42 respectively, and of the Campbell Island specimen calculated on the interzygomatic diameter was 49. These skulls have a much lower index than any of the other crania of seals measured in this Report.

Eumetopias cinereus (Péron). Grey Sea Lion of New Zealand and Australia.

Otaria cinerea, Péron, Voy. aux terres austr., ii. p. 54, 1816.
,, ,, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, May 17, 1866, p. 272, 1867.

This Hair-Seal was first noticed by Péron, but as his account of the animal was too brief to afford much distinct information of its characters, some naturalists, *e.g.*, Mr. Allen, have treated it as a mythical or undeterminable species. In a recent memoir, however,

[1] See Peters, *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, November 1, 1866, p. 671; and Allen, History of North American Pinnipeds, p. 209.

Mr. J. W. Clark[1] gives a careful description of the skins and the more salient features of the skull of several specimens of the Grey Sea Lion from the Seal Rocks near Port Stephens, New South Wales, which animal he identifies with the *Otaria cinerea* of Péron.

The Anatomical Museum of the University, and the Museum of Science and Art, Edinburgh, have recently purchased from Mr. Edward Gerrard, junior, skeletons of a Seal from Victoria, belonging to this species, and the following description is drawn up from the examination of the skulls of an adult male and female, and of a young animal, the dimensions of which are given in the accompanying table :—

TABLE X.—SKULLS OF EUMETOPIAS CINEREUS.

	Male. mm.	Female. mm.	Young. mm.
Extreme condylo-premaxillary length,	301	245	205
From front of premaxilla to occipital crest,	295	225	...
From basion to optic foramen,	125	100	88
From optic foramen to premaxillary tubercle,	173	136	106
Extreme interzygomatic width,	179	137	113
Extreme width immediately behind external meatus,	175	123	100
Greatest width of palate,	38	32	27
Width between outer side of base of upper canines,	62	44	35
Width between outer side of base of lower canines,	...	30	27
Length of palate to incisor teeth,	127	105	87
Height from basion to middle of occipital crest,	104	79	72
Smallest interfrontal width in plane of upper surface,	18	15	36
Length of nasals,	60	47	34
Greatest width of anterior nares,	43	29	26
Greatest length of mandible,	218	169	133
Greatest width at condyles of lower jaw,	163	120	92

The occipital and sagittal crests are moderately developed in both the male and female, but have not appeared in the young skull; the sagittal crest scarcely reaches the constricted part of frontal; in the male a strong parietal tubercle like that seen in the adult *Otaria jubata* is present. A marked character of the skull is its elongation in the adult cranium in front of the cranial box, and this is especially noticeable in the frontal constriction between the anterior wall of that box and the postorbital processes. At the beginning of this constricted part the skull is pinched in laterally, and in front of this constriction it widens somewhat before it reaches the postorbital processes.[2] The nasals

[1] *Proc. Zool. Soc. Lond.*, March 18, 1884, p. 188.

[2] In comparing with each other the skulls of the Seals too much importance must not be attached to differences in the length and degree of the constriction immediately in front of the cranial box as indicative of specific distinction. In the comparison of the young and adult skulls of *Macrorhinus leoninus* and *Otaria jubata* in Part I. of this Report, it is shown that this constriction is both much shorter and less marked in the young than in the adult skull of the same species. In an interesting paper on Cranial Variation in *Mustela pennanti*, Erxl. (*Proc. Zool. Soc. Lond.*, Feb. 16, 1886), Mr. Oldfield Thomas has noted how much the interorbital constriction in this animal also is increased in the aged skull.

are more elongated than in Gillespie's Seal. The premaxilla articulates with a little more than a third of the outer border of the nasal. The lateral borders of the hard palate are almost parallel so that it is of almost uniform width throughout; the dentary border is elevated so that the anterior third of the surface is concave, but the posterior third is flattened; the hinder border is moderately emarginate, though in the adult male a mesial cleft, due to imperfect ossification, separates the two palate bones for a short distance posteriorly; this border is about midway between the maxillary root of the zygoma and the glenoid fossa, and well in front of the hamular pterygoids. The vomer has the usual arrangement of this bone in the Eared Seals. The tympanics are roughened, and, except a moderate ridge behind, with no special development of processes; the mastoids are very prominent, separated by a deep groove from the tympanics, and projecting almost vertically downwards. The widest part of the zygomatic arch is at its glenoid end, from which it rapidly diminishes from behind forwards; in the male the arch is massive in relation to the size of the skull. The post-canine dental formula is $\frac{6-6}{5-5}$; these teeth all possess a cingulum, and in addition to the large central cusp both a much smaller anterior and posterior cusp, though in the last upper molar these accessory cusps have almost disappeared. All the post-canines except the first in the lower jaw and the two last in the upper jaw, are set somewhat obliquely in their sockets, but with distinct diastemata in the adults; the last upper is smaller than the rest and placed distinctly behind the maxillary root of the zygoma. The mandible is massive in the male, with a broad coronoid, a massive quadrangular subcondyloid process and slight angle; the lower border of the body is thickened and slightly inverted. As regards the pes it should be stated that digits II., III., and IV. have strong black nails; I. and V. only rudimentary nails. The toes are almost equal in length, though I. and V. are a little shorter than the intermediate toes. The toe-flap of digit I. projected 117 mm. beyond its rudimentary nail.

The length-breadth index calculated on the interzygomatic width of the adult male skull was 59, of the adult female 55, and of the young skull 55; calculated on the width behind the external meatus the indices were 58, 50, and 49 respectively.

In the number of its post-canine teeth *Eumetopias cinereus* corresponds with *Eumetopias hookeri*, but it differs from it in having the anterior and posterior cusps much more distinctly marked and more general, and in so many of the teeth being set obliquely; further, it has not so great a constriction of the posterior nares and back of the palate as is seen in the latter Seal. Mr. J. W. Clark says that it is distinguished from the *Otaria albicollis* of Péron by the presence of the anterior and posterior cusps in the post-canine teeth. As regards the species which has been named *Otaria albicollis* it should be stated that Peters regards both it and an animal named *Eumetopias lobatus* by Gray as identical with *Eumetopias cinereus*, and Allen is apparently of the same opinion. In Dr. Gray's figure of *Eumetopias lobatus*[1] only five post-canine teeth are shown in the upper jaw, but in form, cuspidation, and oblique setting they correspond closely with the teeth in my male skull. In an imperfect skull in the Museum of the Royal College of Surgeons of England, marked *Otaria lobata*, there are only five upper post-canines.

Arctocephalus, F. Cuvier.

Arctocéphales, F. Cuvier, Mém. du Mus., xi. p. 205, 1824.
Arctocephalus, F. Cuvier, Dict. d. Sci. Nat., t. xxxix. p. 554, 1827.

Professor Peters gives the following definition of this genus :—"With longer ears. Below the contour hairs a thick under-fur, which in both quite young and old animals is very sparing. Structure of skull and bony palate like *Eumetopias*." To these characters may be added, post-canines $\frac{6-6}{5-5}$, the last upper being distinctly behind the maxillary root of the zygoma. It is difficult to say how many species are to be referred to this genus. That it contains several is however undoubted. The Fur-Seal of the Pribylov Islands is quite distinct from the South American Fur-Seal, both of which again differ from that of the Cape of Good Hope, and from the Fur-Seal of Australia and New Zealand. The Fur-Seal of Kerguelen Island is apparently a distinct species, and so also, perhaps, is the one from Juan Fernandez. It is possible also that there are other species.

Arctocephalus australis (Zimmermann). South American Fur-Seal.

Phoca australis, Zimmermann, Geogr. Geschichte, iii., 1783.
,, *falklandica*, Shaw, General Zoology, i. pt. 2, p. 256, 1800.
Euotaria nigrescens, Gray, Zool. Voy. "Erebus" and "Terror," p. 12, 1875.
Otaria falklandica, Abbot, Proc. Zool. Soc. Lond., 1868, p. 192.
Arctophoca falclandica, Burmeister, Die Seehunde der argentinischen Küsten, Buenos Aires, 1883.

I have described, in the first part of this Report, the skull and skeleton of this animal with considerable detail, from specimens shot in the Messier Channel. The skull closely corresponds with certain crania in the British Museum from the Strait of Magellan, labelled *Arctocephalus nigrescens*, and also with the specimens in the Museum of the Royal College of Surgeons of England from Lobos Island, River Plate, and from the Falkland Islands, labelled *Otaria australis* or *Otaria falklandica*, so that the specific terms *falklandicus* and *nigrescens* are obviously synonyms of *australis*. This Seal frequents therefore the southern part of the South American continent on both the

[1] Zoology of Voyage of "Erebus" and "Terror," vol. i., Mammalia, pl. xvii.

Atlantic and Pacific coasts, the Falkland Islands to the east, and perhaps Juan Fernandez and Masafuera to the west. Its geographical distribution almost exactly corresponds with that of *Otaria jubata*.

The distinguishing characters of the skull are as follows; the facial part narrow, slender, and somewhat elongated, the nasal bones are almost in the same plane as the top of the cranium, *i.e.*, horizontal; sagittal crest moderate; tympanic with two or three strong ridge or peg-like processes projecting vertically downwards; mastoid massive, separated from the tympanic by a broad and deep groove. The 6th post-canine not much smaller than the others. Upper and lower post-canines with a cingulum, a large cusp, and a small anterior cusp, the last two also with a small posterior cusp; mandible arching slightly outwards from symphysis to angles.[1]

Arctocephalus gazella (Peters). Kerguelen Island Fur-Seal.

Otaria (Arctophoca) gazella, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, June 10, 1875, p. 393, 1876.

This animal has apparently a more slender configuration of skeleton than the South American species. Nasal bones in the same plane as the top of cranium; sagittal crest absent; tympanic almost flattened, and with feeble processes projecting from its posterior part; mastoid moderate and with broad shallow groove separating it from the tympanic. The 6th post-canine much smaller than the others. Upper and lower post-canines with a feeble cingulum, with one large cusp and no secondary cusps. Mandible as in preceding species.[2]

[1] A. Nehring has recently described (*Archiv f. Naturgesch.*, 1887, Heft i. Taf. ii.) three crania from the River Tramandahy, Rio Grande do Sul, south coast of Brazil, which he considers to be a new species and names it *Arctocephalus gracilis*. His specimens were one male and two females, but they were all young. In the absence of adult crania it would be hasty to pronounce them to belong to a new species. Burmeister has indeed described crania of *Arctocephalus australis* from the north of the mouth of the Rio de la Plata, which is not far to the south of the Rio Grande, so that it is not unlikely that the skulls described by Nehring are the young of *Arctocephalus australis*. For the opportunity of reading Nehring's paper I am indebted to Mr. Oldfield Thomas. In a more recent communication (*Sitzungsb. d. Gesellsch. naturf. Freunde zu Berlin*, Dec. 20, 1887, p. 207), Nehring states that Professor Dr. Goldi has intimated to him that a Fur-Seal has been taken at Ponta Negra, near Rio de Janeiro, which corresponded with the Seal named by Burmeister *Arctophoca falclandica, i.e., Arctocephalus australis*.

[2] In addition to the two carcases of young Fur-Seals and the two skeletons of the same procured at Fuller's Harbour, Kerguelen Island, described on p. 36 as *Arctocephalus gazella*, the Challenger collection contained the skeleton of a young specimen killed at Betsy Cove, Kerguelen. This skeleton was overlooked until after Part I. of this Report had been printed off. All the epiphyses of the long bones of the limbs and those of the vertebræ were unankylosed and the cranial sutures were unossified, but the occipito-sphenoid synchondrosis was closed. The skull was immature, so that the specific characters were not strongly marked, but there can be no doubt, I think, that the animal was a young specimen of *Arctocephalus gazella*.

Arctocephalus pusillus (Schreber). Fur-Seal of Cape of Good Hope and of Crozet Islands.

Phoca pusilla, Schreber, Die Säugthiere, iii. p. 314, pl. lxxxv., 1778.
,, *antarctica*, Thunberg, Mém. Acad. St. Petersb., iii. p. 222, 1811.
Arctocephalus Delalandii, Gray, Brit. Mus. Catal., p. 52, 1866.
Otaria pusilla, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, May 17, 1866, p. 271, 1867.

To this Seal the specific name *Arctocephalus delalandii* was applied by Dr. Gray, who has given the following description of the skull in the British Museum. Hinder aperture of palate narrow, with a rather acute, ovate anterior edge, surface of palate concave; facial part of skull rather short, forehead flattened from nasal bone to vertex; teeth large; lower jaw rather short, strong. Further, he says that the hair is rigid, the under-fur small in quantity, reddish-brown.

I have also examined this specimen. It is obviously an aged male, for the occipital and sagittal crests are strong, a parietal tubercle projects immediately in front of the occipital crest, the two nasals are ankylosed together, and the teeth are worn and broken. The extreme length of the skull is 280 mm., its interzygomatic width is 177 mm., and its width behind the meatus 174 mm. It measures 51 mm. from the front of the cranial box to the posterior border of the postorbital process, and 137 mm. from the same border to the premaxillary tubercle. The mastoids are powerful and project downwards and outwards; tympanic roughened and with shallow ridges projecting vertically. The post-canines though injured are obviously not so large as in *Eumetopias hookeri*. Mandible with a faint angle and with a subcondyloid process vertically elongated and not flattened from before backwards. The length-breadth index calculated on the interzygomatic width is 63, and on the width behind the meatus 62.

Several years ago I described the cranium of an Eared Seal in the Anatomical Museum of the University of Edinburgh, which had been obtained from the Cape of Good Hope.[1] I regarded it as a distinct species, and, owing to a mesial cleft in the palate between the two palate bones, named it *Arctocephalus schisthyperöes*. The skull was 8·1 inches (206 mm.) long, 5·1 inches (130 mm.) broad between the zygomatic arches, and 4·3 inches (109 mm.) immediately behind the external meatus. Although the teeth were but little worn, yet the basicranial synchondroses were ossified, and the cranial sutures had almost disappeared, so that I regarded the skull as an adult but not aged.

Dr. Gray criticised my description of this skull[2] and stated that it was evidently the skull of a half-grown animal with the sutures apparent; he believed the cleft palate to

[1] *Journ. of Anat. and Phys.*, November 1868, vol. iii.
[2] *Ann. and Mag. Nat. Hist.*, vol. iv., 1869, p. 264.

be an individual abnormality, and referred the specimen to *Arctocephalus delalandii*. Mr. Allen has accepted Dr. Gray's view and has made *Arctocephalus schisthyperöes* a synonym of the Seal which has been variously named *Arctocephalus pusillus*, *Arctocephalus antarcticus*, and *Arctocephalus delalandii*. Professor Flower states that a skull of an *Otaria* (*Arctocephalus*) *pusilla* in the Museum of the Royal College of Surgeons of England[1] is very like the specimen to which I gave the name of *Arctocephalus schisthyperöes*. Mr. J. W. Clark also refers it to the same species, and considers that the cleft palate is an individual variation similar to what he has seen in a skull of *Otaria* (*Arctocephalus*) *ursina*.[2]

I now agree with the view which has been expressed both by Dr. Gray and Mr. Clark that the cleft condition of the palate is an individual variation, due, without doubt,

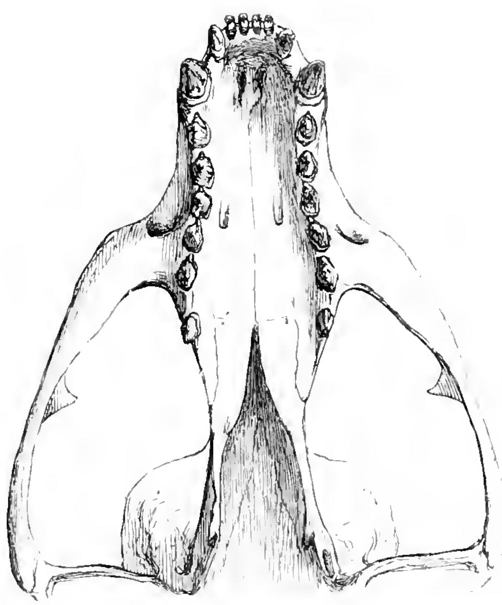


Fig. 2.—This figure represents the palate of the Seal which I named *Arctocephalus schisthyperöes*; reproduced from Journal of Anatomy and Physiology.

to imperfect ossification. But I cannot accept Dr. Gray's statement that the cranium which I described was that of a half-grown animal, for although the sutures between the facial bones are distinct, those of the cranial box have practically disappeared, so that I am still of opinion that the skull is adult though not aged. Undoubtedly the skull is very much smaller than that (apparently an old male) in the British Museum, to which Dr. Gray originally gave the name of *Arctocephalus delalandii*, and which would now be called

[1] Catalogue of Bones of Mammalia, pt. ii. p. 193, 1884.

[2] *Proc. Zool. Soc. Lond.*, March 18, 1884, p. 194. In Mr. Clark's explanation of figure 6, in which a view of the palate is given, *cinerea* is obviously a misprint for *ursina*.

Arctocephalus pusillus, and if my specimen is to be referred to that species it is probably to be regarded as that of a female, for we now know much more definitely than we did a few years ago that the females of the Eared Seals are very much smaller than the males.

Arctocephalus ursinus (Linnæus). Fur-Seal of North Pacific.

Ursus marinus, Steller, Nov. comm. Acad. Petropol., vol. ii. p. 331, pl. xv., 1751.
Phoca ursina, Linn., Syst. Nat., ed. x. p. 37, 1758.
Callorhinus ursinus, Gray, Proc. Zool. Soc. Lond., 1859, p. 359.
Otaria ursina, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, May 17, 1866, p. 273, 1867.

Facial part of skull in front of antorbital process short, relatively broad, and with the nasal bones sloping downwards so as to give an aquiline character to the profile view of the face. Anterior nares almost terminal and nearly vertical. This appearance is so characteristic and peculiar as to have induced Dr. Gray to give it generic value, and to form for this species the genus *Callorhinus*, with which arrangement Mr. Allen coincides. Tympanic distinctly ridged, one ridge running antero-posteriorly; mastoid massive. Premaxilla articulating with about one-half of outer border of nasal. Hard palate somewhat emarginate, its posterior border well in front of hamular pterygoids, which are distinct and curved outwards. Extreme condylo-premaxillary length of an adult male 242 mm., interzygomatic width 141 mm.; width behind external meatus 129 mm. From front of cranial box to posterior border of base of postorbital process 51 mm.; from same border to premaxillary tubercle 118 mm. The length-breadth index calculated on the interzygomatic width is 58, and on the width behind the meatus 53. The 6th post-canine is not much smaller than the others, with one large cusp and no secondary cusps, usually single-fanged, and well behind the maxillary root of the zygoma. The mandible has no definite angle, and the subcondyloid process is massive and strongly inflected.

I may refer to Mr. Elliott's work on Alaska for the most complete account of the appearance and habits of this Seal which has yet been published. Mr. Allen has stated that in the character of the pelage this Seal differs in no marked way from the Fur-Seal of the South Pacific, *Arctocephalus australis*, though the latter is much greyer than the former; but in *Arctocephalus ursinus* the toe-flaps of the pes are greatly developed, their extension beyond the digits being nearly equal to the length of the rest of the foot, 140 mm., whilst, as I have stated, in *Arctocephalus australis* (p. 40) they did not pass more than 110 mm. beyond the toes. Though the males of the two species are almost equal in size the female of *Arctocephalus australis* is very much larger than that of *Arctocephalus ursinus*.

Arctocephalus forsteri (Lesson). Fur-Seal of New Zealand and Australia.

Otaria forsteri, Less., Dict. Class. Hist. Nat., t. xiii. p. 421, 1828.
,, ,, Clark, Proc. Zool. Soc. Lond., 1875, p. 675, pls. lxx.-lxxii.

Mr. J. W. Clark has given a good description of this Seal[1] from an examination of a skin and several crania, supplemented by drawings of the animal made by Sir James Hector. Amongst other characters he states that the hair is coarse in the young, and black when wet, and with a dense under-fur of a yellow colour. In old animals the hairs are tipped with white; snout tapering, obliquely truncated, nostrils on sloping surface. Manus with digits I., II., III. indicated by prolongations, whilst IV. and V. are indicated merely by a wavy edge. Pes with hair extending as far as nails; digits II., III., IV. with strong black nails, in I. and V. nails rudimentary. Hinder edge of palate rounded and some distance in front of hamulars, surface of palate flat behind. Teeth thirty-six; the post-canine formula being $\frac{6-6}{5-5}$, small and conical, the first four upper with an anterior cusp, the 5th tricuspid, the 6th simple; lower molars all with anterior cusp.

Mr. Clark is disposed to regard the Fur-Seal from St. Paul's and Amsterdam Island as a variety of *Arctocephalus forsteri*, and it is not improbable that the specimen from one of these islands, which Professor Peters named *Arctocephalus elegans*,[2] is of the same species.

Arctocephalus philippii (Peters).[3] Fur-Seal of Juan Fernandez.

Otaria Philippii, Peters, Monatsber. d. k. preuss. Akad. d. Wiss. Berlin, May 17, 1866, p. 276, pl. ii. figs. A, B, C, 1867.

This name has been given by Peters to the Fur-Seal of Juan Fernandez and Masafuera. It is a question whether this animal is a distinct species or only *Arctocephalus australis*. Mr. Allen holds the latter opinion as to its position, and he gives both *Arctocephalus philippii* and *Arctocephalus argentatus* as synonyms of *Arctocephalus australis*. The general form of the skull of both *Arctocephalus philippii* and *Arctocephalus argentatus*, as figured by Peters,[4] corresponds closely to that of the specimens of *Arctocephalus australis* described in the first part of this Report, but in these crania the rudimentary anterior cusp of the upper molars is more definite than is represented in Peters' figures. The amount of development of the rudimentary anterior and posterior cusps is, however, without doubt, variable in different crania of the same species of Seal

[1] *Proc. Zool. Soc. Lond.*, December 7, 1875.
[2] *Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, May 18, 1876.
[3] *Idem, op. cit.*, May 17, 1866.
[4] Peters described and figured as *Otaria argentata* (*Monatsber. d. k. preuss. Akad. d. Wiss. Berlin*, November 9, 1871) a skull from Chili.

both in this and in other genera. Only five upper post-canines are figured by Peters in his specimen of *Arctocephalus philippii*, the 5th being in line with the posterior border of the maxillary root of the zygoma; in *Arctocephalus argentatus*, however, six upper post-canines are represented; possibly the absence of a sixth upper post-canine in Peters' specimen of *Arctocephalus philippii* may be an individual peculiarity. In the British Museum is a skull marked *Arctocephalus nigrescens* from Juan Fernandez, and presented by the Government of Chili, which in its general appearance resembles my specimens of *Arctocephalus australis*, and it also has six upper post-canines. The under surface of the tympanic is however smoother, and the lower border of the mandible runs almost straight from symphysis to subcondyloid process. The young Fur-Seal described on p. 52 of this Report was the pup of the Fur-Seal of Juan Fernandez, but its immature condition prevents me from saying definitely whether it was *Arctocephalus australis* or another species.

PART III.

BRAIN OF ELEPHANT SEAL AND OF WALRUS.

The Brain has been examined and described in only a few species of the Pinnipedia. As might naturally be expected, the brain of the Common Harbour Seal, *Phoca vitulina*, is the one which has most frequently attracted attention, and descriptions, often undoubtedly very brief, but in many cases illustrated by figures, have been given by Tiedemann, Vrolik, Daubenton, Cuvier, Leuret, Bellingeri, Owen, Broca, Krueg, Mivart, and Theodor. Rosenthal has written a short description of the brain of *Halichœrus grypus*. Mivart has made a few observations on some of the convolutions of the brain of *Cystophora cristata*. Murie has written an elaborate description and figured the brain of *Otaria jubata*, and Mivart has figured and described some of the convolutions of *Otaria* (*Eumetopias*) *gillespii*. The only observation on the brain of the Walrus to which I can find a reference is by Sir Richard Owen, who states, in the course of an account of the dissection of a female Walrus which died in the Zoological Gardens, "the brain weighed 1 lb. 9 oz. avoirdupois; its convolutions and structure were described," but no further statement is made regarding them.

Numerous anatomists have, however, described in more or less detail the brains of various Carnivora, more especially the Dogs, Cats, and Bears; and through their researches the plan of construction of the Carnivorous brain and the arrangement of the convolutions have been worked out with considerable detail. The convolutions and sulci have also received names, though not unfrequently confusion has arisen both through different parts being similarly named and through the same part being differently named by investigators. The affinity between the Pinnipedia and the proper Carnivora is shown by certain resemblances in brain-structure and arrangement, and as in the study of the brain in the Seals and Walrus the anatomist finds it necessary to refer frequently to the brain of the Dog, Cat, &c., it may be useful to give in this place references to the principal sources of information on the brain of this order of mammals.

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BRAIN OF ELEPHANT SEAL (Pls. VIII., IX.).

Weight and External Form of the Brain.—The brain of *Macrorhinus leoninus* which I have examined was removed from the skull of the young female (*d*) killed at Christmas Harbour, Kerguelen, on January 4, 1874, and at once placed in spirit for preservation, without the pia mater having been stripped off. It reached me in good condition, and weighed, after several years' immersion in spirit, 1 lb. $1\frac{3}{4}$ oz. avoirdupois ($17\frac{3}{4}$ oz.). As the brain loses considerably in weight from the action of spirit, the normal weight of this organ is always greater during life than after being in spirit, so that the fresh brain would have weighed in all probability several ounces more than is expressed by the above figures. As the male brain, where the body of the animal exceeds in size and weight that of the female, is heavier than the female brain, in all probability the brain of the adult male Elephant Seal would be several ounces more than that of this young female.

The principal dimensions of this brain were taken with callipers, and are stated in millimetres in Table XI.

As the brain loses both weight and bulk, and to some extent shape, after prolonged immersion in spirit, it is necessary to correct, as far as possible, the dimensions and form of a hardened brain. This may to some extent be done by taking a cast of the cranial cavity of the skull of the animal. I accordingly asked my assistant, Mr. H. J. Stiles, M.B., to make a cast of the cranial cavity of the skull of the Elephant Seal from which the brain had been removed, and I append in Table XII. a few measurements of this cast, which, although they include the thickness of the dura mater, give most probably a closer approximation to the size of the brain during life than from the measurements of the organ itself.

Table XI.—Brain of Elephant Seal.

	mm.
Extreme length of cerebrum,	111
Greatest breadth of ,,	116
Greatest height of ,,	63
Antero-posterior length of cerebellum,	52
Greatest breadth of ,,	92
Length of pons Varolii,	24
Breadth of ,, ,,	27
Length of medulla oblongata,	24
Greatest breadth of ,,	26
Length of olfactory bulb,	16
Breadth of ,, ,,	6
,, of optic nerve,	4
,, of optic commissure,	8
,, of 3rd nerve,	2
,, of sensory root of 5th nerve,	7
,, of motor root of ,, ,,	1·5
,, of portio dura or facial nerve,	2
,, of portio mollis or auditory nerve,	5

From these dimensions it will be seen that the cerebrum had in the spirit-preserved specimen almost retained its original length, but had diminished greatly both in breadth and height, so that the form of the cerebral hemispheres had become greatly modified. As the cast represents the normal form of the brain the description of the general shape of the cerebrum has been written from it.

Table XII.—Cast of Cranial Cavity of Elephant Seal.

	mm.
Extreme length of cerebrum,	114
Greatest breadth of cerebrum,	149
Greatest height of cerebrum,	82
Length of olfactory bulb,	21
Breadth of olfactory bulb,	10

On a vertex view the cerebrum formed a triangle, the apex of which was in front and the base behind; the apex was somewhat truncated, and the base possessed the breadth of 149 mm., so that the cerebrum was considerably broader than long, and the rounded angles of the base fitted into the hollows of the squamous temporals. The anterior ends of the olfactory bulbs appeared for a short distance in front of the anterior end of the cerebrum. The two hemispheres were parallel, and formed the sides of the mesial longitudinal fissure, but at the posterior end they diverged slightly from each other so as to expose a small portion of the middle lobe of the cerebellum. The space between the diverging hemispheres was occupied by a mesial plate of bone continuous with the upper surface of the ossified tentorium.

The cerebellum projected behind the base of the hemispheres, and the surface of the cerebellum which was exposed was the posterior or occipital, the general direction of which curved from above downwards and backwards. The anterior or tentorial surface again sloped downwards and forwards, and was completely concealed by the cerebral hemispheres, except the small portion of the middle lobe above referred to. In my paper [1] On the Anatomical relations of the surfaces of the Tentorium to the Cerebrum and Cerebellum, I pointed out that in the brains of the Carnivora the surface of the cerebellum which is exposed behind the cerebrum is the occipital, or that which corresponds to the inferior surface of the human cerebellum, and not the anterior or tentorial surface, which is the superior surface of human anatomy. At the time when that paper was published I had not seen the brain of the Seal *in situ*, but in the summer of the same year I had the opportunity of seeing the brains both of a young *Phoca grœnlandica* and a *Halichœrus grypus* in the cranial cavity. In the Greenland Seal the cerebellum was below the hinder part of the cerebrum, and its occipital surface was almost vertical, though with a slightly forward direction. In *Halichœrus grypus* the occipital surface of the cerebellum was posterior and almost vertical, the vermiform process being the most projecting part; the cerebellum was below the cerebrum, but, owing to a slight divergence of the cerebral hemispheres posteriorly, a part of the vermiform process could be seen between them when the brain was looked at from above. In the Elephant Seal the cerebellum was apparently exposed to a greater extent than in the Greenland and Grey Seals.

The base of the brain was comparatively flattened, owing to the shallowness of the middle cranial fossæ. The olfactory bulbs were almost vertical in direction, in conformity with that of the cribriform plate of the ethmoid bone. The olfactory peduncle was 21 mm. long. It was remarkably slender, more so even than in the human brain, and was almost entirely concealed in the olfactory sulcus. It terminated posteriorly in a slight elevation, situated in front of the inner end of the Sylvian fossa, and of the locus perforatus anticus. This elevation, the trigonum or tuber olfactorium, was 16 mm. long and 5 mm. broad, and was directed backwards and outwards into the Sylvian fissure. It is possible that another root had passed inwards to the great longitudinal fissure, but it was not clearly marked, for the surface of the brain was somewhat abraded at this spot. The optic nerves, commissure, and tracts were all very distinct, and the last named curved backwards on the outer aspect of the crura cerebri. The third nerves arose from

[1] *Proc. Roy. Soc. Edin.*, March 3, 1862, vol. iv. p. 549.

the inner aspect of the crura cerebri. The fourth nerves had been torn away in the removal of the brain. The hypophysis or pituitary body was situated behind the optic commissure and between the third pair of nerves. It was about the size of a small hazel nut and small on its surface, though a shallow depression on each side indicated a division into an anterior and a posterior lobe. It was hollowed out internally into a cavity continuous with the infundibulum. On raising the pituitary body the tuber cinereum was seen surrounding the base of the infundibulum. The crura cerebri were short and flattened on the ventral surface.

Convolutions and Sulci.—In entering on a description of the sulci and convolutions of the brain, either of the Carnivora or of the suborder Pinnipedia, one of the difficulties experienced by the anatomist is the selection of the terms to be employed. The literature of the carnivorous brain is extensive, more especially in recent years; and as many authors have employed their own terms without much reference to the nomenclature adopted by other writers, it is sometimes difficult to decide which name should be selected in description. After some consideration I have thought it advisable not to limit myself to the terminology of any single anatomist, but to select from the writings of various authors such of the names as seemed to be most appropriate.

Each hemisphere of the cerebrum of the Elephant Seal was rich in convolutions and intermediate sulci.

The *Sylvian fissure, fissure of Sylvius* (*s*). This was the largest sulcus, and commenced on the base of the brain in the Sylvian fossa, situated in the region of the locus perforatus anticus. It passed almost transversely outwards to the side of the hemisphere, and was then continued upwards and backwards for 32 mm. on the side of the right hemisphere, but not so far on the left, and from it an offshoot ascended almost vertically for 13 mm. The suprasylvian fissure sprang out of it, and seemed as if it were an anterior branch of bifurcation.

The *Crucial fissure* (Leuret), *fissura cruciata* (*c*).[1] This fissure was not visible in the norma verticalis, for it was situated so far forward that the brain had to be looked at from the front in order to see it, so that it corresponded with Leuret's description of its position in the brain of the common Seal. In the Elephant Seal it extended at first obliquely and then almost transversely outwards for 30 mm. from the mesial longitudinal fissure. It formed a well-marked feature in this region of the brain, and a large sigmoid gyrus (*sgc*) was bent around its outer end.

Bounded above and in front by the crucial fissure, and behind by the basal part of the Sylvian fissure and fossa and the locus perforatus anticus, was a well-defined area on the hemisphere, which rested on the sphenoid and frontal bones where they formed the roof of the orbit. This *supraorbital area*[2] obviously corresponded in position to the orbital surface of the frontal lobe in the human brain, and like it was subdivided

[1] Frontal fissure, Owen.

[2] *Supraorbital convolution*, Leuret; *Orbital convolution*, Langley.

into convolutions by certain fissures. The most obvious of these sulci was the *olfactory fissure* (*ol*), in which the slender olfactory peduncle was lodged, and which was situated parallel to the mesial longitudinal fissure. Between and parallel to the olfactory and longitudinal fissures was the *gyrus rectus* (*rc*), which extended from the locus perforatus anticus forward to the proreau convolution at the anterior end of the hemisphere. The *rhinal fissure* (*rh*) (Wilder),[1] formed the outer boundary of the tuber olfactorium; it was shallow and was prolonged forwards into the olfactory fissure and backwards into the Sylvian fissure. External to the tuber olfactorium and the olfactory peduncle was an *intraorbital fissure*[2] (*io*) closely resembling what I have described in the brain of Man and the Chimpanzee as the *triradiate fissure*.[3] Its radiations by breaking up the supra-orbital area contributed materially to the convoluted character of this part of the brain. Between it and the olfactory sulcus was a convolution which I shall name *internal supraorbital* (*isc*), and between it and the præsylvian fissure was a convolution which may appropriately be named *external supraorbital* (*esc*).

Returning again to the crucial fissure, at the spot where it changed from the oblique to the transverse, a short sulcus (*fissura præcruciata*, *pc*, Krueg) proceeded forwards and inwards from it, which along with the crucial and mesial longitudinal fissures marked off a convolution 27 mm. long, and as this arrangement occurred in both hemispheres a lozenge-shaped area was produced. This area was first noticed by St. George Mivart in the brain of the Arctoid Carnivora, and was named by him *Ursine lozenge*. In the Elephant Seal, as Mivart has also described in *Phoca vitulina*, this lozenge could not properly be seen until the hemispheres were slightly separated from each other (*ur*). It is of small size as compared with the corresponding area in the brain of *Ursus maritimus*. The *proreau convolution* (*prc*) was 17 mm. long; it was bounded externally by the *proreau fissure*, and internally by the mesial longitudinal fissure; it was immediately above the gyrus rectus, whilst the ursine lozenge was placed above and to its inner side.

The convolutions which lie around the Sylvian fissure were much more complex in arrangement than in the brains of the Dogs, Cats, and Bears, which was due in the Elephant Seal to their greater tortuosity and the more numerous secondary sulci.

Owing to the various modes of nomenclature which have been adopted by different anatomists in describing the tiers of convolutions which surmount the Sylvian fissure, the selection of the names to be applied to them in this description has been difficult. Leuret, in those brains where the tiers were four in number, simply distinguished them by numbers—I, II, III, IV—in their order from below upwards from the Sylvian to the mesial longitudinal fissure. Broca also named them from below upwards the 1st, 2nd,

[1] Ecto-rhinal, Owen.

[2] *Intraorbital fissure* of the carnivorous brain, Flower and Langley.

[3] The convolutions of the Human Cerebrum topographically considered, Edinburgh, 1866. Notes more especially on the Bridging Convolutions in the Brain of the Chimpanzee, *Proc. Roy. Soc. Edin.*, February 19, 1866, vol. v. p. 578.

3rd, and 4th parietal convolutions. Ferrier called them the 1st, 2nd, 3rd, and 4th external convolutions, but he numbered them in the opposite direction from Leuret and Broca, the first being next the longitudinal fissure whilst the fourth bounded the Sylvian fissure. Owen preferred the following descriptive terms from above downwards—medial, medilateral, supersylvian, and Sylvian folds or convolutions. Pansch named them from above downwards—marginal, suprasylvian, outer Sylvian, inner Sylvian; whilst Langley called them from above downwards—superior, suprasylvian, ectosylvian, and Sylvian.

If numerical terms are employed, then I think the plan pursued by Ferrier of numbering the convolutions from above downwards is to be preferred to that of Leuret and Broca, as the order of arrangement is thus brought into conformity with the numbering of the convolutions of the frontal, occipital, and temporo-sphenoidal lobes in the human brain, where in each lobe the highest convolution is the first. If on the other hand descriptive terms are used, then I prefer Owen's name of suprasylvian for the convolution immediately above the Sylvian convolution, instead of outer Sylvian or ectosylvian as employed by Pansch and Langley; whilst the highest convolution may appropriately be called sagittal or marginal, and the one immediately below it mediolateral. Moreover, I shall call the fissure which separates the Sylvian from the suprasylvian convolution the suprasylvian fissure; that between the suprasylvian and mediolateral convolutions the lateral fissure; whilst that between the mediolateral and marginal convolutions is the mediolateral or sagittal fissure. On both the numerical and descriptive methods the following terms are synonymous in brains with four tiers of convolutions:—

1st external convolution	Sagittal or Marginal convolution.
1st curved fissure	Mediolateral or Sagittal fissure.
2nd external convolution	Mediolateral convolution.
2nd curved fissure	Lateral fissure.
3rd external convolution	Suprasylvian convolution.
3rd curved fissure	Suprasylvian fissure.
4th external convolution	Sylvian convolution.

Along with Flower and Ferrier I shall call the convolution which bounds the crucial fissure in front, behind, and externally the *sigmoid gyrus* (*sgc*).

The Sylvian and suprasylvian convolutions were bounded in front and below by the *præsylvian fissure* (*ps*), Owen,[1] which passed forwards, upwards, and inwards to the anterior part of the cerebrum, but did not reach the mesial longitudinal fissure. It was separated from the triradiate fissure by the external supraorbital convolution, and from the crucial fissure, above which its inner end was situated, by the sigmoid convolution. Between the præsylvian and Sylvian fissures the anterior limbs of two convolutions were situated, which were separated from each other by the suprasylvian fissure. The more posterior and narrower of these two convolutions was the anterior

[1] *Supraorbital fissure*, Flower and Langley.

limb of the *Sylvian convolution* (*syc*). The commencement of this limb was at first concealed in the Sylvian fissure, but it became superficial as it passed upwards and forwards; it then wound tortuously above the apex of that fissure to become continuous with the posterior limb of the Sylvian convolution, which was a broad convolution on the side of the hemisphere behind the fissure and formed a part of its posterior lip.

The Sylvian convolution was bounded above by the *suprasylvian fissure* (*ss*), which arose out of the fissure of Sylvius just before that fissure passed backwards and upwards; in its course backwards the continuity of the suprasylvian fissure was broken by the passage across it of a bridging convolution; but it was prolonged downwards and forwards behind and below the posterior limb of the convolution of the Sylvian fissure, where it formed the *fissura suprasylvia posterior* (*ssp*), which did not extend into either the Sylvian fissure or the fissura rhinalis posterior. The *suprasylvian convolution* (*ssc*) formed the tier above the suprasylvian fissure; its anterior limb, which lay next behind the præsylvian fissure, passed almost directly upwards and forwards, and then turning backwards became tortuous and was subdivided by short sulci; but its posterior limb was prolonged downwards and forwards below and behind the Sylvian convolution to join the uncinate convolution, and to form with it the inner end of the posterior boundary of the transverse portion of the fissure of Sylvius.

The *fissura coronalis* (*co*) (Owen), commenced at the outer end of the sigmoid gyrus which it bounded externally; it was continuous in one hemisphere with about the middle of the præsylvian fissure, though in the other it was separated from it by a short gyrus continuous with the suprasylvian convolution. It was separated by a bridging convolution from the lateral fissure. It curved upwards and inwards, but did not quite reach the mesial longitudinal fissure, and it formed along with the præsylvian fissure the anterior boundary of the suprasylvian convolution. The *fissura lateralis* (*l*) bounded the suprasylvian convolution above, and was continued backwards in a tortuous course and almost reached the posterior border of the hemisphere.

Between the lateral fissure and the mesial longitudinal fissure two slender gently wavy convolutions passed from before backwards. The most internal of these was the *sagittal convolution*[1] (*sac*), which formed the marginal convolution of the longitudinal fissure. It was in part divided by longitudinal sulci into two secondary convolutions, the more internal of which dipped in places into the longitudinal fissure so as to become concealed within it. The sagittal convolution commenced as far forward as the posterior limb of the sigmoid gyrus; it also bounded the inner end of the coronal fissure, whilst behind it reached the posterior border of the hemisphere and then inclined to the tentorial surface.

[1] *Medial fold* of Owen.

The convolution which was placed immediately to the outer side of the sagittal convolution was the *mediolateral* or *2nd external convolution* (*mlc*). It extended forward to the coronal fissure where it formed a tortuous fold—the *coronal gyrus;* on the vertex it was narrow, but as it passed backwards it formed a broad tortuous convolution, subdivided by sulci, which assisted the sagittal convolution in forming the posterior boundary of the hemisphere. Between the mediolateral and sagittal convolutions was the *mediolateral fissure* (*ml*); it was not continuous with the coronal fissure in either hemisphere, and on the right side both it and the sagittal and suprasylvian convolutions were so pushed inwards by the highly tortuous suprasylvian convolution, that it approached close to the mesial longitudinal fissure.

The corpus callosum and the other mesial structures in the cerebrum were then divided longitudinally, and the pons and cerebellum were removed by cutting through the crura cerebri. The convolutions and sulci on the mesial and tentorial surfaces were thus exposed, and the following arrangement was recognised. The corpus callosum (*ccl*) was 44 mm. long; posteriorly it had a rounded free end or splenium, whilst anteriorly it bent down to the base of the brain to form the genu; it could be easily torn up into transverse fasciculi of nerve fibres. A septum lucidum occupied the hollow of the genu between it and the fornix. The *splenial fissure* (*sp*), Krueg, was well marked. It commenced immediately behind the lobus hippocampi and curved backwards, upwards, and then forwards behind the splenium, from which it was separated by the gyrus hippocampi; it then ran forwards above the corpus callosum, but separated from it by the callosal convolution, and was continuous at the anterior end of the hemisphere with the crucial fissure. It was not interrupted in its course in either hemisphere by a superficial bridging convolution. An offshoot of this fissure was prolonged upwards and forwards to the sagittal border of the hemisphere 31 mm. behind the crucial fissure. Sixteen mm. below the splenium the splenial fissure gave origin to a branch which I have named the *postero-horizontal fissure* (*ph*); it ran horizontally backwards almost as far as the posterior border of the hemisphere. The *hippocampal fissure* (*h*) was situated between the hippocampal gyrus and the tænia hippocampi, and curved round the splenium to become continuous with the *callosal fissure*, which separated the callosal convolution from the corpus callosum.

These fissures marked out very distinctly an arched convolution, the *great limbic lobe* of Broca,[1] comparable with the *gyrus fornicatus* of human anatomy, which may conveniently be divided into *callosal* and *hippocampal* convolutions, the latter of which terminated in the *uncinate* gyrus or *lobus hippocampi*.[2] The lobus hippocampi (*lh*) was the inferior end of the gyrus fornicatus, and formed the inner part of the posterior lip of the

[1] Strictly speaking, Broca's term "le grand lobe limbique" includes also the olfactory lobe, *i.e.*, the olfactory bulb, peduncle, tuber, and roots.

[2] Lobus pyriformis or natiform protuberance of some authors.

Sylvian fossa; it was bounded externally by a short *postrhinal fissure* (*pr*), which was not continuous with the splenial fissure, but was prolonged forwards into the Sylvian fissure, and across that fissure into the rhinal fissure which formed the outer boundary of the tuber olfactorium. A slender prolongation of this tuber passed backwards, but concealed within the Sylvian fissure, to become continuous with the uncinate gyrus. The *hippocampal gyrus* (*hc*) was prolonged from the uncinate gyrus backwards and upwards, and was marked by shallow depressions due to the pressure of the small arteries which turned round the gyrus to enter the choroid plexus situated in the transverse fissure of the cerebrum. Opposite the splenium it was continued into the callosal gyrus by a slightly constricted part or *isthmus*. The *callosal gyrus* (*cc*) was prolonged forwards, at first horizontally, and then bending down in front of the genu it formed the genual part of the callosal gyrus, and reached the end of the mesial longitudinal fissure on the base of the brain in front of the optic commissure. The *suprasplenial fissure* of Krueg (*sps*) could scarcely be said to exist in the right hemisphere, but in the left the convolution which intervened between the splenial fissure and the margin of the hemisphere was partially divided by a fissure running horizontally into an upper and a lower tier. This fissure was the suprasplenial; the convolution between it and the splenial fissure was the *suprasplenial convolution* (*sspc*), whilst the convolution between it and the free edge of the mesial longitudinal fissure was that aspect of the sagittal or marginal gyrus which was directed to the mesial surface of the hemisphere. The suprasplenial fissure terminated anteriorly on the dorsum of the brain behind the crucial fissure. The *postsplenial fissure* (*psp*) of Krueg was not definitely marked, but the surface of the cerebrum, which was situated below the postero-horizontal fissure, was divided by fissures into four slender convolutions running parallel to each other; below the lowest of these was a fissure which opened into the splenial fissure, and then ran backwards and outwards to the border of the hemisphere. Should this fissure represent the postsplenial fissure, then the slender convolutions might be collectively regarded as representing the *splenial convolution*.

I can make no definite statement as to the presence of the Island of Reil, unless the concealed part of the anterior limb of the Sylvian fissure be regarded as representing it.

The Pineal body or Epiphysis cerebri, after the cerebral hemispheres were separated from each other, was seen to project backwards immediately behind the corpus callosum. It was 17 mm. long, 9 mm. in greatest breadth, and 6 mm. in greatest vertical diameter. In shape it was like a three-sided pyramid with the apex forwards. The inferior surface rested in its anterior half on the corpora quadrigemina, and in its posterior half on the anterior part of the middle lobe of the cerebellum, whilst the two lateral surfaces were in relation with the sides of the two cerebral hemispheres in the limited region in which it lay between them. By its apex it projected forwards to the cleft between the two optic thalami. In *Phoca vitulina* the pineal body also projected behind the corpus callosum, and resembled in shape and in its relations to corpora quadrigemina, cerebrum, and cerebellum the epiphysis cerebri in the Elephant Seal. It was 16 mm. long, 8 mm. in greatest breadth, and 6 mm. in greatest vertical diameter.[1] The length of the cerebrum in this specimen was 78 mm. (3 inches). Dr. James Murie is, I think, the only anatomist who has systematically described the brain of an Eared Seal, and he states that in *Otaria jubata* the pineal body is "relatively large," but he does not give its actual dimensions, though, if I may judge of its size as represented in his fig. 44, it does not seem to have been more than about 8 mm. long. It would appear, therefore, that in the Seals this body is undoubtedly larger than in Mammals generally, though, as will be shown later on, it is when largest in them only about one-half as big as in the Walrus, and does not project so far back as to be visible between the two hemispheres of the cerebrum.

Cerebellum.—This was of large size, and consisted of a middle and of two lateral lobes. On the tentorial aspect of the cerebellum the middle lobe was greatly elevated above the lateral lobes, and from its summit the surface sloped rapidly downwards and outwards to the sides of the organ. At the superior border of the cerebellum, which corresponded to the ossified tentorium, there was a slight notch opposite the termination of the middle lobe. On the ventral surface the middle lobe formed the roof of the 4th ventricle and was situated in a fossa between the two lateral lobes. The middle lobe was separated in the greater part of its extent from the lateral lobes or hemispheres by a deep fissure on each side. Each lateral lobe, much thicker when in apposition with the middle lobe than at the borders of the hemisphere, was separated into a tentorial and an occipital surface by a deep fissure, which corresponded to the great horizontal fissure of the human cerebellum, but owing to the different plane occupied by the cerebellum in the Elephant Seal, it may more appropriately be called the *vertical transverse fissure.* The surface of both the middle and lateral lobes was subdivided into numerous folia, but as this surface was much broken up by fissures possessing considerable depth, and often tortuous in direction, the folia were short, and did not have the broad plate-like character one sees in the human cerebellum. These fissures were especially marked on the occipital surface of the hemispheres, on which they ran from within outwards, but were not quite symmetrical on the two sides.

Pons Varolii.—The pons had the usual form. Its mesial line on the ventral surface was marked by a shallow groove for the basilar artery, and this surface consisted of the superficial transverse fibres. It gave origin at the posterior part of its lateral and ventral aspect to the two roots of the 5th nerve, the motor root being immediately internal to the sensory. The sensory root was much thicker than the motor, and its fasciculi were

[1] That the pineal gland in *Phoca* is larger than is usual in the Mammalia was recognised by Ehlers, *Zeitschr. f. wiss. Zool.*, Bd. xxx. p. 628, Supplement, 1878.

more compactly enclosed in a common envelope of connective tissue. The 6th nerve, about equal in size to the same nerve in man, arose from the posterior border of the pons in the groove between it and the anterior pyramid.

Medulla oblongata or *Bulb.*—The Bulb was sharply differentiated above by the groove between it and the pons, but the demarcation between it and the spinal cord below was not so clear, for the decussation of the pyramids was not very distinct in the ventral longitudinal fissure. On each side of this fissure a definite anterior pyramid was seen, much more distinct where it entered the pons than near the spinal cord. On each side of this pyramid was a slight ovoid elevation which was continuous with the anterior pyramid on its inner side, but was more clearly defined on its outer border by a shallow fissure. Outside this elevation and in the interval between it and the pons the trapezium was very distinct. The restiform body formed a definite elevation on the side of the medulla. The dorsal surface was hollowed in the usual way into the 4th ventricle, which was prolonged forwards to the dorsal surface of the pons. The 7th or facial nerve arose immediately behind the sensory root of the 5th from the groove between the pons Varolii and the trapezium. The 8th or auditory nerve arose immediately behind but lateral to the 7th, from the outer part of the trapezium in close relation to the cerebellum; as it passed outwards it grooved the ventral surface of the hemisphere of the cerebellum. The 9th or glossopharyngeal nerve arose immediately behind the auditory from the outer part of the trapezium. The 10th or pneumogastric nerve arose by a number of distinct fasciculi, some of which were situated mesial to the others; they were placed behind the glosso-pharyngeal and passed outwards in relation to the ventral surface of the hemisphere of the cerebellum. The 11th or spinal accessory nerve was a cord of considerable magnitude; its roots arose from the side of the medulla behind the pneumogastric and also from the side of the cervical cord between the anterior and posterior nerve roots. The roots of the 12th or hypoglossal nerve came out of the medulla at the fissure which marked the outer border of the ovoid elevation above referred to, so that this "elevation" can scarcely be regarded as the homologue of the "olive" which in the human medulla lies to the outer side of the roots of the hypoglossal nerve.

Arteries of the Brain.—Two *vertebral arteries* converged and joined on the ventral surface of the medulla oblongata to form the basilar. From each vertebral two small *spinal* arteries passed backwards in relation to the ventral surface of the spinal cord, and a much larger branch, a *postero-inferior cerebellar*, was distributed to the posterior part of the occipital surface of the cerebellum. The *basilar* artery ran forwards mesially, at first in relation to the ventral surface of the medulla oblongata, and then to the corresponding surface of the pons as far as its anterior border. When in line with the posterior border of the pons the basilar gave off a pair of large branches, *antero-inferior cerebellar*, which passed outwards to supply the more anterior part of the occipital surface of the cerebellum. As it lay in the groove in the pons several small *transverse* branches arose from the basilar. The artery divided at the anterior border of the pons into three pairs of branches, two of which passed to the tentorial surface of the cerebellum as the *superior cerebellar* arteries, and the third pair passed to the tentorial surface of the cerebrum behind the Sylvian fissure as the *posterior cerebral* arteries. At the inner end of the Sylvian fossa was a short trunk, apparently the divided *internal carotid* artery, which was joined with the posterior cerebral by a *posterior communicating* artery. From this short trunk a *middle cerebral* or *Sylvian* artery ran outwards in the Sylvian fossa and fissure to supply the cerebrum both in front of and behind the fissure; another branch, an *anterior cerebral*, ran forwards to the mesial longitudinal fissure, which it entered along with its fellow of the opposite side, it ascended in front of the corpus callosum and then ran backwards above it to supply the mesial face of the hemisphere. The two anterior cerebrals were connected close to their origin by a large transverse *anterior communicating* artery. A small branch, apparently a *choroid* artery for the supply of the choroid plexus of the lateral ventricle, was seen at the inner end of the Sylvian fossa. In their general arrangement these arteries at the base of the brain resembled the well-known circle of Willis in the human brain.

BRAIN OF WALRUS (Pls. VIII., IX., X.).

Weight and External Form of the Brain.—I have been fortunate to examine three specimens of the brain of *Trichechus rosmarus*. The first was procured for me in 1865, by my then pupil Mr. (now Dr.) Charles Moon of Dundee, from an animal (*a*) killed by an officer of a whaling ship. I dissected it in the course of the following year, and drawings were made in October 1866 by my then pupil Mr. (now Professor) Richard Caton of Liverpool. The description of the brain and the drawings were at that time reserved for future publication. Since then I have received two additional specimens,[1] one from a young animal (*b*), the other from a larger specimen (*c*). The following description is based on an examination of all three specimens, and the drawings have been revised with the help of the two additional brains.

The brain of specimen *a* weighed after the removal of the membranes and hardening in spirit 24 oz. 7 drachms avoirdupois; that of *b* $13\frac{1}{4}$ oz.; that of *c* 26 oz. The two cerebral hemispheres in *c* weighed $20\frac{1}{4}$ oz.; the pons, medulla, and cerebellum $5\frac{3}{4}$ oz. Brains *a* and *c* were therefore even after prolonged immersion in spirit heavier than the brain of the specimen examined by Sir Richard Owen, which was probably weighed immediately after removal.

The principal dimensions of the brains were taken with callipers, and are stated in millimetres in Table XIII.

[1] These were removed from the crania and brought to me by the late Mr. C. E. Smith and by Mr. Peffers.

Table XIII.—Brain of Walrus.

	a.	b.	c.
	mm.	mm.	mm.
Extreme length of cerebrum,	128	89	121
Greatest breadth of cerebrum,	140	109	142
Greatest height of cerebrum,	...	58	66
Antero-posterior length of cerebellum,	60	62	58
Greatest breadth of cerebellum,	94	87	112
Length of pons,	31	20	30
Breadth of pons,	42	30	38
Length of medulla oblongata,	...	19	24
Breadth of medulla oblongata,	...	23	29

A cast of the cranial cavity of an adult Walrus gave the following as the three great dimensions of the cerebral hemispheres—length 136 mm., breadth 174 mm., height 105 mm. All these dimensions were considerably in excess of the largest of my three brains, so that even when allowance is made for the thickness of the cerebral membranes included in the cast, and for some loss of size from the action of spirit, it is obvious that none of my spirit-preserved specimens represented the full adult magnitude of the organ.

Viewed from the vertex the cerebrum possessed the form of a broad triangle, the apex of which was forward and truncated, whilst the base was directed backwards; the sides of the triangle were convex, and the junction of the sides and base was rounded so that the greatest transverse breadth of the cerebrum was distinctly in front of the base. About midway between the base and apex the side of each hemisphere was deeply constricted in the region of the Sylvian fissure (Pl. X. fig. 1). This constriction formed a definite feature in the configuration of the hemisphere; it curved upwards, inwards, and backwards, and corresponded to a crescent-shaped ridge of bone on the inner aspect of the cranial wall.

The olfactory bulbs curved upwards in front of the anterior end of the cerebrum, and were almost vertical in direction so as to be adapted to the cribriform plate of the ethmoid. The mesial longitudinal fissure was occupied by the falx cerebri, and the mesial surfaces of the hemispheres were parallel to each other and to the falx for the greater part of their length. Posteriorly they diverged from each other and exposed a portion of the middle lobe of the cerebellum, and the posterior end of the pineal body (fig. 1, P). The angle of the divergence was occupied above by a thick mesial plate of bone continuous with the upper surface of the ossified tentorium and below by the pineal body. The tentorial surface of the lateral lobes of the cerebellum was under cover of the hinder part of the cerebrum, but the occipital surface of the cerebellum was almost vertical, and directed backwards and seen behind the cerebrum.

The base of the brain was comparatively flattened. The olfactory bulbs in the larger brains were 22 mm. long by 11 mm. broad. Each possessed a peduncle which in two brains was 3 mm. broad but 6 mm. in the third. The peduncle was placed on the olfactory sulcus, but was not concealed within it. This peduncle terminated behind in a distinct tuber olfactorium (*to*), 21 mm. long by 6 mm. broad, which passed backwards and outwards into the Sylvian fossa and joined the anterior end of the lobus hippocampi; from the olfactory tuber a band, which formed an inner root, passed inwards to the mesial longitudinal fissure and the gyrus rectus. The optic tracts and nerves were from 2 to 3 mm. broad; the nerves and commissural end of each tract were rounded cords, the outer part of the tract formed a flattened band winding round the outer side of the crus cerebri, and was traced to the posterior end of the optic thalamus; the optic commissure was smaller than in the human brain. Behind the commissure was a broad tuber cinereum, from which the dilated infundibulum proceeded to the pituitary body. This body, the hypophysis cerebri, was indented as if divided into two lateral and two median lobes, of which the postero-median was much smaller than the antero-median and the lateral (Pl. X. fig. 6). Corpora albicantia were not recognised. The crura cerebri were massive, diverged from each other, and had between them the tuber cinereum and grey matter of the locus perforatus posticus. The ventral surface of each crus was flattened and marked with fasciculi, some of which ran in the long axis of the crus, whilst others formed on the surface a raised bundle, which curved from within outwards. The third nerve was a little larger than in man, and arose from the inner side of the crus. The fourth nerve was similar in size and position to the human nerve.

Convolutions and Sulci.—The *Sylvian fissure* (*s*) commenced in the Sylvian fossa at the locus perforatus anticus; it passed at first almost transversely outwards, and then mounted upwards and somewhat backwards in the notch on the side of the hemisphere already referred to, and ended in two short branches of bifurcation. The *Crucial fissure* (*c*) was not visible on the vertex, but was situated at the anterior end of the hemisphere immediately above the olfactory bulb; it was short and passed outwards and slightly downwards. The sigmoid gyrus which bounded it was comparatively slender, and in brain *c*, though not in *a*, was concealed at its outer end in the coronal fissure owing to the overlapping of that fissure by the broad anterior end of the mediolateral convolution. It is doubtful if either a præcruciate fissure or ursine lozenge can be said to exist.

The *supraorbital area* of the hemisphere was bounded in front and above by the crucial fissure, and behind and below by the Sylvian fossa and commencement of the Sylvian fissure and the locus perforatus anticus. In this area the *olfactory fissure* was situated parallel to the longitudinal fissure and concealed by the olfactory peduncle; a well-marked *rhinal fissure* (*rh*) extended backwards and outwards from the olfactory fissure, and, bounding externally the tuber olfactorium, passed deeply into the Sylvian fissure. An *intraorbital fissure* (*io*), which, whilst representing the *triradiate* fissure, was sometimes not furcated, was also present. The *gyrus rectus* (*rc*) was definitely marked between the olfactory and mesial longitudinal fissures; between the olfactory fissure and the intraorbital fissure was a well-marked *internal supraorbital gyrus* (*isc*), and between the intraorbital and præsylvian fissures was a relatively broad *external supraorbital gyrus* (*esc*).

The bridging convolutions were not so numerous in the brain of the Walrus as in the Elephant Seal, and the arrangement of the convolutions in four successive tiers, with intermediate sulci, above the Sylvian fissure, was more simple and more easily determined. But it should be stated that the convolutions in opposite hemispheres of the same cerebrum were not perfectly symmetrical, and that one of the larger brains had more frequently bridging convolutions than the other. The convolutions, lying in relation to the Sylvian fissure, were bounded in front by the *præsylvian fissure* (*ps*), which, commencing on the supraorbital area, ran outwards and then upwards on the side of the hemisphere to become continuous on the vertex with the lateral or second curved fissure. The external supraorbital gyrus separated it from the intraorbital fissure, whilst between its upper end and the cruciate fissure the anterior part of the mediolateral and the sigmoid convolutions were interposed. The *Sylvian convolution* (*syc*) immediately bounded the Sylvian fissure; its anterior limb consisted of a narrow, tortuous part which was at its commencement so sunk into the Sylvian fissure as to be concealed within it. As it ascended it emerged from the fissure, and formed the immediate boundary of the apex of the fissure, round which it bent, and was continued behind into a broad convolution situated on the surface of the hemisphere, which formed the posterior lip of the Sylvian fissure and consequently the posterior limb of the Sylvian convolution. The broad posterior limb was partially divided into two parallel gyri by a fissure, which in one brain ran almost vertically, in another obliquely.

Between this Sylvian convolution and the mesial longitudinal fissure three distinct convolutions intervened, which were separated from each other by fissures both on the vertex and anteriorly, though the two uppermost blended with each other posteriorly. The general direction of these convolutions was antero-posterior, but they dipped downwards towards the under surface of the hemisphere both in front of and behind the Sylvian fissure. The convolution next above the Sylvian convolution was the *suprasylvian convolution* (*ssc*), which was strongly developed and tortuous both in front of and behind the Sylvian convolution; it showed a tendency, both in front of the Sylvian convolution and opposite the apex of the fissure of Sylvius, to subdivide into two secondary gyri lying parallel to each other. The Sylvian and suprasylvian convolutions were separated from each other by the *suprasylvian fissure* (*ss*), which was partially concealed within the Sylvian fissure anteriorly, owing to the depression of the corresponding portion of the Sylvian convolution, but it was very distinct on the surface of the hemisphere behind, and formed the *fissura suprasylvia posterior* (*ssp*).

Bounding the mesial longitudinal fissure was the *sagittal convolution* (*sac*), which commenced at the anterior end of the hemisphere at the posterior limb of the sigmoid gyrus, and then passed back as the marginal convolution of the longitudinal fissure to where the hemispheres diverged from each other, when it inclined outwards to reach the tentorial surface of the hemisphere, though in one specimen it reappeared for a short distance at the posterior border. Between the sagittal and suprasylvian convolutions an intermediate *mediolateral convolution* (*mlc*) was placed, which broadened out in front, ascended from the anterior border of the supraorbital area, and then passed backwards to reach the posterior border of the hemisphere, down which it extended behind the suprasylvian convolution. The *coronal fissure* was a short sulcus, not continuous with either the præsylvian fissure or the mediolateral fissure, from both of which it was separated by short intermediate gyri. In brain *c*, where the outer end of the sigmoid gyrus was overlapped by the mediolateral convolution, the coronal fissure was partially concealed by it, and this broad anterior end of the convolution may be called the *coronal gyrus*. The *lateral fissure* (*l*) ran at first upwards and backwards, and then curved downwards to reach the tentorial border of the hemisphere; it formed the boundary of the suprasylvian convolution in front, above, and behind. The mediolateral convolution was separated from the sagittal convolution by a definite *mediolateral fissure* (*ml*) running antero-posteriorly, which almost reached the sigmoid gyrus, but was separated from the coronal fissure by a narrow bridging convolution; behind it reached the posterior border and tentorial surface of the hemisphere. In the brain drawn in Pl. X. figs. 1, 3, this fissure was not bridged across, but in the left hemisphere of one of the other specimens a secondary gyrus passed across it about the middle of its length. The sagittal and mediolateral convolutions were wider in front than behind, and formed a larger proportion of the hemisphere anterior to the Sylvian fissure, whilst on the other hand the Sylvian and suprasylvian convolutions were wider behind than in front, and formed much the larger portion of the postsylvian part of the hemisphere.

The *prorean convolution* was short, and not beak-like as in the Dog, and was concealed by the olfactory bulb.

The convolutions and sulci on the mesial and tentorial surfaces of the hemisphere were examined after the pons and cerebellum had been removed, and the corpus callosum mesially bisected. In the larger brains the corpus callosum was 50 mm. long, and was distinctly differentiated from the grey surface of the convolution. One of the best marked fissures on these surfaces of the hemisphere was the *splenial fissure* (*sp.*) of Krueg. In its general direction it curved behind the splenium of the corpus callosum, from which it was separated by the gyrus hippocampi. It was not quite uniform in its disposition in the two larger brains.

In the one brain (*a*) (Pl. IX. fig. 3) it commenced well forwards on the tentorial surface, and was separated from the postrhinal fissure by two narrow convolutions, which connected the hippocampal gyrus with the Sylvian and suprasylvian convolutions; the ascending part of this fissure ran backwards behind the splenium, and then curved upwards and forwards so as to get above it; here it was interrupted by a bridging convolution, beyond which it was continued horizontally forwards above and parallel to the corpus callosum, but separated from it by the callosal convolution; it ended anteriorly in two branches, both of which reached the margin of the hemisphere, the one ended a little above the inner end of the crucial fissure, but the other was continuous with the crucial fissure itself. Behind and below the end of the splenium the splenial fissure gave off a *postero-horizontal fissure* (*ph*), which, running horizontally backwards, extended almost to the posterior border of the hemisphere. Immediately in front of the interrupting convolution an offshoot of the splenial fissure was prolonged upwards and slightly backwards to the sagittal margin of the hemisphere.

In the other well-grown brain, the part of the splenial fissure in relation to the hippocampal gyrus was interrupted by two bridging convolutions in the left hemisphere, but by only one in the right. The part above the callosal convolution was not interrupted by a bridging convolution in the left hemisphere, though it was so in the right. In both hemispheres this fissure terminated anteriorly by becoming continuous with the inner end of the crucial fissure. In both hemispheres, also, a postero-horizontal fissure (*ph*) extended backwards from the splenial fissure almost to the posterior border of the hemisphere (Pl. X. fig. 5).

The *hippocampal fissure* (*h*) was situated above the hippocampal gyrus, between it and the tænia hippocampi; it curved round the splenium, and became continuous with the *callosal fissure;* at the bottom of this fissure, between it and the tænia hippocampi, was the dentate gyrus.

The great arched convolution, *gyrus fornicatus* or the *great limbic lobe* of Broca, was differentiated by the splenial, hippocampal, and callosal fissures, and consisted of *callosal* and *hippocampal* convolutions with the *uncinate gyrus* or *lobus hippocampi.* The *lobus hippocampi* (*lh*) was the inferior end of the hippocampal convolution, and formed the inner portion of the posterior lip of the Sylvian fossa; it was demarcated on its outer lateral side by the *postrhinal fissure* (*pr*) which was continued forwards into the Sylvian fissure, to become through it continuous with the rhinal fissure; the tuber olfactorium was also continuous with the uncinate gyrus, but the intermediate band was small and so deeply lodged in the Sylvian fissure as to be recognised with some difficulty. The recurved part of the lobus hippocampi was continuous with the tænia hippocampi and with the band of grey matter at the bottom of the hippocampal fissure which in human anatomy is called *fascia dentata* or *dentate gyrus.* The *hippocampal gyrus* (*hc*) was prolonged from the uncinate gyrus backwards and upwards, and was marked by shallow arterial depressions similar to those described in the Elephant Seal. The *callosal gyrus* (*cc*) at first passed horizontally forwards and then bent downwards in front of the genu of the corpus callosum, where it formed the genual part of the callosal convolution, to reach the basal part of the mesial longitudinal fissure. The *suprasplenial fissure* (*ssp*) of Krueg was as a rule elementary, but in the right hemisphere of brain *c* it was a distinct fissure situated on the mesial surface of the hemisphere parallel to the splenial fissure, and separated from it by a distinct gyrus, which may be called the *suprasplenial gyrus*. It was continuous behind the splenium with the splenial fissure, whilst it terminated anteriorly in a sulcus, which indented the sagittal gyrus above the crucial fissure. Between the suprasplenial fissure and the free edge of the mesial longitudinal fissure was that aspect of the sagittal gyrus which was directed to the mesial marginal surface of the hemisphere. The *postsplenial fissure* (*psp*) of Krueg was situated behind the ascending part of the splenial fissure, and ran backwards and upwards nearly to the posterior border of the hemisphere below the postero-horizontal fissure; it was separated from the splenial fissure by the *splenial convolution* (*spc*), which is consequently bounded in front by the splenial and behind by the postsplenial fissure.

I could not speak with any precision of the Island of Reil, unless the concealed part of the anterior limb of the Sylvian convolution be regarded as representing it; for the lower end of this limb of the Sylvian convolution passed deeply into the fissure, and was concealed by the anterior limb of the suprasylvian convolution, which for some distance therefore formed the anterior lip of the fissure of Sylvius.

Interior of the Cerebrum.—A vertical transverse section through the right hemisphere, immediately in front of the anterior pillar of the fornix, showed the fibres of the corpus callosum extending outwards to become continuous with the white core of the hemisphere. Immediately below the anterior mesial part of the corpus callosum the right half of the septum lucidum formed a vertical lamina which was relatively thick. Laterally to the septum lucidum was the lateral ventricle, the inner part of which was vertical, but the outer part extended horizontally outwards below the corpus callosum, though it curved a little downwards at its lateral limit. When the ventricle was opened into by slicing away the corpus callosum the nucleus caudatus of the corpus striatum was seen to form a large and well-defined pear-shaped body at the anterior part of the floor; but the ventricular chamber was not prolonged in front of the caudate nucleus. The greatest transverse diameter of this nucleus was 27 mm., and its antero-posterior diameter was 30 mm.

The optic thalamus was behind and to the inner side of the nucleus caudatus, a shallow groove in which the tænia semi-circularis could be seen, being placed between them. Its upper surface was covered by the fornix and choroid plexus, on removing which structures this surface was seen to be 25 mm. in transverse and 35 mm. in antero-posterior diameter.

The fornix was prolonged in a curve backwards, outwards, downwards, and forwards into the descending horn of the ventricle as the tænia hippocampi, and followed the curve of the hippocampus major. Internal to it the choroid plexus was also prolonged downwards, to become continuous through the great transverse fissure with the pia mater covering the gyrus hippocampi. Where the cavity of the ventricle curved downwards and outwards into the horn an indication of a recess was seen in its posterior horn, but it did not amount to a cornu, and there was no elevation which could be called a hippocampus minor. The inner surface of the optic thalamus formed the lateral wall of the third ventricle. The corpora quadrigemina were well marked, and the testes overlapped the nates.

The *Pineal body* or *Epiphysis cerebri* was remarkable for its size. In specimen *c* it measured 30 mm. in its long and 18 mm. in its greatest transverse diameter; in *b* it measured 29 mm. by 13 mm. It was somewhat pyriform in shape, with the apex directed forwards to the optic thalami, whilst the base, which was free, projected backwards so as to be visible, when the brain was looked at from above, between the two cerebral hemispheres, where they diverged from each other posteriorly. It possessed three surfaces—one was inferior, and rested in almost its whole length on that surface of the middle lobe of the cerebellum which was in relation with the tentorium, and this surface was somewhat depressed below the level of the corresponding surface of the hemispheres of the cerebellum for its lodgment. The other two surfaces were lateral, and in relation to the inner and posterior border of the cerebral hemispheres, between which the epiphysis was placed. These surfaces were slightly concave in their anterior two-thirds, so as to be adapted to the convex borders of the hemispheres; but more posteriorly, where the pineal body projected between the hemispheres, they were somewhat convex, and mounted upwards to form a ridge in the inter-hemispherical interval (Pl. X. fig. 1). The pineal body was separated by the tentorium from the cerebrum, and was closely tied down to the cerebellum by the arachnoid and the pia mater; so close indeed was this relation, that in brain *a* of the Walrus, which I dissected as far back as 1865, I mistook the pineal body for a special thickening of the pia mater covering the middle lobe of the cerebellum. The apex of the epiphysis passed forwards in front of the cerebellum and superficial to the corpora quadrigemina to the region of the optic thalami, but, owing to this part of the brain being somewhat friable from imperfect preservation, I could not ascertain its exact connections, though there can, I think, be little doubt that, as in other Mammals, it was attached to the thalami by a pair of peduncles.

The very remarkable size of the epiphysis cerebri in the brain of the Walrus, and its unusual development also in the brain of the Seals, are of especial interest in connection with recent important observations on the connections and homology of the pineal body Ehlers showed[1] that in the Plagiostomata the epiphysis cerebri is lodged in a depression in the cartilaginous cranium, whilst retaining its connection with the brain through its

[1] *Zeitschr. f. wiss. Zool.*, Bd. xxx., Supplement, 1878.

peduncle. Sir Richard Owen makes use[1] of this and other facts connected with the extension of the pineal body into or towards the cranium in these Fishes and in Reptiles in support of the hypothesis that the conario-hypophysial tract represents the passage of the gullet to the neural aspect of the body and the formation of a neural mouth. But additional interest has quite recently attached to the pineal body by the discovery, as the result of independent research, both by H. W. de Graaf[2] and W. Baldwin Spencer[3] during the year 1886 of a mesial pineal eye in the Lacertilia. By these naturalists the mesial foramen in the parietal bone in this group of Reptiles has been seen to be occupied by an eye, and Mr. Spencer has worked out in a number of species of Lizards the structure of this eye and its connections, from which it would appear that the pineal eye is connected by an elongated stalk or peduncle with the thalamencephalon. This peduncle grows out of the optic thalami; at first it passes upwards in the interval between the cerebral hemispheres and the optic lobes, and then runs forwards on the dorsal aspect of the cerebrum, to end in the mesial eye, situated in the parietal foramen.

In the Mammalia this apparatus has practically disappeared, and is represented only by the aborted structure which we call the pineal body, though it should be stated that in the Horse, as M. Chauveau has pointed out,[4] it may occasionally assume larger dimensions, and project backwards so as almost to touch the cerebellum. But in the Seals to some extent, and in the Walrus in a more remarkable manner, the pineal body has retained a greater magnitude than is customary in Mammals. The direction, however, which this body takes in these Mammalia is different from that of the stalk of the pineal eye in the Lizards. For in these Reptiles the direction of the peduncle is at first upwards and then forwards, so as not to overlie either the optic lobes or the cerebellum, whereas in the Walrus and Seals the direction of growth is always backwards. Two factors may operate in the cranial cavity of the Walrus and Seals to induce the backward direction to which I have referred, viz., the growth of the tense unyielding tentorium, and the backward development of the hemispheres of the cerebrum. Through lying subjacent to the tentorium the growth of the elongated pineal body in the direction either of the parietal bone or of the superior part of the occipital bone is effectually prevented, and the only course which it can take is towards the cerebellar region of the occiput. Similarly the posterior development of the cerebral hemispheres, which overlie both the optic lobes and the cerebellum, would by the compression of the pineal body between the cerebrum and cerebellum assist in giving it a backward direction. It is possible, also, that these same factors may operate in producing the aborted condition of this body which one finds in the Mammalia as compared with the Lizards. For the pressure exercised by the growth

[1] *Rep. British Assoc.*, York, 1881, p. 719; Aspects of the body in Vertebrates and Invertebrates, Lond., 1883.
[2] *Zool. Anzeiger*, March 29, 1886.
[3] *Quart. Journ. Micr. Sci.*, October 1886.
[4] Traité d'Anatomie comparée des animaux domestiques, 1857, p. 650, fig. 177.

both of the tentorium and cerebral hemispheres upon an elongated structure, like the pineal stalk, would occasion atrophy both of the stalk and of the pineal eye, and a consequent disappearance of the mesial parietal foramen in the mammalian skull. It is conceivable, however, that the atrophy might begin distally by bone formation closing up the parietal foramen, as a result of which both eye and stalk would disappear. But whatever cause has been in operation to lead to the disappearance of both pineal eye and stalk, only the proximal end of the pineal organ, where it arises from the thalamencephalon, is left in the Mammalia. It is, however, of interest to note that in at least one Mammal, viz., the Walrus, this proximal part may retain such magnitude as to be visible between the hinder ends of the cerebral hemispheres, so that it does not present so aborted or residual a character as in other Mammals. But the special function, if any, which may be discharged by the pineal body in this animal will be difficult to ascertain.

The Cerebellum was a massive organ and consisted of a middle lobe and of two lateral lobes or hemispheres. The middle lobe on the tentorial surface was separated by a furrow on each side from the corresponding lateral lobe, and the distance from this furrow to the extreme lateral border of the hemisphere was 54 mm. At the superior margin of the cerebellum the middle lobe was concealed in a cleft which separated the two hemispheres from each other. Inferiorly where the middle lobe formed the roof of the 4th ventricle it was depressed between the two lateral lobes of the cerebellum. Each hemisphere was divided into a tentorial and an occipital part by a *vertical transverse fissure*, and the surface of the tentorial aspect was split up into numerous broad plate-like folia by intermediate fissures. The occipital aspect was similarly subdivided, but there was also evidence of a division of this aspect into lobelets by broader fissures. Thus about opposite the middle of the side of the medulla oblongata a broad and deep fissure curved outwards and forwards, so as to divide this aspect of the cerebellum into an anterior and a posterior lobelet. The folia which bounded the fissure dipped into it in a whorl-like manner, so that the fissure may be distinguished as the *vorticose fissure* (*v*). On raising the anterior lobelet the superficial transverse fibres of the pons could be traced without any difficulty into the white core of the hemisphere.

The *Pons Varolii* was broader in the middle than either in front or behind. It had the usual mesial groove for the basilar artery, and the superficial transverse fibres were very distinct, and could readily be traced outwards into the hemispheres of the cerebellum. The 5th nerve arose from the side of the pons by a large sensory and a small motor root. The motor root was at first on the inner side of the sensory, and then passed outwards in contact with its ventral surface to join the inferior maxillary division of the ganglion. The sensory root was 13 mm. in its transverse diameter, and expanded anteriorly into a flattened Gasserian ganglion which gave off the three divisions of the nerve; some fibres of this root entered the substance of the pons, but others passed backwards between the facial and auditory nerves to the anterior and outer part of the medulla oblongata. The 6th nerve had been torn away in *a* and *c*, but in *b* was situated in the groove between the pons and anterior pyramid. The 7th or facial nerve arose from between the pons and medulla external to the anterior pyramid. The 8th or auditory nerve arose from the lateral aspect of the medulla immediately behind the pons.

The *Medulla Oblongata* or *Bulb* was much injured in specimen *a*, but in good order in the two others. It possessed on each side of the mesial fissure a distinct anterior pyramid which passed above into the substance of the pons. Immediately external to this pyramid but not reaching the pons was an elongated oval swelling 14 mm. long and 4 mm. in greatest transverse diameter; this swelling was bounded both on its inner and outer borders by a shallow groove. The roots of a nerve, which were unfortunately torn across in *c* close to the medulla, emerged from the groove at the inner border; in *b* they were entire and were the roots of the hypoglossal or 12th cranial. The swelling is to be regarded as like the olive in the human medulla, where the hypoglossal nerve arises from the groove on its inner side between it and the anterior pyramid. In *Phoca vitulina* a swelling was also seen in the same region but not separated by a groove from the anterior pyramid so that it is a part of that structure. External to the upper end of the anterior pyramid was a body which apparently represented the trapezium, though it was not marked with transversely arranged bundles of nerve fibres. Below this body the side of the medulla swelled out into a restiform body, the surface of which was marked by arciform fibres running from before backwards around the side of the medulla. Springing out of the restiform body were some nerve roots, which in *c* were torn across close to the medulla, but were entire in *b*, and were the origins of the 9th, 10th, and 11th cranial nerves. Of these nerves the 11th or spinal accessory was large, and its spinal roots were traced for a short distance along the side of the cord. The dorsal surface of the medulla was hollowed out into the 4th ventricle, which was prolonged forwards on to the corresponding surface of the pons.

Nothing is known of the development of the convolutions and fissures in the cerebrum of the Walrus, and I have not met with any description of the order in which the convolutions and fissures appear in the hemispheres of the Seals. Some years ago I was presented by one of my pupils, Mr. T. G. Ker, with twin fœtuses of *Phoca grœnlandica* which he had extracted from the uterus of the mother, when acting as surgeon on a ship engaged in the Seal fishing. The fœtuses were preserved in rum, and after they came into my possession I removed the brains. The length of the fœtus from the snout to the tip of the pes was 222 mm. The cerebrum was 20 mm. long and 22 mm. wide. The cranial surface of each hemisphere was quite smooth, except that about the junction of the anterior and middle thirds a very shallow furrow passed from the mesial longitudinal fissure transversely outwards for 8 mm.; it seemed to be a slight tear on the surface (Pl. VIII. fig. 4). Low down on the outer side of the hemisphere a shallow depression marked the position of the future fossa and fissure of Sylvius. With a pocket lens one could also see the commencement of the differentiation of a Sylvian convolution about this fissure. On the tentorial surface of the hemisphere a shallower fissure was also seen, which was probably the beginning of the splenial fissure.

I do not intend to enter into a discussion of the question whether the fissures on the surface of the hemispheres are primarily due, either to unequal growth of the cortex in different parts, or to unequal resistance offered to the growth of the cortex, or to both causes acting in different parts of the same brain. I would, however, state that in stripping off the pia mater from certain parts of the hemispheres of the brains which I have dissected I have been struck with the tension and consequent pressure exercised by the arteries on the surface of the cortex in the direction of their course. This was well seen in the fissure of Sylvius occupied by the large middle cerebral artery. Also in a less degree by the arteries which ran in the pia mater occupying the great transverse fissure of the cerebrum, and which as they turned round the hippocampal convolution undoubtedly indented its surface by their pressure.[1] In these localities therefore there seems to be sufficient evidence to show that fissures may be produced and deepened by the tension of the arteries, and doubtless the same cause operates also elsewhere.

Comparison of the Convolutions of the Seals and Walrus with those of the Carnivora and of Apes and Man.

M. Leuret, in his well-known Anatomie comparée du Système Nerveux, both figures and describes the cranial surface of the brain of a Seal, probably *Phoca vitulina.* He considers that the convolutions in this animal are analogous to those of the Ungulata, especially the Pig, though without resembling them throughout, and in his arrangement of the Mammalia, according to the grouping of their convolutions, he places the Ungulata, Edentata, and Marsupialia between the Carnivora and the Seals. He recognises only three convolutions in the hemisphere of the Seal—one *internal*, on the inner surface, which is obviously the gyrus fornicatus or great limbic lobe of Broca; one *external* bounding the fissure of Sylvius and very irregular; one *superior* extending from before backwards on the top of the hemisphere and forming two tiers, with two subdivisions in front and three behind, whilst he regards the supraorbital convolution as only an offshoot of the two anterior subdivisions. Sir Richard Owen again has recognised in the brain of *Phoca* a prefrontal lobe in front of the frontal crucial fissure; an orbital fold above the orbit; Sylvian, supersylvian, medilateral, and medial folds or convolutions arranged in tiers above the fissure of Sylvius; it is obvious, however, from

[1] Johannes Seitz has recently published an elaborate memoir (Ueber die Bedeutung der Hirnfurchung, *Jahrbücher für Psychiatre*, 1887) on the signification of the fissures in the hemispheres, in which he associates them with the places of entrance and emergence of the blood and lymph vessels of the brain—that they are in fact nutrient fissures.

his diagram of the outer surface of the hemisphere (*op. cit.*, fig. 93, p. 118) that he does not consider the interval of separation between the medial and medilateral folds to be as definite as those between the other convolutions on the same surface. Krueg, who has also studied the brain of *Phoca vitulina*, devotes his description to an account of the fissures, and does not even name the convolutions. It would seem, however, both from his description of the fissures and accompanying figures of the brain, that he only recognises three tiers of convolutions on the outer surface of the hemisphere, whilst a well-marked splenial fissure on the inner surface individualises the hippocampal and callosal convolutions. Paul Broca's account of the brain of a *Phoca* is principally taken up with a description of the great limbic lobe and its relation to the olfactory apparatus.

In the brain of *Phoca vitulina*, two specimens of which I have dissected, I found on the outer surface of the hemisphere a distinct fissure of Sylvius, with its Sylvian convolution, the anterior limb of which was narrower than the posterior, and at its commencement concealed within the fissure of Sylvius. When this fissure was widely opened out, prolongations of the Sylvian convolution were traced deeply into it, and occupied the position of an insula. Above the Sylvian convolution were a suprasylvian fissure and convolution, the latter of which showed at its summit a disposition to subdivide into two parallel gyri for a short distance. This convolution was bounded above by a lateral fissure, between which and the mesial longitudinal fissure were two slender convolutions running antero-posteriorly; the lateral of these was apparently the mediolateral convolution, whilst the medial one bounded the longitudinal fissure and was the sagittal convolution; as in Owen's figure, however, the fissure which separated the sagittal (medial) from the mediolateral convolution was not continuous, but was bridged by short annectent gyri. As this mediolateral fissure was imperfect and not prolonged far forward in front, the coronal fissure was not continuous with it. In one instance the coronal was prolonged backwards into the lateral fissure, but it might be separated from it by an intermediate bridging convolution. In this region, therefore, the brain of *Phoca vitulina* closely corresponded in the arrangement both of convolutions and fissures with the Elephant Seal, though in the latter, from its greater size, the convolutions were bigger, also I think more tortuous, and certainly with a greater number of bridging convolutions.

In the Walrus, again, the four tiers of convolutions were more definitely expressed on the outer surface of the hemisphere, partly owing to the comparative absence of bridging convolutions, and partly because the mediolateral fissure formed so definite a plane of separation between the sagittal and mediolateral convolutions. In this animal also the anterior limb of the Sylvian convolution was narrower, and sunken into the fissure of Sylvius much more than either in *Phoca* or *Macrorhinus*, and from Dr. Murie's description and plate of the brain of *Otaria jubata* (*op. cit.*, fig. 40) it is obvious that a corresponding depression occurred also in that of the Eared Seal. This narrowing and depression were more marked than in Leuret's figures of the Brown Bear, Coati, and

Otter in pl. vi. of his Atlas. But I find that in the brain of an Otter (*Lutra vulgaris*), of the Badger (*Meles taxus*), and Ratel (*Mellivora indica*) in the University Museum a similar sunken condition of this limb of the Sylvian convolution exists.

From the examination of these brains of *Trichechus*, *Phoca*, and *Macrorhinus*, I am disposed to regard these animals as more or less approximating in the arrangement of the convolutions of the outer face of the hemisphere to those Carnivora which possess four tiers of convolutions in relation to the fissure of Sylvius. This arrangement is found in the Dog, Jackal, Fox, and Wolf.[1] From Dr. Murie's figures of the brain of *Otaria jubata* it would appear that in that animal, whilst the Sylvian and suprasylvian convolutions are quite definite, yet that the subdivision of the marginal convolution of the longitudinal fissure into mediosagittal and mediolateral convolutions is so partial that the arrangement seems to be intermediate to that which one finds in *Trichechus* and the Canidæ on the one hand, and the Cats on the other. In regarding this affinity in the general arrangement of the convolutions of the cranial surface of the hemisphere in the Seals with those of the Canidæ, it must be kept in mind that in the Dogs the convolutions are less tortuous, and with fewer secondary fissures and gyri than in the Pinnipedia.

The hemisphere of the cerebrum of *Phoca vitulina* possessed on the mesial and tentorial surfaces a distinct gyrus fornicatus, or great limbic lobe, which was divided into uncinate, hippocampal, and callosal convolutions, and was differentiated on its peripheral side by the splenial fissure or the limbic fissure of Broca. This fissure was bridged in its posterior part by a short retrolimbic gyrus, the *pli de passage retrolimbique* of Broca. The splenial fissure had not always the same termination at its upper and anterior end, for in the same brain I have seen it prolonged forwards into the crucial fissure in one hemisphere, but in the other separated from it by a bridging convolution. Both the suprasplenial convolution and fissure existed in the region above the corpus callosum, though in one hemisphere the fissure was bridged by a short gyrus. Neither the postsplenial fissure nor the splenial convolution was distinctly differentiated, and the tentorial surface was subdivided into narrow convolutions. At its inferior end the splenial fissure was continuous with the postrhinal fissure, and through it with the transverse part of the fissure of Sylvius, across which it was prolonged into the rhinal fissure, which defined the tuber olfactorium externally. The tuber was distinctly prolonged into the uncinate gyrus across the bottom of the fissure of Sylvius. Immediately to the outside of the connecting band between the tuber and uncinate gyrus was the concealed portion of the anterior limb of the Sylvian convolution, which apparently represented the Island of Reil. The supraorbital area possessed a gyrus rectus, olfactory fissure, intraorbital fissure, internal and external supraorbital convolutions. The olfactory peduncle was very slender, more so indeed than would be imagined

[1] See pl. iv. in Leuret and Gratiolet's Atlas.

from the figures published by Tiedemann and Leuret. The crucial fissure was at the anterior end of the hemisphere, and about 14 mm. in its transverse diameter, and had the usual relation to the sigmoid gyrus, with which the sagittal convolution was continuous. No præcruciate fissure could be seen on the cranial surface of the cerebrum, but, when the hemispheres were separated from each other, a short fissure was recognised passing downwards from the crucial fissure, which apparently was the præcruciate fissure, whilst the short convolution which it differentiated represented the ursine lozenge, situated as Mivart has stated entirely on the mesial surface of the hemisphere. The prorean convolution was continued into the gyrus rectus.[1]

The convolutions and sulci on the inner and tentorial surface of the hemisphere of *Macrorhinus* corresponded in essential particulars with those of *Phoca*. Some differences are, however, to be noted. Thus in *Macrorhinus* the splenial fissure was not continuous with the postrhinal fissure, neither was it bridged across superficially by a retrolimbic pli-de-passage, though there was a short gyrus projecting backwards from the hippocampal convolution which may represent it. In both hemispheres the splenial fissure was continued into the crucial fissure; the demarcation of the splenial from the sagittal convolution by a continuous antero-posterior suprasplenial fissure was less marked in *Macrorhinus* than in *Phoca*.

In the Walrus, also, the splenial and postrhinal fissures were not continuous with each other. In one brain (*a*) (Pl. IX. fig. 3) there was no retrolimbic bridging convolution, which was present however in both hemispheres of another specimen, and in one of these hemispheres was represented by two convolutions. In two brains the splenial fissure joined anteriorly the crucial fissure. The definition of the suprasplenial convolution and fissure varied in opposite hemispheres. Both brains possessed postero-horizontal and postsplenial fissures and a splenial convolution. The olfactory peduncle and bulb were larger than in the Phocidæ.

In *Otaria jubata*, if I may judge from Dr. Murie's drawings of the brain of that animal, the postrhinal and splenial fissures were not continuous with each other; the splenial fissure was bridged by a retrolimbic convolution; the splenial fissure was not prolonged directly into the crucial fissure; the suprasplenial convolution and fissure were not sharply differentiated; the olfactory apparatus was more like in size the same parts in the Walrus than in the Phocidæ.

Dr. St. George Mivart has recently introduced into the study of the brain in the Carnivora and Pinnipedia the consideration of the area which he has named the Ursine lozenge, and has pointed out that it constitutes a well-marked feature in the anterior part of the dorsal surface of the cerebrum of *Otaria gillespii*. I have already stated that, in both *Phoca* and *Macrorhinus*, but especially in the former, this area is rudimentary, and concealed in the mesial fissure of the cerebrum. In the Walrus, again, the single con-

[1] Theodor's essay on the brain of *Phoca vitulina* did not come into my hands until after this Report was in proof.

volution which represents this area was not definitely defined. Dr. Mivart attaches much importance to the presence of the ursine lozenge in the Pinnipedia, as indicating phylogenetic relations to the ursine group of the Carnivora.

I shall now compare the convolutions on the mesial and tentorial surfaces of the hemisphere in the Pinnipedia with the corresponding surfaces in the brains of several of the Canidæ, and the brains which I have examined are those of the Dog, Jackal, and Fox. In all these animals the postrhinal fissure joined the splenial fissure as in *Phoca vitulina*. The splenial fissure on the tentorial surface was not bridged superficially by a retrolimbic convolution. The lobus and the hippocampal and callosal divisions of the gyrus fornicatus were definitely expressed. The splenial fissure was continued at its anterior end into the crucial fissure, which was placed in the anterior third of the dorsum of the hemisphere. In none of these brains was a suprasplenial convolution differentiated from the sagittal convolution by a suprasplenial fissure, though in the Dog's brain an indication of such a fissure was present. The crucial fissure was bounded by the sigmoid gyrus, which was continuous with the sagittal convolution. Immediately external to the sigmoid gyrus was the coronal fissure, which was continued backwards into the mediolateral fissure, but not forwards into the præsylvian fissure. There was neither præcruciate fissure nor ursine lozenge. The olfactory peduncle was both relatively and absolutely larger than in the Seals and Walrus notwithstanding the much smaller brain, and the continuity of its large root with the lobus hippocampi was plainly marked across the fissure of Sylvius.

In the Polar Bear (*Ursus maritimus*) the postrhinal fissure was deep, and passed back towards the splenial fissure, but was separated from it by a slender retrolimbic gyrus partially sunk in the fissure. The anterior end of the splenial fissure was not continuous with the crucial fissure, but bifurcated; the posterior branch reached the dorsum of the hemisphere as a sulcus in the ursine lozenge, the anterior passed horizontally forwards in front of the knee-like bend of the callosal convolution. The suprasplenial was not differentiated from the sagittal convolution by a suprasplenial fissure, although there was an indication of such a fissure posteriorly. The tentorial surface possessed both a postsplenial fissure and a splenial convolution. The ursine lozenge was large, being 34 mm. long by 42 mm. wide. It formed a large proportion of the anterior third of the dorsum of the hemispheres, and was partially intersected by small sulci, one of which was the posterior branch of bifurcation of the splenial fissure. The crucial fissure was 40 mm. long. The sigmoid gyrus which enclosed it was strongly developed, and its posterior limb was continuous with the sagittal convolution. The coronal fissure was behind and to the outer side of the posterior limb of the sigmoid gyrus, and was prolonged backwards into the 1st curved fissure, but not forwards into the præsylvian fissure. The Polar Bear had three distinct convolutions above the Sylvian fissure. It seemed at first as if they represented the Sylvian, suprasylvian, and marginal convolutions, and as the last named was partially divided by an antero-posterior fissure into two, it looked as if it might represent both the sagittal and the mediolateral convolutions of the Dog and Walrus. On opening up the Sylvian fissure I found to my surprise that a definite arched convolution was completely concealed within it. It was separated from the convolution which bounded the Sylvian fissure by a deep fissure which was also concealed. Its anterior limb, not quite so bulky as the posterior, was continued into the supraorbital area immediately external to the rhinal fissure, and to the outer root of the olfactory peduncle. Its posterior limb reached the postrhinal fissure and the lobus hippocampi. I could not but think that we had here, more completely than either in the Walrus or Seals, a sinking into the Sylvian fissure of the convolution which ought to have bounded it, so that both the Sylvian convolution properly so called, and the suprasylvian fissure, were concealed within it. If this be a proper explanation of the arrangement, then the three convolutions on the cranial aspect would be sagittal, mediolateral, and suprasylvian; whilst the two complete curved fissures between them would be the mediolateral and lateral. The 1st curved fissure therefore into which the coronal fissure is prolonged, would then as in the Dog be the mediolateral fissure. The olfactory apparatus was large, and the external root formed a thick broad band of connection with the lobus hippocampi, so that the Sylvian fossa was shallow.

In the Badger (*Meles taxus*) the postrhinal fissure was deep and prolonged towards the splenial fissure, from which it was separated by a short retrolimbic gyrus; anteriorly the splenial fissure was continuous with the crucial fissure; a short præcruciate fissure marked off a small ursine lozenge, consisting of a single convolution, and situated about the junction of the anterior and middle third of the dorsum of the hemisphere. The suprasplenial was not differentiated from the sagittal convolution. The crucial fissure was 18 mm. long, and bounded by a relatively large sigmoid gyrus, the posterior limb of which was continuous with the sagittal convolution. Below and behind the sigmoid gyrus was the coronal fissure, which was continued backwards into the 1st curved fissure, but not forwards into the præsylvian fissure. Only three convolutions surmounted the Sylvian fissure, the anterior limb of the Sylvian convolution was partly concealed in that fissure, the suprasylvian and marginal convolutions were distinct, and the latter was not divided into a sagittal and a mediolateral convolution. The olfactory apparatus was large.

In the Ratel (*Mellivora indica*) the postrhinal fissure was deep and separated from the splenial fissure by a short and partially concealed retrolimbic gyrus. The callosal convolution was relatively wide and closely resembled in its proportion the corresponding convolution in the Otter as figured by Broca (*op. cit.*, fig. 1, p. 399). The splenial fissure terminated a little in front of the middle of the dorsal surface of the hemisphere in the crucial fissure; a short præcruciate fissure was also present, and between it and the crucial fissure was a distinct ursine lozenge formed of a single convolution. The marginal convolution was very narrow, and the suprasplenial convolution and fissure were absent, though it is possible that this convolution was potentially present in the callosal convolution. The crucial fissure was 17 mm. long, and enclosed by a broad sigmoid gyrus which was continuous by its posterior limb with the marginal gyrus. The coronal fissure which bounded it was prolonged backwards into the 1st curved fissure, but not forwards into the præsylvian fissure. Well-defined Sylvian and suprasylvian convolutions were present, but only a slight indication of a division of the marginal convolution into sagittal and mediolateral convolutions was visible. No arched convolution was concealed within the Sylvian fissure. The olfactory apparatus was large.

My dissection of the inner and tentorial surface of the hemisphere of the Otter (*Lutra vulgaris*) closely accords with Paul Broca's figures and description.[1] In this animal the crucial fissure was 14 mm. long; the sigmoid gyrus was relatively large; the coronal fissure was not continuous with the præsylvian fissure; Sylvian, suprasylvian, and marginal convolutions were present; the anterior limb of the Sylvian was almost entirely concealed in the fissure, and there was evidence of separation of the marginal convolution into sagittal and mediolateral by a short mediolateral fissure which was interrupted; but the coronal fissure should be regarded as prolonged into the fissure bounding the upper aspect of the suprasylvian convolution, which may therefore be termed lateral.

In the Coati (*Nasua rufa*) the postrhinal was separated from the splenial fissure by a short retrolimbic gyrus; the splenial did not join the crucial fissure, but terminated behind it in a sulcus in the sagittal convolution, which did not reach the margin of the hemisphere. The marginal part of the sagittal convolution was relatively wider than in the Otter and Ratel. The crucial fissure was distinct, but owing to an injury to this part of the brain, I could not speak with certainty of the presence of a præcruciate fissure leading forwards and inwards from the crucial fissure; a small convolution in front of the crucial fissure apparently represented the ursine lozenge, a convolution which Mivart also considers to exist in the brain of this animal. Only three tiers of convolutions were present.

In the Weasel (*Mustela vulgaris*) the postrhinal fissure was separated from the splenial by a retrolimbic gyrus which was broad in relation to the size of the hemisphere. The splenial fissure ended in the crucial fissure on the dorsum of the hemisphere. No præcruciate fissure was visible on the dorsum, but on opening up the crucial fissure a very short sulcus indented the convolution which formed the boundary of the crucial fissure and marked off the anterior boundary of a minute ursine lozenge. In the Ferret (*Mustela furo*), however, a short but distinct præcruciate fissure differentiated the anterior boundary of a minute ursine lozenge. The splenial fissure ended in the crucial fissure on the dorsum of the hemisphere. The splenial was separated behind from the postrhinal

[1] Figures of the ursine lozenge in the brains of *Ursus maritimus* and *Mellivora indica* have been given by St. George Mivart in his memoir already quoted, and its presence in the brains of the Otter, Badger, Coati, and other Arctoid Carnivora is described by him.

fissure by a short retrolimbic gyrus. In both the Weasel and Ferret the marginal part of the sagittal convolution was much narrower than the callosal convolution. In both, also, the olfactory apparatus was largely developed. In the Coati, Weasel, and Ferret, the relations of the sigmoid gyrus to the coronal fissure, and of that fissure to the 1st curved fissure, closely corresponded to the arrangement in the Badger and Ratel.

I have examined in the Felidæ the tentorial and mesial surfaces of the hemisphere in the brains of the common Cat (*Felis domesticus*) and the Tiger (*Felis tigris*). In the Cat one retrolimbic gyrus, and in the Tiger two, separated the splenial from the post-rhinal fissure, and in the latter a third bridging convolution crossed the splenial fissure immediately behind and above the splenium. In both, the crucial fissure was situated in the anterior part of the dorsum of the hemisphere, and was not joined by the splenial fissure, which in both animals reached the margin of the hemisphere behind the crucial fissure. In neither animal was there an ursine lozenge. In the Tiger the convolutions were more subdivided by secondary fissures than in the Cat, and on the tentorial surface both a postsplenial fissure and a splenial convolution were present. Both animals had a large olfactory apparatus connected by a strong tract with the uncinate convolution.

In the common Cat the coronal fissure was short and cut off by an intermediate narrow gyrus from the præsylvian fissure in front and the 1st curved fissure behind; it bounded the sigmoid gyrus externally. In the Tiger, in which the sigmoid gyrus was large and tortuous, the coronal fissure formed its outer boundary, and though not prolonged forward into the præsylvian fissure, it was continued backwards into the 1st curved fissure. In both the Cat and Tiger the sagittal convolution was continuous with the posterior limb of the sigmoid gyrus.

It is well known that in the Felidæ the differentiation of the convolutions on the cranial surface of the hemisphere into four tiers is not so precise as in the Canidæ. The convolution which bounds the Sylvian fissure is, in all probability, homologous in both families. In the Tiger the suprasylvian convolution was differentiated in its whole length from the Sylvian convolution by the suprasylvian fissure, and from the sigmoid gyrus and sagittal convolution by the 1st curved fissure. There was no distinct mediolateral convolution, but a convolution which might represent it was partially differentiated from the sagittal convolution by an imperfect mediolateral fissure.. In the common Cat the sagittal and the 2nd external convolution were distinctly differentiated from each other by an intermediate fissure, but the Sylvian and suprasylvian convolutions were partially blended together, especially in their posterior limbs.

In the series of brains examined the coronal fissure was seldom continued forward into the præsylvian fissure, but it was very frequently prolonged backwards into one of the curved fissures on the cranial aspect of the hemisphere,[1] though sometimes it was

[1] In Leuret's figure of the brain of the Lion, the coronal fissure is continuous with the 1st curved fissure, but in Victoria Familiant's figure of the brain of this animal these fissures are separated from each other, as in the common Cat, by an intermediate bridging convolution.

interrupted by a short bridging convolution. When prolonged into a fissure it joined that which lay next to the marginal convolution or the 1st curved fissure. But this was not necessarily morphologically the same in all these brains. Where four tiers of convolutions were differentiated, it was, of course, the mediolateral fissure, but when only three tiers were differentiated, then it probably represented the lateral fissure, as in these brains both the mediolateral fissure and convolution were either absent or only imperfectly differentiated. The coronal fissure formed the outer boundary of the sigmoid gyrus. The coronal gyrus was the anterior part of the 2nd external convolution, which in those brains that possessed four tiers of convolutions was the mediolateral convolution; but, when only three tiers were present, it was most probably represented by the suprasylvian convolution.

The crucial fissure varied materially in its position in the genera of the Carnivora and Pinnipedia. In the Seals and Walrus it was so far forward as not to be seen on the dorsum of the hemispheres, but only at the anterior end of the cerebrum. In the Cat and Tiger it was visible in about the anterior fourth of the dorsum of the hemispheres; in the Dog, Weasel, Ferret, and Coati at about the junction of the middle and anterior third; in the Badger, Polar Bear, and Ratel it was even further back, so as to be just in front of a line dividing the dorsum of the hemispheres into an anterior and a posterior half. This variation in the position of the fissure necessarily affected that of the sigmoid gyrus which bounded it in front, behind, and on the outer side, and in those brains in which the fissure was elongated and far back, this gyrus formed a well-marked convolution on the dorsum of each hemisphere. When the crucial fissure was elongated both it and the sigmoid gyrus were continued downwards on the outer surface of the hemisphere,[1] and the direction of the coronal fissure, which formed the outer boundary of the sigmoid gyrus, was from below obliquely upwards and backwards.

It will now be of interest to compare the convolutions of the cerebrum in the Carnivora and Pinnipedia with those in Man and Apes, with the view of endeavouring to ascertain if any correspondence in their arrangement exists, and to what extent, in these orders of Mammals. The importance of instituting this comparison has already, indeed, presented itself to several anatomists, and various attempts have been made to harmonize the arrangement of the convolutions of the Carnivora with those of Man and Apes. The desirability of arriving at some definite conclusion on this matter is owing both to the interest of the subject from a purely morphological point of view, and to its physiological value in connection with the numerous experiments which have of late years been made for the determination of the functions of the cerebral cortex.

It will be obvious, if in the brains of these different orders one or two leading fissures

[1] The anterior limb of the sigmoid gyrus is sometimes called *gyrus præcruciatus* (*præfrontalis*), the posterior limb *gyrus postcruciatus* (*postfrontalis*).

and convolutions can be identified as without question morphologically alike in their development and relations, that a certain basis would be obtained from which it may be possible to extend the comparison to other parts of the surface. A most important investigation conducted in accordance with this method was published by Dr. Paul Broca, on Le grand lobe limbique et la scissure limbique. In the course of this memoir he reviewed the arrangement of the limbic lobe or convolution, and showed that it can be identified throughout the mammalian series. It consists of a callosal and hippocampal portion with a lobus hippocampi, and forms the boundary both of the corpus callosum and the transverse fissure of the cerebrum. Moreover it is continuous with the roots of the olfactory lobe, more especially through the lobus hippocampi, though the band of union varies materially in thickness in the brains of different orders. In the proper Carnivora, for example, the connecting band is large and very distinct, in the Pinnipedia it is less marked, and in Man and Apes it is reduced to a fine thread.

In the Carnivora proper the rhinal fissure is distinct and continued across the fissure of Sylvius into the postrhinal fissure, which again is prolonged towards the splenial fissure, though frequently the exact continuity is interrupted by a superficial retrolimbic convolution. In *Phoca* the rhinal and postrhinal fissures resemble those in the Carnivora proper, though relatively they are somewhat smaller. In *Macrorhinus* and *Trichechus* the retrolimbic convolution is nearer the lobus hippocampi, so that the postrhinal fissure is shorter. In Man and Apes, owing to the absolute and relative diminution in size of the olfactory apparatus, the rhinal fissure is scarcely recognisable, and the postrhinal fissure cannot be said to be continuous with it.

The limbic lobe is differentiated on its peripheral aspect by the fissure which has been named the splenial fissure in the brains of the Carnivora and Pinnipedia described in this Report. In Man and Apes the calloso-marginal fissure represents that part of the splenial fissure placed peripherally to the callosal convolution, whilst the collateral (occipito-temporal) fissure is apparently the representative of that part of the splenial fissure which forms the peripheral boundary of the hippocampal convolution.

In the larger Carnivora and the Pinnipedia the supraorbital area possesses an olfactory sulcus, a gyrus rectus, an intraorbital fissure, internal and external supraorbital convolutions; though in the brains of the smaller Carnivora, especially when the olfactory apparatus is relatively large, these fissures and convolutions are scarcely if at all differentiated. In Man and Apes these parts are also seen, and the intraorbital fissure, from so frequently trifurcating, was named by me the triradiate fissure.

The fissure of Sylvius forms a recognisable feature in the brains of the Carnivora, but where it begins as the Sylvian fossa on the under surface of the brain, it is usually shallow, owing to the thickness of the olfactory root which passes backwards to join the lobus hippocampi. In the Pinnipedia, and still more in Man and Apes, owing to the diminished size of this root, the Sylvian fossa is much deeper. In the Carnivora and Pinnipedia the fissure of Sylvius passes upwards and with only a slight inclination backwards on the cranial surface of the hemisphere, its length being regulated by the length of the Sylvian convolution which bounds it. In Man and Apes, more especially the Anthropoids, it is longer than in the Carnivora, and passes upwards and with a marked inclination backwards; its backward direction being more decided in Man than in the highest Apes.

Up to this point there does not seem to be much difficulty in finding a morphological correspondence between the fissures and convolutions in the brains of these orders of Mammals, but beyond this stage many difficulties undoubtedly present themselves. In the human brain, for example, the magnitude and direction of the convolutions of the frontal lobe, the fissure of Rolando, the parieto-occipital fissure, the definite occipital lobe lying behind that fissure, the calcarine fissure, the elongated convolutions of the temporo-sphenoidal lobe, and the convolutions of the insula are all characteristic features, which are repeated though in a less pronounced form in the brains of Apes except that in the latter the distinctness of the occipital lobe is more accentuated. In the Carnivora and Pinnipedia again the presence of three or four tiers of convolutions with their intermediate fissures surmounting the fissure of Sylvius, the existence of a crucial fissure, and also in many genera of a præcruciate fissure and ursine lozenge, are noticeable characteristics, and at first sight seem so divergent from the human arrangement as to be apparently irreconcilable with it.

In the Human cerebrum four elongated convolutions running obliquely from above downwards and forwards intervene between the fissure of Sylvius on the cranial surface and the gyrus and lobus hippocampi on the tentorial surface; viz., the superior, middle, and inferior temporo-sphenoidal convolutions, and the occipito-temporal convolution. In the Ape's brain the differentiation of the three temporo-sphenoidal convolutions is more or less distinct in various species, but the occipito-temporal convolution is frequently not differentiated from the inferior temporo-sphenoidal gyrus.

The apparently corresponding region in the brain of the domestic Cat is short and stunted, but in the larger brain of the Tiger it is more elongated; in the Dog's brain it is a little longer than in the Cat; in *Phoca*, *Macrorhinus*, and *Trichechus* it is also well marked and the convolutions are tortuous. In these Carnivora and Pinnipedia three convolutions lie behind the fissure of Sylvius on the cranial aspect of the hemisphere, for they are almost vertical in direction and the most posterior forms the boundary of the hemisphere at the junction of its cranial and tentorial surfaces. These convolutions are the posterior limbs of the tiers of convolutions which surmount and arch above the fissure of Sylvius. In the larger Carnivora and Pinnipedia a fourth convolution, varying in its degree of differentiation, but not recognisable in the brains of the smaller Carnivora, is situated on the tentorial surface peripherally to the hippocampal convolution, and separated from it by the splenial (limbic) fissure, which fissure is usually bridged by the retrolimbic convolution. In their relations to the Sylvian fissure on the one hand, and to the gyrus and lobus hippocampi on the other, these four convolutions in the Carnivora and Pinnipedia might seem at first sight as if they approximated to the temporo-sphenoidal and occipito-temporal convolutions in Man and Apes, though in Man they are greatly elongated and approach the horizontal in their direction, in conformity with the direction of the fissure of Sylvius. Moreover, they project in front of the uncus or lobus hippocampi so as to form the tip of the temporo-sphenoidal lobe and the greater part of the boundary of the Sylvian fossa, so that the lobus hippocampi with the short postrhinal fissure is not visible at the base of the human brain, but is displaced inwards on to the tentorial aspect. But further, in the brains of the Carnivora and Pinnipedia the lobus hippocampi appears as a distinct protuberance on the base of the brain, and itself forms the posterior boundary of the Sylvian fossa. These differences in the two types of brain might seem to be accounted for simply by the great development and the change in direction of the convolutions of the temporo-sphenoidal lobe in the brains of Man and Apes, causing in them displacement of the lobus hippocampi to the inner surface of the hemisphere, and its concealment, when the hemisphere is looked at from the cranial aspect, by the greatly elongated temporo-sphenoidal convolutions.

But I am of opinion that this does not express the whole difference between these brains in this region. In the description of the brain both of the Walrus and the Seals I have indicated that the Island of Reil may find its representative in these animals in the anterior limb of the Sylvian convolution, which is more or less concealed within the fissure of Sylvius; and in the brain of the Polar Bear I have shown that an entire arched convolution is concealed within that fissure. If I am right in this indication, then I believe that the Island of Reil, which in the brain of the Ape and still more in that of Man is entirely concealed within the Sylvian fissure, is either the homologue of the Sylvian convolution of the carnivorous brain, or that the Sylvian convolution in the Carnivora potentially represents both that convolution and a rudimentary insula. In the true Carnivora the Sylvian convolution was as a rule superficial and on the cranial aspect, though in the Otter and Badger indications of the depression of its anterior limb within the fissure were seen. In the Seals and Walrus the concealment of this convolution was still more marked, so that the brains of these animals form apparently in this particular a transition to those of Man and Apes, in which the concealment of the Island is complete. On the supposition therefore that the Island of Reil in Man and Apes is morphologically related to the Sylvian convolution of the Carnivora, the superior temporo-sphenoidal convolution in the Human and Ape's brain cannot be regarded as corresponding with the posterior limb of the Sylvian convolution, but with that of the convolution of the tier immediately above and behind the Sylvian convolution, *i.e.*, the 3rd external convolution of Ferrier or the suprasylvian convolution of my description. The sinking of the Sylvian convolution into the fissure may perhaps to some extent be associated with a diminution in magnitude of the olfactory apparatus. When that is large the Sylvian fissure is shallow, but when the olfactory peduncle and roots diminish in size, as in the Seal and Walrus, the fissure deepens and the Sylvian convolution becomes partially concealed, until in Apes and Man, with a still greater diminution in the importance of the olfactory sense, the fissure attains its maximum depth. In this connection, however, it must be remembered that the Polar Bear, though with an arched convolution concealed within the Sylvian fissure, yet possesses large olfactory nerve roots.

This view of the homology of the convolutions in this region enables one to harmonize the results of physiological experiment with anatomical arrangement, and to remove a difficulty which is experienced so long as the superior temporo-sphenoidal convolution is regarded as corresponding with the posterior limb of the Sylvian convolution. Dr. Ferrier, from his experiments, determined that the areas marked (14) in his figures were the auditory centres. Thus when these areas in the superior temporo-sphenoidal convolution were stimulated in Monkeys the opposite ear became pricked, the head and eyes were turned to the opposite side and the pupils became widely dilated; whilst stimulation of areas (14) in the 3rd external convolution of the brain of the Dog and Jackal also produced a pricking or retraction of the opposite ear, and stimulation of a similar area in the Cat produced both pricking of the opposite ear and turning of the head and eyes to the opposite side. Hence these areas in the carnivorous and Ape's brain are regarded as physiologically the same; though in the Ape the convolution stimulated bounds the Sylvian fissure, whilst in the Carnivora it is separated from that fissure by an intermediate convolution. On the theory that the Sylvian convolution either becomes the Island of Reil or blends with the insula and sinks into the fissure, the 3rd external convolution would then become the boundary of the fissure and its posterior limb would be homologous with the superior temporo-sphenoidal convolution of the brain of Man and Apes, whilst the suprasylvian or 3rd curved fissure would become lost in the Sylvian fissure, and be represented by the sulcus insulæ. This theory is somewhat different from the conception of the relation of parts in this region entertained by Ferrier, who suggests that the Sylvian convolution is in the Monkey's brain represented within the lips of the Sylvian fissure, overlapping and concealing the Island of Reil.

Ferrier has also shown that electrical stimulation of the posterior limb of the Sylvian convolution gives no definite reactions, and similarly stimulation of the Island of Reil is not followed by movements except after increased irritation, when some movements of the mouth and tongue occur, which he considers may be due to conduction of the stimulus to the motor areas situated immediately anterior to the part irritated. Ordinary stimulation in both instances therefore produces no definite results, showing that neither of these convolutions responds to the electrical stimulus, and although the experimental result is negative, it is certainly not adverse to the view that they are homologous with each other. Confirmation of this theory is also furnished by the fact that stimulation of the area marked (16) on the lower end of the anterior limb of the Sylvian convolution in Dr. Ferrier's figures of the brain of the Dog and Cat is occasionally associated with movements of the lips, whilst similar movements are produced by irritation inside the fissure of Sylvius in the Monkey,[1] doubtless due therefore to irritation of the areas (9) and (10) which lie in proximity to the fissure.

To harmonize the arrangement of the convolutions of the frontal, parietal, and occipital lobes of the human and Ape's brain with the tiers of convolutions which in the Carnivora surmount the fissure of Sylvius, is undoubtedly a task of some difficulty. Several anatomists have, however, attempted to do so. M. Broca, in his memoir already quoted, has argued with great emphasis, that in the brain of the Primates the character which dominates over all others in importance is the enormous development of the frontal lobe, from whence results the backward position and the oblique direction of the fissure of Rolando. The position which I took up many years ago[2] that the fissure of Rolando, or central fissure, should be regarded as forming the posterior limit of the frontal lobe and the plane of demarcation between it and the parietal lobe, is now generally accepted. It becomes therefore a matter of some moment to determine if possible the fissure in the carnivorous brain which corresponds to the fissure of Rolando in Man and Apes, the oblique and backward direction of which must be borne in mind.

Broca regarded the fissure of Rolando as represented in the Carnivora by the præsylvian fissure, so that he practically confined the frontal lobe in these animals to the region in front of and below that fissure, which has been named in this Report the supra-orbital area. Schwalbe is apparently inclined to attach some weight to this view; but owing to the divergence in development of the Carnivora and Ungulata on the one hand, and the Primates on the other, he does not consider it possible to make a strict comparison between the convolutions and furrows of these orders of Mammals. I believe that the limitation of the frontal lobe to the area in front of the præsylvian fissure would be too great a restriction of that lobe, which on developmental and other grounds may, I think, be shown to extend further back in the hemisphere.

At the first glance there might seem to be a strong likeness between the crucial fissure in the carnivorous brain and the fissure of Rolando. They are both directed more or less vertically and transversely downwards on the cranial surface of the hemisphere, and each is bounded in front and behind by a gyrus having a corresponding direction; in the Carnivora the gyri are the anterior and posterior limbs of the sigmoid gyrus; in Man and Apes they are the ascending frontal and parietal convolutions. These general resemblances have led more than one anatomist to regard them as homologous. But in discussing the homology of the crucial fissure it is important to attend to its relative period of appearance

[1] I am indebted to Dr. Ferrier for this information, which he wrote to me in reply to a request as to the area in the Monkey's brain which corresponds to (16) in the brain of the Dog.

[2] The Convolutions of the Human Cerebrum topographically considered, Edinburgh, 1866, p. 11. Notes more especially on the Bridging Convolutions in the Brain of the Chimpanzee, *Proc. Roy. Soc. Edin.*, 19th Feb. 1866, vol. v. p. 578.

on the surface of the cortex, and to its relations to the splenial fissure on the mesial aspect of the hemisphere. There can, I think, be no doubt that the anterior and upper part of the splenial fissure in the brains of the Carnivora and Pinnipedia corresponds with the fissure which is known as calloso-marginal in Man and Apes. Both the splenial and calloso-marginal fissures are separated from the corpus callosum by the callosal convolution of the limbic lobe, and each runs in this part of its course about midway between the corpus callosum and the free upper margin of the hemisphere. In the Canidæ, the Badger, Ratel, Weasel, Ferret, Elephant Seal, and Walrus the splenial fissure was continuous with the crucial fissure, but in the Cat, Tiger, Coati, and Polar Bear they were not continuous; whilst in a *Phoca vitulina* the two fissures were continuous in the one hemisphere, but not in the other. In those cases in which the fissures were not continuous, the splenial ended in or near the margin of the mesial longitudinal fissure in proximity to the crucial fissure and usually a little behind it.

In the human brain the calloso-marginal fissure turns round the genu of the corpus callosum and then runs backwards about midway between the corpus callosum and the margin of the great longitudinal fissure; when a little in front of the splenium of the corpus callosum it bends upwards to reach the margin of the hemisphere somewhat behind the fissure of Rolando. Where it makes this bend a fissure is prolonged for a variable distance backwards from it, but does not reach the collateral fissure, for it is so interrupted by convolutions in this region which are continuous with the præcuneus or quadrilateral lobule, that the callosal convolution loses immediately above the splenium its sharp line of demarcation superiorly. Both in the human brain and that of the Ape the limbic lobe, where the callosal and hippocampal convolutions approach each other, possesses a less definite differentiation peripherally than is the case both in the Carnivora and in Mammals generally, a condition which is apparently due to the much greater development of bridging convolutions at its splenial end. In the Walrus, for example, the bridging convolution in this region (Pl. IX. fig. 3) is a single narrow gyrus, whilst in the human and Ape's brain they correspond to the broad base of the præcuneus. Not unfrequently I have seen one or more short fissures arise from the calloso-marginal about opposite the genu and indent transversely the superior frontal convolution at the anterior end of the cerebrum, which was bent around each fissure like a short sigmoid gyrus. In its direction and relation to the calloso-marginal fissure any one of these fissures resembled the crucial fissure, but cannot be morphologically the same as the fissure of Rolando, which is situated much further back on the side of the hemisphere, and which has no definite relation with the calloso-marginal fissure. It is obvious that the crucial fissure is not of primary importance, as it is not always present in gyrencephalous Mammals, and in those Carnivora, such as the Dog and Cat, in which its development has been examined, it has been shown by Pansch to appear subsequently to the splenial fissure having assumed a certain depth, so that it has only a secondary value.

We must therefore look elsewhere in the carnivorous brain for the homologue of the fissure of Rolando.

Owen, from a comparative survey of the brain in a large number of gyrencephalous Mammals, was led to regard the coronal fissure in the Carnivora as corresponding with the fissure of Rolando in Man, which he also called the coronal fissure. Pansch and Meynert took a similar view of the homology of the coronal fissure, and Pansch held that the fissure of Rolando was the anterior part of the upper or first curved fissure and was the second in order of position from before backwards of the three primary fissures which occur on the cranial surface of the hemisphere of all Mammals with convoluted brains. In the Primates they were placed radially above the Sylvian fissure, but in other Mammals the first or most anterior was more vertical, whilst the second and third had a sagittal direction. Pansch's determination of the homology was based on the relative period of appearance and on the depth of the fissure in various Mammals, and guided by these considerations he regarded the ascending frontal and parietal (or the central) convolutions as having their morphological equivalents in the anterior parts of the 4th and 3rd convolutions of Leuret, *i.e.*, the sagittal and mediolateral convolutions of the Dog or the 1st and 2nd convolutions of Ferrier.

Ferrier, who was at one time disposed to agree with the anatomists who looked upon the fissure of Rolando as the homologue of the crucial fissure, now holds with those who consider it to be represented by the coronal fissure, and he supports his present opinion by the result of his experiments on the cerebral cortex in Monkeys and Carnivora. From a comparison of these results it would seem that a number of the effects produced are reconcilable with the view that parts of the brain in front of the fissure of Rolando and of the coronal fissure in these animals are physiologically homologous. Thus the area marked (12) by Ferrier, which in the Monkey includes the posterior half or two-thirds of the superior and middle frontal convolutions, and in the Dog is situated on the anterior limb of the sigmoid gyrus, when stimulated occasioned in both animals wide opening of the eyes, dilatation of the pupils, and turning of the head and eyes to opposite sides; stimulation of the area (3), which in the Monkey lies in the upper end of the ascending frontal convolution close to its sulcus, and in the Dog in the 1st external or sagittal convolution just behind the crucial sulcus, produced in both animals movements of the tail; stimulation of the area (4), situated in the Monkey in the upper end of the ascending frontal and anterior margin of the adjacent part of the ascending parietal convolution, and in the Dog in the back of the posterior limb of the sigmoid gyrus, produced corresponding movements in the fore limbs of both animals; stimulation of (5), situated in the Monkey in front of (3) where the superior frontal joins the ascending frontal, and in the Dog in the sigmoid gyrus about opposite the outer end of the crucial fissure, occasioned in both animals an extension forward of the opposite fore limb. It will also be observed that the area marked (12) in both animals was the most anterior region to respond to electrical stimulus. These experiments all indicate a homology between both limbs of the sigmoid gyrus in the Dog and the ascending, superior, and middle frontal convolutions in the Monkey, which is incompatible with the view that the crucial fissure is the homologue of the fissure of Rolando, but quite reconcilable with the theory that the coronal fissure and fissure of Rolando are homologous; for in the respective brains both the coronal and Rolando's fissures lie behind the areas stimulated, with the exception of a small part of (4), which just touches the ascending parietal convolution.

On the other hand, it is more difficult to reconcile some other of Ferrier's experiments with this conclusion as to the homology of the two fissures. For stimulation of area (1), placed in the Monkey in the postero-parietal convolution just in front of the parieto-occipital fissure, and in the Dog in the posterior limb of the sigmoid gyrus just behind the crucial fissure, produced in both animals an advancement of the opposite hind limb as in walking; in the Monkey the area stimulated was distinctly behind the fissure of Rolando, in the Dog well in front of the coronal fissure. Again, the areas (7) (8), which when stimulated gave rise to movements of the zygomatic muscles and upper lip, lie in the Monkey in the ascending frontal convolution, and therefore anterior to the fissure of Rolando; but in the Dog the one is situated in the coronal part of the 2nd external convolution, the other in the anterior composite convolution formed by the junction of the anterior ends of the 2nd and 3rd external convolutions, and both therefore are behind the coronal fissure.

If we regard, however, the whole evidence based on comparative anatomy, on the depth and relative time of appearance of the fissures and on the results obtained by stimulating the brain in front of the fissures, we may, I think, fairly assume the fissure of Rolando to be homologous with the coronal fissure in the carnivorous brain. The sigmoid gyrus with the adjoining part of the sagittal convolution, and in animals which have an ursine lozenge that area also, would therefore represent the superior, middle, and ascending frontal convolutions in the brain of Man and Apes.

But there are other fissures in the brains of these Mammals the homologies of which it is desirable, if possible, to determine. A well-marked fissure in the carnivorous brain is the præsylvian or supraorbital fissure. It is the most anterior of the three primary fissures described by Pansch as appearing on the cranial surface of the brain of the fœtal Dog, and it separates in this animal the anterior limbs of the four tiers of convolutions from the supraorbital area and the prorean convolution. If we place side by side the hemispheres of the Human and the Dog's brain we can see in the former two fissures, the præcentral fissure of Ecker and the ascending branch of the Sylvian fissure, one or other of which would appear to represent the præsylvian fissure in the Dog. Meynert was of opinion that the præsylvian fissure is homologous with the ascending branch of the Sylvian fissure. Broca objected to this [1] on the ground that the ascending branch, whilst present in Man

[1] Sur le cerveau du Gorille, *Revue d'Anthropologie*, sér. 2, t. i.

and the Anthropoid Apes, is absent in the non-anthropoid Apes; and that it is not likely that a character which is only found in the most highly developed brains of the Primates should, when absent in the lower Apes, reappear in the Carnivora in which the frontal lobe is only rudimentary. In connection with this matter it should be stated that the area (8), which Ferrier associates with elevation of the upper lip so as to display the canine teeth, is situated in the Monkey in the lower part of the ascending frontal convolution and in the Dog at the anterior composite end of the 2nd and 3rd external convolutions; whilst the area (9), which he associates with the opening of the mouth, movements of the tongue, and not unfrequently barking or growling, is situated in the Monkey in the lowest part of the ascending frontal convolution, where the inferior frontal convolution springs from it; and in the Dog in the composite convolution formed by the junction of the lower ends of the anterior limbs of the 3rd and 4th external convolutions. Areas (8) and (9) are placed therefore in the Monkey immediately behind the præcentral fissure and in the Dog immediately behind the præsylvian fissure.

The results obtained by experiment would seem therefore to harmonize with the conclusion founded upon more purely anatomical data, and I think it probable that the præsylvian and præcentral fissures are homologous.

A number of years ago I described in the brain both of the Chimpanzee and of Man[1] a fissure within the parietal lobe which I named the intraparietal fissure.[2] It is situated in the first instance behind and parallel to the ascending parietal convolution, and then runs almost horizontally backwards to separate the ascending and postero-parietal convolutions from the supramarginal gyrus or convolution of the parietal eminence, and it may be seen in the brain of a sixth month's human fœtus. Pansch subsequently recognised the importance of this fissure and regarded it as the third and most posterior of the three primary fissures on the cranial surface of the brain; he believed it to be homologous with the anterior part of the middle or second curved fissure of the Dog—the lateral fissure of this Report.

In the Human brain the intraparietal fissure is separated from the Sylvian fissure by a convolution which, under the name of supramarginal gyrus, or, as I have termed it, the convolution of the parietal eminence,[3] forms a single tortuous tier. In the Dog, again, two tiers lie between the lateral and Sylvian fissures, viz., the suprasylvian and Sylvian convolutions, separated from each other by the suprasylvian fissure. Pansch makes no attempt to explain this difference, and, in the absence of such explanation, difficulties at once suggest themselves as to accepting his view of the homology of the intraparietal fissure and the anterior part of the 2nd curved fissure. But, on the theory

[1] See my memoirs already quoted, pp. 95, 126.

[2] Ecker and some other anatomists have misnamed it the interparietal fissure.

[3] Relations of the Convolutions of the Human Cerebrum to the Outer Surface of the Skull and Head, *Journ. of Anat. and Phys.*, vol. viii. p. 142.

which I have expounded on p. 124, *e.s.*, that the Sylvian convolution of the Dog subsides in Man and Apes into the Sylvian fissure, and that the suprasylvian and Sylvian fissures become, as it were, thrown into one, then one can account for the presence of only a single convolution on the lower aspect of the intraparietal fissure, which convolution represents the anterior limb of the suprasylvian convolution of the Dog, and is the supramarginal convolution in the higher brains. Ferrier's experments also to some extent bear out this view, for his area (11), stimulation of which produces retraction of the angle of the mouth, is situated in the Monkey partly in the lower end of the ascending parietal, but more so on the adjoining supramarginal gyrus, and in the Dog in the anterior limb of the suprasylvian convolution.

One of the most noticeable fissures of the cerebrum of Man and Apes is that which under the name of parieto-occipital fissure separates the parietal from the occipital lobe. In the human brain it is as a rule more strongly marked on the mesial than on the cranial aspect, owing to the development on the cranial surface of strong bridging convolutions which pass across its upper end. In the brains of Apes it is as well marked on the one surface as on the other, though in the brain of both the Orang and Chimpanzee superficial bridging convolutions sometimes obscure its upper end.[1]

Almost all writers have stated that this fissure is absent in the brains of the Carnivora, so that in them the occipital lobe is not differentiated from the parietal part of the brain. In a recent memoir, however, Max Flesch has described in the brain of the Brown Bear (*Ursus arctos*) a short fissure as arising from the highest part of the fissure which he calls middle-curved or suprasylvian, but which I have named in this Report 2nd curved or lateral fissure, and as passing towards the mesial longitudinal fissure, near its hinder end, though without reaching it. He represents it as arising by a stem about 3 mm. long, and then as bifurcating into an anterior and a posterior part, of which the latter is apparently the deeper. On the mesial surface of the hemisphere, however, there is no fissure which could be regarded as parieto-occipital. He considers that in the brain of the Bear the upper curved fissure is only partially present, as in the short coronal fissure and one or two other short fissures near it. He associates the appearance of a parieto-occipital fissure as in direct relation to the disappearance of the 1st curved fissure, also to the metamorphosis of a part of this fissure into the fissure of Rolando (central fissure) and to the disappearance (Rückbildung) of the crucial fissure. He obviously considers that in the corresponding part of the brain of the Felines there is an indication of a parieto-occipital fissure, but that this fissure is absent in all Carnivorous brains where the three curved fissures are completely developed.

I have examined the brain of *Ursus maritimus* with the object of seeing if a corresponding fissure existed in it. In the right hemisphere a shallow fissure situated

[1] See my Notes more especially on the Bridging Convolutions in the Brain of the Chimpanzee, *Proc. Roy. Soc. Edin.*, vol. v. p. 578.

at a corresponding spot did for about 4 mm. indent the marginal convolution in the same region as in *Ursus arctos*, and a somewhat longer one was present in the left hemisphere. These fissures were so short and shallow that they gave me the impression of being quite subordinate furrows. On the other hand, the parieto-occipital fissure in the brain of Man and Apes is one of primary importance; it appears in the human fœtus at about the fifth month, and is especially marked on the inner surface of the hemisphere; whilst neither in *Ursus arctos* nor *Ursus maritimus* was there any evidence of a fissure which corresponded with the internal parieto-occipital fissure of the human brain.

Dr. Murie, in the course of his description of the brain of *Otaria jubata*, employs to a large extent the terminology of human anatomy, and believes that he can recognise in the brain of this Eared Seal the majority of the convolutions and fissures present in the human brain. Amongst other fissures he describes, by the name of internal perpendicular, the fissure which is more usually named parieto-occipital. He figures it as indenting the marginal convolution towards the hinder end of the hemisphere, and as present both on the mesial and cranial surfaces. In conformity with the method of nomenclature which he has adopted he has named the convolution in front of the inner part of this fissure the quadrilateral lobule of the parietal lobe, whilst that which lies behind it he names the internal occipital lobule. In the brains both of the Elephant Seal and Walrus the marginal convolution was indented in a position almost corresponding to that in *Otaria jubata*, by a continuous fissure both on the cranial and mesial surfaces, the length of which was, however, variable in the different brains, especially on the mesial surface. Partly owing to this variability, and partly because we have no information on the development of this fissure in the Pinnipedia, I am not prepared to say that it is homologous with the parieto-occipital fissure of the human brain.

The evidence obtained from experiments on the cerebral cortex has established the important fact that stimulation of the occipital lobe in the brain of the Monkey produces no definite reaction; whilst stimulation of the angular gyrus, both in its anterior and posterior limbs (13), affects the pupils and occasions movements of the eyes to the opposite side, so that this convolution is a visual centre.[1] In the Dog also the most posterior parts of the 1st and 2nd external convolutions do not respond to stimulus, whilst a portion of the 2nd external convolution in front of the most posterior part (13), when stimulated, gives reactions similar to those obtained from the angular gyrus in the Monkey. There is reason to think, therefore, that the most posterior parts of the 1st and 2nd external convolutions of the Dog are potentially equivalent to the occipital lobe in the brain of the Monkey, although they are not differentiated by a parieto-occipital fissure, whilst the 2nd external convolution immediately in front of the part which does not respond to stimulus and the angular gyrus are homologous with each other physiologically. In all probability these convolutions are also anatomically identical, for Gratiolet, who was the

[1] See the researches of Ferrier and other experimentalists.

first to differentiate the angular gyrus (*pli courbe*) in the brain of Man and Apes,[1] places it behind the supramarginal gyrus, *i.e.*, behind the tier of convolutions immediately above the Sylvian fissure, and therefore in a position corresponding to what that part of the 2nd external convolution which gives a similar response to stimulus would assume were this convolution in the Dog's brain pushed backwards by a great development of the frontal lobe.

The general results arrived at in this comparison of the brains of these Mammals are to some extent to be regarded as tentative and provisional. For, until the development of the fissures and the development and structure of the convolutions have been worked out with greater detail than up to this time has been done, it will not be possible to speak with certainty on all the points which have to be considered in a detailed comparison of the cortex of the cerebrum in the Carnivora with that of Man and Apes. Further, it should be stated that in this, as in other organs of complex constitution, it does not follow that all the parts which are seen in the more highly developed brains are of necessity present, even in a rudimentary condition, in those whose organisation is not so complicated. It must also be remembered that whilst the brains of the Carnivora, and still more so those of the Pinnipedia, are highly convoluted, those of such Apes as the Marmoset Monkey (*Hapale jacchus*) are smooth on the surface, and, with the exception of the large surfaces separated by such fissures as the Sylvian and hippocampal, have no definite subdivision into morphological areas which are capable of being recognised by the naked eye. But both in the Marmoset Monkey and in such other New World Apes as *Œdipus*,[2] in which the convolutions are either absent or rudimentary, the cerebral hemispheres are prolonged forwards to the front of the olfactory bulbs and backwards above the cerebellum to an extent which is not seen in the Carnivora. In this respect, therefore, these brains, though either without convolutions or having them only feebly developed, are more highly organised than is the case in the Carnivora proper or in the Seals.

From the point of view of the hypothesis of evolution there would be no reason to think that the smooth-brained lower Apes had originated out of the Carnivora, at least after the cortex of the cerebrum in this latter order had begun to assume a convoluted arrangement. If they had been derived from a carnivorous animal with a convoluted brain, then in all likelihood the convoluted character of the cerebrum would not have disappeared in the process of evolution. If the higher Apes have been derived by descent from the lower Apes, then the hemispheres in the former with their complex arrangement of fissures and convolutions have been evolved from a smooth-brained stock and not from an animal with such an elaborate arrangement of convolutions as is possessed by either a Dog or a Seal. Hence the acceptance of this hypothesis is not inconsistent with the

[1] Mémoire sur les plis cérébraux de l'homme et des primates, Paris, 1869.

[2] See Gratiolet, *op. cit.*

fact that the convolutions of the brain in the Apes assume from the first their own method of arrangement, and not necessarily that of the orders of Mammals with convoluted brains which are lower in the series. Beyond therefore a certain general correspondence in the arrangement of those fundamental parts of the cortex which serve a similar purpose in these various orders, one does not find it possible to determine the presence of convolutions arranged in a precisely corresponding manner in the brains of the Carnivora and Pinnipedia on the one hand, and of Man and Apes on the other. In each of these orders the developmental process which gives rise to the disposition of the fissures and convolutions is regulated by the vital and mechanical necessities of the animals constituting the order, as well as by the conditions of hereditary descent. Subject to the qualifications and reservations which have been just expressed, and with the *proviso* that the homologies of the cortical areas of the cerebrum are in many instances histological and physiological rather than morphological, the following summary of the corresponding fissures and convolutions in the Dog and the Monkey has been drawn up in a tabular form:—

TABLE XIV.

Dog.	Monkey.
Fissures.	*Fissures.*
Sylvian,	Sylvian.
Hippocampal,	Hippocampal.
Splenial,	Collateral and calloso-marginal.
Olfactory,	Olfactory.
Intraorbital,	Triradiate.
Coronal,	Rolando's.
Præsylvian,	Præcentral.
Anterior part of lateral,	Intraparietal.
Convolutions.	*Convolutions.*
Callosal,	Callosal.
Hippocampal,	Hippocampal.
Lobus hippocampi,	Uncinate or uncus.
Gyrus rectus,	Gyrus rectus.
Internal supraorbital,	Internal supraorbital.
External supraorbital,	External supraorbital.
Sylvian,	Island of Reil in whole or in part.
Posterior limb of suprasylvian,	Superior temporo-sphenoidal.
Sigmoid gyrus, part of sagittal convolution, and composite convolutions,	Ascending, superior, middle, and inferior frontal convolutions.
Anterior limb of suprasylvian,	Supramarginal or convolution of parietal eminence.
Part of 2nd external convolution posteriorly,	Angular gyrus.
Most posterior part of 1st and 2nd external convolutions,	Occipital lobe.

PART IV.

VISCERA OF ELEPHANT SEAL.

The heart and some of the abdominal viscera, and the male and female genitalia, of specimens of *Macrorhinus leoninus* had been removed and preserved in spirit.

The heart was from the female killed at Christmas Harbour, and was as big as the heart of a large bullock; it showed a slight cleft where the two interventricular grooves met at the apex, and each surface was almost equally divided between the two ventricles.

A broad flattened thymus gland overlapped the ascending aorta and trunk of the pulmonary artery. It measured 150 mm. in transverse and 154 mm. in antero-posterior diameter. It was unequally divided into two lateral lobes, of which the left was about twice the size of the right, and the left in its turn was almost completely subdivided into two portions by intermediate connective tissue. Each lobe was subdivided into numerous lobules, which had no appearance of having undergone fatty degeneration. Two lymphatic glands about the size of walnuts were attached by areolar tissue to the ventral surface of the thymus.

When the thymus was removed the ascending aorta was seen to emerge from under cover of the pulmonary arterial trunk. Its transverse diameter externally about the middle of its length was 66 mm., but immediately between the origin of the left subclavian and the attachment of the ductus arteriosus the transverse diameter of the arch was only 34 mm. A great contrast was presented between the dilated condition of the ascending and transverse parts of the arch as compared with the descending part, for immediately beyond the ductus arteriosus the transverse diameter of the aorta was only 29 mm. The rapid diminution in the calibre of the artery immediately beyond the origins of the great vessels for the head, neck, and anterior limbs would without doubt facilitate the flow of blood into these vessels.

The ascending aorta close to its origin gave rise to the pair of coronary arteries for the supply of the heart's walls. From the middle of its ventral surface a thymic branch nearly as large as the human radial entered the thymus and was distributed to its substance. From the transverse part of the arch the wide but short innominate artery, the left common carotid, and left subclavian arose; the innominate almost immediately divided into the right subclavian and common carotid. From the right side of the base of the innominate a branch as large as the human ulnar proceeded, which passed backwards to the bifurcation of the trachea where it was cut across; it was probably a bronchial artery and in its course it supplied some large lymphatic glands placed at the side of the trachea.

There was only one anterior vena cava, which received immediately in front of the right bronchus a large azygos vein. The posterior vena cava was large where it opened into the right auricle.

The uteri were bicornuated and non-gravid. In the largest uterus the corpus was $4\frac{1}{2}$ inches (114 mm.) long, and each cornu was $7\frac{1}{2}$ inches (190 mm.) long. The walls of the uterus were tough and densely fibrous. In the cervix the wall was 20 mm. thick, in the corpus 5 mm., in the cornu 4 mm. The mucous membrane was elevated into strongly projecting parallel folds, which had a direction corresponding to the long axis of the cavity; these folds closely resembled the appearance which I have previously described in the non-gravid uteri of *Halichœrus grypus* and *Cystophora cristata*.[1] The ovary was about the size of a walnut, and was enveloped by a sac-like expansion of the peritoneum.

The testicles were 7 inches (178 mm.) long, 3 inches broad, and about $1\frac{1}{2}$ inch thick. A large and projecting epididymis ran along one border of each gland.

The kidneys were multilobulated, $6\frac{1}{4}$ inches (159 mm.) long, 3 inches broad, and 2 inches thick. The lobules were about the same size as one finds them in the kidney of *Globiocephalus melas*.

Nearly four feet of the small intestine had been preserved. It was firmly contracted so that the lumen was closed, and the transverse diameter of the tube was only $\frac{3}{8}$ths of an inch.

The pyloric end of the stomach was preserved. It contained no food, but a quantity of sand and fine gravel, the largest particle of which was about the size of a coffee bean. After the Challenger had returned home there was forwarded to Sir Wyville Thomson, from the Cape of Good Hope, a small box labelled "Seal's Ballast Bag." It contained a dried and somewhat shrivelled membranous hollow organ, $11\frac{1}{2}$ inches (292 mm.) long by $5\frac{1}{2}$ inches (140 mm.) in its greatest circumference. The cavity of this organ was to a large extent occupied with smooth pebbles, flattened at the sides as if from mutual attrition. I have not removed them from the cavity of the organ, as it would be difficult to replace them, so that I cannot state the exact number, but there are certainly upwards of twenty. They vary in size; one of the largest is $1\frac{1}{2}$ inch (38 mm.) in its long diameter, and there are several of almost equal dimensions, but the smallest is not much larger than a coffee bean. There is but little doubt that this so-called "ballast bag" is the dried stomach of a Seal.

[1] On the Placentation of Seals, *Trans. Roy. Soc. Edin.*, 1875, vol. xxvii. p. 275.

That Seals do take stones into the stomach has been observed both by the seal fishermen and by naturalists. Captain Henry Pain, of the S.S. "Scanderia," when writing upon the habits of the Sea Lion, says[1] that he has seen upwards of twenty-five pounds weight of stones, some of which were the size of a goose's egg, in "a pouch" inside the animal, obviously the stomach. He states that as these animals get thin they have the power of throwing the stones up, a sufficient quantity only being retained to keep the Seals from coming up too freely to the surface. Mr. Elliott relates[2] that he has opened the stomach in many specimens of *Callorhinus ursinus*, and that in old bulls he has seen stones which weigh half a pound, and in one stomach he found about five pounds of large pebbles: he also possesses the stomach of a Sea Lion in which more than ten pounds of stones were present, some of which weighed two and three pounds. Mr. Robert Brown, in his account of the Pinnipedia of the Greenland Seas,[3] states that he has often seen small stones or gravel in the stomach of the Walrus, and that this is a habit which it possesses in common with *Phoca barbata* and even *Beluga catodon*. The intelligent keeper of the Seals in the Zoological Gardens, London, informs me that he is familiar with this practice, and that he has seen the Sea Lion both swallow large pebbles and subsequently disgorge them.

Various uses have been ascribed to this peculiar habit of the Seals. The prevailing opinion amongst sailors is that the animals swallow the stones as ballast to enable them to dive so as to catch fish, and that they can at will disgorge them. Mr. Elliott considers that their use is, by grinding against each other, to destroy the numerous Nematode worms with which the stomach is infested. Others again maintain that they serve the same purpose as the stones in the gizzard of a fowl, and assist in the trituration of the food. I am myself inclined to favour this view, for a Seal literally "bolts" entire the fish which serve as its chief food, without any mastication, and the action of the pebbles on the fish so swallowed would without doubt, through the movements of the muscular wall of the stomach, most materially assist the gastric juice in the trituration and chymification of the food.

[1] *Proc. Zool. Soc. Lond.*, 1872, p. 681.
[2] Quoted in Allen's History of North American Pinnipeds, p. 353.
[3] *Proc. Zool. Soc. Lond.*, June 25, 1868, p. 430.

It had been my original intention to have dissected the carcases of the specimens of *Arctocephalus gazella* and of *Macrorhinus leoninus* collected by H.M.S. Challenger, and to have compared the anatomy of their muscular, vascular, and nervous systems, so far as these were uninjured, with the corresponding parts in species of the genus *Phoca* which I had from time to time collected and stored in the Anatomical Museum of the University. As time went on I found that, from the pressure of many duties, I should be unable to overtake this part of the work. I entrusted the specimens therefore to a former pupil, Dr. William C. Strettell Miller, in whose skill as a dissector I had confidence, to make the dissections and to draw up an account of his observations. This he has now done so far as regards the muscular system and the nerves which supply the muscles, and his description appears as an Appendix to this Report. The time occupied in dissecting, comparing, and describing the specimens was upwards of a year, and the dissections were very carefully conducted. I should also say that the responsibility of this part of the investigation rests with Dr. Miller, for beyond giving an occasional superintendence over the dissections, and an opinion on some point when he was in doubt, I have not interfered in the conduct of his work.

APPENDIX TO THE REPORT ON THE SEALS.

The Myology of the Pinnipedia. By Wm. C. Strettell Miller, M.D. Edin.

INTRODUCTION.

This memoir embodies the result of a series of dissections of Seals, commenced in November 1886, in the anatomical department of the University of Edinburgh, at the request of Professor Sir William Turner, to whom I am much indebted for his kindness in placing the material for this research at my disposal.

The animals which I have dissected are as follows:—an adult *Phoca vitulina*, a half-grown imperfect specimen of *Phoca hispida*, an imperfect specimen of a pup of *Phoca barbata*, two partially damaged young specimens of *Arctocephalus gazella* brought by the Challenger from Kerguelen Island, and a specimen of *Macrorhinus leoninus*, also brought by the Challenger from the same island, which, unfortunately, was so imperfectly preserved that the hind limbs were the only parts which could be dissected. In addition, a half-grown specimen of *Phoca vitulina* was kindly given to me by Professor Cossar Ewart for this investigation.

The plan which has been pursued in drawing up this description has been to take the arrangement found in *Phoca vitulina* as the standard, and to describe fully the muscles as seen in that animal, and then to point out wherein the other Seals agreed with or differed from it; but as *Arctocephalus* is far removed from *Phoca vitulina* in its structure, its myology has had to be described in considerable detail. It must be understood that when I use the term Phocinæ in the course of my narrative I mean by it *Phoca vitulina*, *Phoca barbata*, and *Phoca hispida*. Opportunity has frequently been taken to compare the result of my own dissections with those of previous writers.

The muscles have been arranged in natural groups, and so far as possible the nervous supply of each muscle has been stated.

The memoirs on the myology of the Pinnipedia which I have consulted in connection with my dissections are as follows:—

Duvernoy, G. B., Sur les organes du mouvement du Phoque Commun. *Mém. du Muséum*, tom. ix., 1822.

Vrolik, W., Specimen Anatomico-Zoölogicum de Phocis, speciatim de Phoca vitulina. Trajecti ad Rhenum, 1822.

Rosenthal, F., Ueber die Sinnesorgane der Seehunde. *Nova Acta Acad. Cæs. Leop.-Carol.*, 1831.
Humphry, G. M., On the Myology of Orycteropus capensis and Phoca communis. *Journ. Anat. and Physiol.*, May 1868.
Murie, J., Upon the Anatomy of the Pinnipedia. *Trans. Zool. Soc. Lond.*, vols. vii., viii.
Lucae, J. C. G., Die Robbe und die Otter. *Abhandl. Senckenberg. Naturf. Gesellsch.*, 1873–75.
Cunningham, D. J., Report on some points in the Anatomy of the Thylacine (Thylacinus cynocephalus), Cuscus (Phalangista maculata), and Phascogale (Phascogale calura), collected during the Voyage of H.M.S. Challenger in the years 1873–1876; with an account of the Comparative Anatomy of the Intrinsic Muscles and the Nerves of the Mammalian Pes. Zool. Chall. Exp., vol. v. part xvi.

Dermal Muscles.

The *Panniculus carnosus* in *Phoca vitulina* is an extensive sheet of subcutaneous muscular fibres subjacent to pelt, blubber, and the deep fascia, which is dense and coarse in some regions, fine and transparent in others. Dorsally, the panniculus almost covers the axial part of the animal. It stretches from above the orbits to the root of the tail, ending as two finger-like prolongations between the tail and the dorsal surface of the legs. Upon the ventral aspect, it begins at the lower lip, covers all the neck, recedes from the presternum, exposing a small part of the sterno-mastoid and cephalo-humeral muscles; overlaps the pectoral,[1] with the exception of a margin near the sternum, and extends almost longitudinally, from the side of the thorax to the femur, which it crosses midway between the trochanter and the external condyle, to join the finger-like prolongations. The belly, therefore, wants a subcutaneous muscular layer, and the abdominal part of the pectoral and the external oblique lie next the investing fascia.

It is capable of division into five parts by the direction of the fibres:—*a*. The *Platysma*, on the ventral side of the neck. *b*. The *Lateral cervical*, between the platysma ventrally and the cervico-scapular dorsally. *c*. The *Pectoral*, on the sternal pectoral muscle. *d*. The *Cervico-scapular* covers the back of the neck, and stretches from the orbit to the spine of the scapula. *e*. The *Dorso-abdominal* extends from the scapular spine to the tail.

a. The *Platysma* is pale, and covers the muscles between the rami of the lower jaw, and extends backwards to the junction of the presternum with the meso-sternum. The fibres are longitudinal where they spring from the side of the presternum, but turn outwards at their anterior ends; some of these terminate over the sterno-mastoid, and partially overlap it near its insertion. The remainder become more and more obliquely directed outwards; at the anterior termination of the presternum they become transverse, and over the thyroid cartilage also are transverse. The most posterior fibres join the lateral cervical part; all in front of these terminate after passing over the ramus of the lower jaw, by mingling with the fibres of the lateral cervical, round the angle of the mouth, and *insert* themselves into the skin round the lower lip.

b. The *Lateral cervical* is also pale, and passes forwards from the side of the neck. It begins over the cephalo-humeral and sterno-mastoid muscles near their insertions. The fasciculi ascend to the angle of the mouth, the lower lip, and the zygoma, where they end. The sides of this longitudinal band are joined dorsally by the cervico-scapular part, and ventrally by the platysma.

c. The *Pectoral* is fan-shaped, and rests upon the presternal and sternal parts of the pectoral muscle, which originate from the presternum and meso-sternum. The inner margin of the fan

[1] Only one specimen had a pectoral panniculus.

lies next the sternum; the posterior border extends from about 3 inches to the outer side of the xiphi-sternum to the forearm, and there joins the dorso-abdominal part. The band of fibres, representing the handle of the fan, stretches outwards over the inner surface of the forearm, and blends with its deep fascia. A few fibres of the anterior border turn over the shoulder to join the cervico-scapular part. In the large *Phoca vitulina* the pectoral part was wanting.

d. The *Cervico-scapular* begins $1\frac{1}{2}$ inch posterior to the spine of the scapula, covers the back of the shoulder, the dorsum, and the posterior part of the side of the neck, and reaches as far forwards as the orbits. Laterally it joins the lateral cervical part, and in the ventral thoracic region the pectoral part over the great humeral tuberosity. It *arises* about 2 inches posterior to the scapular spine, from the aponeurotic band covering the spines of the vertebræ. This aponeurosis runs to a point anterior to the scapula, from whence it takes origin from the ligamentum nuchæ, as far forwards as the occipital bone, and then from a fine fibrous slip continuous from this forwards between the parietal eminences to opposite the orbit.

The posterior fibres are transverse, and sweep over the deltoid and the trapezius. A little further forwards they turn round the humerus to the ventral thoracic region to unite with the pectoral part over the shoulder joint. From here the fibres begin to turn upwards, and curl round the posterior lateral region of the neck, stopping upon the cephalo-humeral muscle, so that part of it is uncovered by the panniculus. The middle fibres have the same direction, and join the lateral cervical part. The bulk of the anterior fasciculi are directed forwards and outwards, and terminate upon the vertex of the cranium, midway between the lambdoidal and coronal sutures, near the posterior termination of the zygoma. The fibres, arising from the fibrous slip, extending from midway between the lambdoidal and the coronal sutures to near the root of the nose, have a peculiar distribution.[1] The most posterior fasciculus stretches onwards and outwards, to end above the middle of the orbit; the next fasciculus stretches outwards and ends to the inner side of the last. In this way is formed a muscular slip, which, with its fellow of the opposite side, forms a V with a leg resting above each orbit. A little anterior to the root of the zygoma a muscular slip about half an inch broad ascends, and a few of its fibres join the two or three which cross the line midway between the lambdoidal and coronal sutures. The fibres separated by this arrangement are connected by fasciæ stretching between these groups. This part is with difficulty removed from the cephalo-humeral and anterior part of the trapezius, which lie beneath. In the large *Phoca vitulina* the cervico-scapular part was fused with the dorso-abdominal and not defined as in the smaller specimen. The fibres were very coarse and stronger than the dorso-abdominal. They had gaps between them, and the fibres were closely adherent to the fascia above.

e. The *Dorso-abdominal part.* The extreme hindmost fibres lie in the hollow between the tibia and the sides of the caudal vertebræ behind the great trochanter of the femur. Anteriorly, the fibres extend nearly as far forwards as the spine of the scapula. The intermediate ones embrace the back, the flank, and the side wall of the thorax, and reach as far forwards laterally as the outer edge of the abdominal pectoral. From the plane of the xiphi-sternum to the flipper the fibres intermingle with the pectoral part. Posterior to the elbow joint and the forearm it passes from the side of the thorax over the outer surface of the ulna. It *arises* from the spines of the vertebræ by a broad aponeurotic band, which is continuous posteriorly with the deep fascia over the tail. This fibrous origin is narrow at the hinder extremity, expands over the middle of the back, and,

[1] They represent the occipito-frontalis.

as already shown, tapers off to a point between the scapulæ. The fibres between the tail and the tibia are directed obliquely upwards and outwards, and remain so for about $1\frac{1}{2}$ inch; the anterior $\frac{1}{2}$ inch is continuous with the hindmost fibres of the lateral abdominal part of the pectoral. Those in front of the portion joining the pectoral upon the leg sweep more obliquely forwards and outwards over the great trochanter of the femur, slightly cover its shaft, and overlap for about half an inch the outer margin of the abdominal pectoral at the level of the knee joint. The fibres lying between the knee and the level of the xiphi-sternum become more oblique in their direction forwards and outwards the nearer they get to the axillary fold. Their lateral ventral terminations cover the lateral portion of the abdominal pectoral for half an inch. The fibres anterior to the plane of the xiphi-sternum are very obliquely directed upwards and outwards; some of them end by mingling with the pectoral panniculus, others branch out along the dorsum of the forearm, and join its deep fascia; a few are lost in the fascia over the triceps and the external condyle; and lastly, those between the spines of the vertebræ and the external condyle of the humerus fade away among the almost transverse fibres of the cervico-scapular part, posterior to the spine of the scapula. It is closely adherent to the latissimus dorsi until it reaches the elbow joint and the posterior border of the ulna; here it leaves the latissimus, and passes over the olecranon and the outer surface of the forearm to join the panniculus descending from the neck. At this position there is a quantity of fat, no doubt to facilitate the movement of the elbow. In the large *Phoca vitulina* a small fasciculus joined the abdominal pectoral muscle near the axilla. It was abundantly supplied with nerves and vessels, coming through the digitations of the external oblique, between the latissimus dorsi and the lateral part of the abdominal pectoral.

The fibres of the cervico-scapular, dorso-abdominal, and pectoral parts are of the ordinary red colour, and the two latter are of uniform strength. The cervico-scapular fibres are coarse, and intermixed with fibrous tissue. Every part is closely connected by fibrous strands with the cutaneous structures above and the muscles beneath. No part is directly *inserted* into bone. The cervico-scapular and the dorso-abdominal are connected to the deep fascia, which is bound to the outer side of the tendon of the pectoral muscle, and so indirectly to the humerus. In the large *Phoca vitulina*, the panniculus terminated abruptly over the dorsum of the scapula, and did not run gradually into the deep fascia on the dorsum of the forearm. All the dermal muscles were composed of red muscle-fibres, and the platysma and lateral cervical had no fascial line dividing them, but were intimately blended.

In the specimens of *Arctocephalus gazella* the panniculus was destroyed.

Myology of the Fore-Limb.

The fore-limb of the Phocinæ and of *Arctocephalus gazella* has inserted into its bones the superficial muscles of the back which are arranged in two layers. The First Layer consists of the Cephalo-humeral, Trapezius, and the Latissimus dorsi.

Before describing this layer, let us glance at the human trapezius. It has a cephalic and a vertebral origin, and a twofold insertion; part of the insertion going to the clavicle and the remainder to the scapular spine. The latter may be regarded as in two parts, because the lowermost fibres form a tendon which glides upon the smooth surface at the vertebral end of the spine, and is fixed to a tubercle at the outer edge. What is found in the Seals is a complete division of the muscular sheet resembling the human trapezius into three muscular masses—(1) the cephalo-humeral, which represents the clavicular fibres of human anatomy; (2) the trapezius anterior part, the fibres fixed to the spine; and (3) the trapezius posterior part, the fibres forming the tendon attached to the tubercle.

The *Cephalo-humeral* as in the Carnivora generally forms a bulky mass. It is triangular, the base rests upon the ligamentum nuchæ, and the apex upon the shoulder, and is under cover of the cervico-scapular part of the panniculus. It *arises* from the occipital ridge, from the fascial slip anterior to the ligamentum nuchæ, and from the anterior half of the ligamentum nuchæ. The fibres trend obliquely backwards and outwards, and cover the side of the neck; at the shoulder they converge and are *inserted* by a short tendon into the upper end and anterior edge of the great humeral tuber above the pectoral insertion, with which the tendon blends; and into the transverse ligament, stretching between the two tubera over the biceps. The fibres are a little coarser than those of the trapezius; there is a cellular interval between the cephalo-humeral and the anterior part of the trapezius, which is not distinct, but continuous. Above the shoulder the atlanto-humeral muscle appears between the anterior part of the trapezius and this muscle, before it reaches the humerus. From the shreds of this muscle traced in *Phoca barbata* and in *Phoca hispida* it appears to be disposed as in *Phoca vitulina*.

In *Arctocephalus gazella* the lacerated condition of the muscle in both specimens compels me to pass over the origin. The muscle is larger and better developed than in the other specimens; it extends from the head to about 1 inch posterior to the anterior angle of the scapula, and partially overlaps the anterior part of the trapezius; above and behind the shoulder it forms a broad muscular band of which the anterior two-thirds blends with the sterno-mastoid, whereas in the Phocinæ it only touches the trapezius, and is a small bundle of muscle near its insertion. It is *inserted* into the humerus between the insertion of the deltoid posteriorly, and the insertion of the sterno-mastoid anteriorly.

Professor Humphry in his description does not use the names cephalo-humeral and trapezius, anterior and posterior parts, but includes the whole mass under the name trapezius.

In the Phocinæ and *Arctocephalus* the cephalo-humeral pulls the humerus forwards and rotates it inwards; this action is much greater in the latter, for the insertion is lower down upon the shaft, and it also abducts. In the Phocinæ it is supplied by the spinal accessory nerve. In *Arctocephalus* the nerve was destroyed; both receive branches from the cervical nerves.

The *Trapezius* (proper) is in two parts, an *anterior* and a *posterior*.

The anterior part with its fellow of the opposite side forms a trapezium. It is opposite the vertebral border of the scapula, and *arises* from the posterior half of the ligamentum nuchæ, from the spines of the first six dorsal vertebræ, and from the supra-spinous ligaments. The fibres of this muscle are distributed in a threefold manner. The most anterior fibres pass anterior to the scapular spine at its axillary termination, and are partially concealed by the atlanto-humeral muscle before being *inserted* into the anterior surface of the great humeral tuber, to the inner side of this muscle; a few fibres do not reach the bone but blend with the atlanto-humeral. The posterior fibres attach themselves to the vertebral end of the spine. The ones intervening between the most anterior fibres and the posterior must be studied in two layers, a superficial, and a deep. The superficial layer passes over the scapular spine and terminates upon the surface of the deltoid.

The deep layer attaches itself to the whole extent of the scapular spine, to its posterior lip, and posterior border; some fasciculi immediately below the spine are confluent with the deltoid. In the larger *Phoca vitulina* it *arises* from the 1st dorsal vertebra to the 5th. This part was destroyed both in *Phoca barbata* and in *Phoca hispida*.

In *Arctocephalus gazella* the insertion was traceable, and for the sake of clearness it is advantageous to divide this attachment into an outer and an inner half. The outer half consists, as in the intervening fibres of *Phoca vitulina*, of a superficial and a deep set of fibres. The superficial ones of the outer half blend with the deltoid posterior to the scapular spine. The deeper fibres of this half are inserted into the outer half of the spine, into its posterior lip, and posterior border, to within one-eighth of an inch from the axillary termination. The fibres of the inner half cross the spine of the scapula to blend with the deltoid.

As in the Earless and Eared Seals, owing to absence of a clavicle the spine of the scapula does not possess a well-formed acromion process but ends abruptly about 1 inch from the axillary border, a modification in the attachment of the fibres is occasioned. In the Phocinæ the most anterior fibres correspond with those in human anatomy attached to the acromion, and cross to the humerus over the gap formed by the stunted spine; in *Arctocephalus* the anterior part of the trapezius is smaller and does not pass to the humerus. In both, some of the fibres of the anterior part blend with the deltoid and must at times work in unison with it. The posterior part of the trapezius is at right angles to the deltoid, and the anterior part nearly in a plane with the deltoid fibres. This part will draw the shoulder forwards and slightly backwards with rotation upon the ribs; also pull the scapula towards the vertebral column.

In the Phocinæ and *Arctocephalus* it is supplied by the spinal accessory and spinal and cervical dorsal nerves.

The posterior part of the trapezius is an elongated triangular slip situated alongside of the vertebral column. It *arises* from the 6th, 7th, 8th, 9th, and 10th dorsal spines, from the supra-spinous ligaments, and from the lumbar aponeurosis as far back as the 12th dorsal transverse process. It ascends over the posterior angle of the scapula, passes beneath the anterior part of the trapezius, and is *inserted* by a tendon into the extreme vertebral termination of the scapular spine, and by expansion of this tendon on either side into the scapula, between the vertebral end of the spine and the vertebral border, and into the spine on the outer side. In the large *Phoca vitulina* it *arises* from the 8th to the 14th dorsal vertebræ, the posterior half of the origin being tendinous. There is some difference in the origins of this part in *Phoca barbata* and *Phoca hispida*. In the former it *arises* from the 10th, 11th, 12th, and 13th dorsal spines, and in the latter from the 9th, 10th, 11th, and 12th dorsal spines.

This part in *Arctocephalus gazella* is riband-like. It *arises* from the spines of the 8th, 9th, 10th, and 11th dorsal vertebræ, and, in addition to the parts described in *Phoca vitulina*, has *insertions* into the dorsal surface of the deltoid by its fibres blending with it. In all the specimens it drags the scapula backwards, tilting the glenoid forwards at the same time.

In the Phocinæ and *Arctocephalus* it is supplied by the spinal accessory and dorsal spinal nerves.

The *Latissimus dorsi* is rectangular; it covers the back, the lateral aspect of the abdomen, and the thorax. It is hidden by the dorso-abdominal panniculus. It *arises* from the spines of the 5th, 6th, 7th, 8th, and 9th dorsal vertebræ by muscular fibres, which touch those on the opposite side of the spine; from the lumbar aponeurosis as far back as the 5th lumbar vertebra; and from the outer surfaces of the five lower ribs below the insertion of the lateral division of the erector spinæ. These five origins interdigitate with the external oblique. The hindmost fibres curve sharply forwards, the rest are almost longitudinal, the anterior ones most so. It passes over the posterior angle of the scapula and divides into two parts; the *outer* is *inserted* into the posterior border of the abdominal part of the pectoral muscle; the *inner* blends with the tendon on the dorsal surface of the teres major, and is *inserted* with it into the inner border of the humerus, the tendon being next the bone and the fleshy part of the teres above. The *origin* in *Phoca barbata* is from the spines of the 5th dorsal vertebræ to the 3rd lumbar, otherwise the description is the same; and in *Phoca hispida* the *origin* is from the 4th dorsal spine, and the spines of all the remaining dorsal vertebræ, from the lumbar aponeurosis as far back as the 4th lumbar spine, and for the rest as in *Phoca vitulina*.

In *Arctocephalus gazella* it *arises* from the lumbar aponeurosis opposite the 3rd lumbar spine as far forwards as the 12th dorsal vertebra, from the spines of the 12th dorsal vertebra to the spines of the 7th dorsal by muscular fibres, and from the outer middle surfaces of the 9th to the 15th ribs. The posterior fibres do not curve sharply forwards but ascend obliquely forwards and outwards, the anterior, as in *Phoca vitulina*, are almost transverse. The anterior border passes outwards, touching the posterior angle of the scapula above the serratus magnus, and beneath the dorsi-epitrochlear division of the triceps. At the middle of the posterior border of the latter muscle it divides into two parts. The *inner* part has the same insertion as in *Phoca vitulina*, and the *outer* part blends with the thoracico-abdominal part of the pectoral muscle opposite the lateral aspect of the 5th rib. The inner part brings the fore-limb backwards and turns it inwards. The outer acts on the pectoral muscle.

In the Phocinæ and *Arctocephalus* it is supplied by dorsal and lateral cutaneous spinal and lumbar nerves, and by the subscapular nerve.

The latissimus separates into two parts about midway between its origin and insertion, forming an inner and outer division. In *Arctocephalus* the outer division of the latissimus goes to the thoracico-abdominal part, in the Phocinæ to the abdominal. There are no slips coming from the posterior angle of the scapula.

The Second Layer of the superficial muscles of the back connected with the fore-limb consists in the Phocinæ of the levator anguli scapulæ, three rhomboidei, and the atlanto-humeral; but in *Arctocephalus gazella* the muscles are levator anguli scapulæ, two rhomboidei, and atlanto-scapular.

The *Levator anguli scapulæ* in the Phocinæ lies below the cephalo-humeral and the trapezius. It is an elongated slip and *arises* by an aponeurotic band from the ventral surface of the transverse process of the atlas. At its origin it is situated dorsally to the atlanto-humeral, coming in contact with the anterior angle of the scapula and overlapping it, to be *inserted* into the scapula between the spine and the vertebral border, and into the vertebral border between the spine and the anterior angle. The ventral surface at the origin is posterior at the insertion, giving the muscle half a turn.

This muscle in *Arctocephalus gazella* is an elongated triangle, and lies under cover of the rhomboideus capitis over the back of the scapula. The *origin* was destroyed. It is *inserted* as in the Phocinæ, but falls short of the anterior end of the vertebral border of the scapula by 1 inch. It moves forwards the anterior angle of the scapula and rotates it upon the back.

In the Phocinæ and *Arctocephalus* the levator is supplied by the spinal accessory anterior to the scapular spine and by the cervical nerves.

Rhomboidei.—There are three rhomboidei in the Phocinæ, and these are named—*a.* Rhomboideus capitis; *b.* Rhomboideus cervicis; *c.* Rhomboideus dorsi.

The *Rhomboideus capitis* is a long narrow band, lying below the cephalo-humeral and the trapezius. It *arises* from the superior posterior angle of the parietal bone, to the inner side of the origin of the temporal muscle, and from the margin of the adjacent occipital bone. Opposite the spine of the scapula at the vertebral border, it passes beneath the rhomboideus cervicis, and is *inserted* into the ventral side of the cartilaginous plate of the scapula, near its posterior angle, between the insertions of the serratus. Professor Humphry has not described two separate muscles coming from the neck and head, but one, and to this the name rhomboideus minor is given. In the Phocinæ it is supplied by filaments from the cervical nerves.

The *Rhomboideus cervicis arises* from the forward fascial prolongation of the ligamentum nuchæ opposite the occipital bone, and from the ligamentum nuchæ. Until the fibres reach the middle of this ligament, the muscle is a slender band, then it becomes broader, and the fasciculi are obliquely directed to the base of the scapula. It is *inserted* into the vertebral border of the scapula posterior to the spine, and into the vertebral border of the cartilaginous plate. Some of the hindmost fibres run into those of the serratus magnus at its insertion. In the large *Phoca vitulina* the origin is as far back as the 2nd dorsal vertebra. This muscle is not specially noted by Humphry, but named rhomboideus minor with the last muscle. In *Phoca vitulina* it is supplied by the 4th cervical, and in *Phoca barbata* and *Phoca hispida* from the 5th cervical.

The *Rhomboideus dorsi* is a small triangular muscle lying between the scapula and the serratus magnus. It *arises* from the first four dorsal spines, and from the supraspinous ligaments. The fibres go towards the posterior angle of the scapula on its ventral surface. It is *inserted* into the axillary border of the cartilaginous plate, and to a very small extent into the axillary border of the scapula. In the large *Phoca vitulina* the origin is from the 2nd dorsal vertebra to the 4th. There is a slight difference in *Phoca barbata*, it *arises* from the 3rd, 4th, and 5th dorsal vertebræ. To this muscle Professor Humphry has given the name rhomboideus major. In *Phoca vitulina* and *Phoca hispida* it is supplied by a lateral nerve from the 1st intercostal space; in *Phoca barbata* by nerves from the 3rd and 4th, and 4th and 5th, intercostal spaces; in the large *Phoca vitulina* by a large dorsal branch passing between the 2nd and 3rd ribs.

In *Arctocephalus gazella*, instead of three distinct muscles, there are only two, but these have three insertions. They are the rhomboideus capitis (et scapularis) and the rhomboideus dorsi.

Rhomboideus capitis (*et scapularis*).—As the attachments of this muscle are vastly different from the corresponding muscle in the Phocinæ, I have added "et scapularis" to emphasise the peculiarity. The origin was mutilated. The fibres proceed backwards and slightly outwards, and cover half the dorsal surface of the scapula anterior to the spine. It is *inserted* into the inner half of the scapular spine, into the posterior lip, and into the scapula between the spine and the vertebral border. Some fibres unite with those of the atlanto-scapular just anterior to the spine.

The *Rhomboideus dorsi* is of a rhomboid shape. It *arises* from the spine of the 7th cervical, and then from the same spines as in *Phoca vitulina*. There is no division at the origin, but as the fibres approach the vertebral border of the scapula they collect into two parts. The anterior part has the same insertion as the rhomboideus cervicis of *Phoca vitulina*, but it extends anterior to the spine for 1 inch along the vertebral border of the scapula. The posterior part is *inserted* behind the anterior part into the vertebral border of the cartilaginous plate for a slight distance; then into the ventral side of this plate, reaching nearly to the posterior angle. It closely resembles the insertion of the rhomboideus capitis of the Phocinæ, but is outside the insertion of the serratus and not inside it on the ventral side of the plate.

In *Otaria* the muscle is regarded as the rhomboideus major and minor, but from its attachment is considered more likely to be the minor. It is supplied by the dorsal and lateral intercostal nerves. The rhomboideus dorsi approximates the posterior angle to the spinal column. All the others pull forwards the anterior angle of the scapula, the rhomboideus capitis et scapularis having the greatest efficiency in this direction.

The *Cartilaginous Plate of the Scapula.*—This plate is found in many animals, and is of the greatest magnitude in younger ones; when present it gives origin and insertion to muscular fibres. As an instance of the variety in shape, take the sheep as an illustration; in it the plate extends along the entire vertebral border of the scapula, and is of equal depth throughout: it only adds another inch or so to the transverse length of the bone. In the Seals it is like a small triangle with the apex beginning a little anterior to the spine and the base in a line with the axillary border (Pl. IV. fig. 1). When removed from the scapula the vertebral border is semilunar, but when attached is almost straight and closely approaches the shape of the human vertebral border. It enlarges the scapular surface, and one must remember its presence when examining a macerated bone, otherwise the surface for muscular attachment may be undervalued.

The *Ligamentum nuchæ.*—Owing to the shortness of the neck in the Seal, especially in the Phocinæ, to the support given to the head by the water in which they spend most of their lives, to the relative lightness of the cranium, and to their not requiring much up and down movement of the head in search of food, this ligament is not the well-formed elastic band found in many animals, which relieves the muscles of the neck, but a thin septum in a line with the cervical spines. Its anterior termination is a thin fascial prolongation and ends upon the vertex of the cranium; in the cervical region it is much better marked, and altogether is not unlike this ligament in man.

The *Atlanto-humeral arises* from the aponeurotic band, which gives origin to the levator anguli scapulæ, and from the transverse process of the atlas anterior to this band. It goes towards the shoulder under cover of the cephalo-humeral; over the shoulder it emerges from beneath this muscle, and is *inserted* into the anterior surface of the great tuberosity of the humerus in its upper two-thirds. Professor Humphry does not give this muscle in his description, and it does not exist in the *Arctocephalus*.

The representative of the atlanto-humeral in *Arctocephalus gazella* is the *atlanto-scapular*. It *arises* from the ventral surface of the transverse process of the atlas, by a tendon common to it and the levator scapulæ, and from the transverse process of the 2nd cervical vertebra. The fibres pass backwards over the outer half of the dorsum of the scapula; a few of the posterior internal ones join the rhomboideus capitis. It is *inserted* into the outer half of the scapular spine along its anterior lip. A small fasciculus joins the fibres of the deltoid outside the spine of the scapula over the back of the shoulder.

In *Otaria jubata* and the Walrus the levator muscles are alike, and the insertions are the same as that of the atlanto-scapular in *Arctocephalus*. From this I gather that there is no levator anguli scapulæ in *Otaria* and *Trichechus* resembling in insertion the muscle of human anatomy. In all the Phocinæ and the two *Arctocephali* I find there is one with a very similar insertion to that found in man, so there is reason for giving the name atlanto-scapular to the muscle in *Arctocephalus* corresponding to Dr. Murie's levator anguli scapulæ.

In his paper on the *Trichechus* he points out that there is also a muscle which may be the representative of the so-called levator-claviculæ. The atlanto-humeral has the same action as the cephalo-humeral. The atlanto-scapular pulls the scapula forwards and rotates it.

Up to the present there have been differences in the muscles of *Phoca barbata* and *Phoca hispida*, and special descriptions of various points have been required; but now we come to a stage in this myological study where all these agree, with only an occasional difference. It must therefore be remembered that the description of *Phoca vitulina* is also the description of *Phoca barbata* and *Phoca hispida*, and only when a deviation occurs from the one selected as the standard animal will their names be cited.

The Ventral Thoracic Region contains the pectoral muscle. The pectoralis minor and subclavius are absent.

The Pectoral Muscle.—In consequence of the importance of this muscle both in swimming and in moving on land, I have very carefully examined it. It has received numerous names. Vrolik and Humphry call it the pectoralis major, Lucae the pectoralis, and Murie in the *Otaria* the pectoral muscles, whilst in the *Trichechus* he divides it into three—(*a*) a fleshy pectoralis major, (*b*) a second, (*c*) a third layer. It is situated in the pectoral region at its insertion, but the origin is more extensive, for it covers the neck, chest, abdomen, and leg. The panniculus partially conceals it. This most extensive muscle is divisible into three parts—(*a*) the presternal, (*b*) the sternal, and (*c*) the abdominal. The presternal and sternal form one triangle, the abdominal another. The presternal part *arises* from the fascia over the trachea 1 inch anterior to the presternum, and from the side of it. It is separated, close to the junction of the presternum with the meso-sternum, by a very faint cellular line, seen best on the under surface of the muscle. The fibres pass towards the shoulder. The sternal part *arises* from the whole length of one side of the meso-sternum, and from the cartilages of the eleven true ribs, and by an antero-posterior slip from the xiphi-sternum. A cellular interval separates it from the third part. The abdominal part must be studied as three groups of fibres. The first group *arises* posterior to the xiphi-sternum from $3\frac{1}{2}$ inches of the linea alba; the second group, from the fascia over the external oblique muscle, by several finger-like prolongations, which are shortest and most obliquely directed outwards near the middle line. Between these the fibres of the external oblique are seen ascending to the ribs. The third group *arises* from the fascia on the back of the leg. These hindmost fibres rest on the back of the leg, are continuous with the hindmost fibres of the panniculus, turn round the leg, sweep over the femur, touch the outer side of the patella, and course antero-posteriorly with the rest of the abdominal fasciculi, which are obliquely turned outwards. All meet at the axillary border of the sternal part and disappear beneath it. The three parts—presternal, sternal, and abdominal—converge on nearing their attachment to the humerus. They are *inserted* in the following manner:—The presternal part blends with the sternal, and the anterior third of this combination is *inserted* into the inner margin of the deltoid tuberosity of the humerus, with the exception of a small part at the upper end. The posterior two-thirds join the posterior layer of the deep fascia of the forearm, reaching near to the lower end of the ulna on the posterior border of the flipper, and the anterior border of the radius about its middle.[1] The abdominal part, after disappearing beneath the sternal, is joined by the outer division of the latissimus dorsi, and then joins the portion of the sternal part which is *inserted* into the humerus. The humeral portion is muscular on the under surface in the upper third and tendinous in the lower two-thirds.

In *Arctocephalus gazella* there are also three parts having almost similar names. The presternal part is most anterior, and consists of a narrow muscular band. It *arises* from the lateral anterior termination of the presternum by a small tendon. It is half under cover of the sternal part, and courses almost transversely outwards to the shoulder over the sterno-cleido-mastoid, which descends behind its inner half to gain the fascial slip occupying the position of the absent clavicle. The outer half is between this muscle, which is now ventral to it, and the sternal part. Over the shoulder it is lost among the fibres of the sterno-mastoid above and the sternal part behind.[2] The sternal part lies posterior to the presternal, and anterior to the thoracico-abdominal, partly covering it. It is a fleshy mass of transverse fibres of considerable depth and breadth. It *arises* from the lateral half of the presternum and meso-sternum; and from the cartilages of the four anterior ribs. It blends over the presternum and meso-sternum with the same part of the opposite side. The fibres reach the anterior border of the humerus in a sheet of the same breadth as at the origin. This wide bundle is *inserted* in its anterior half after blending with the thoracico-abdominal part into the inner lip of the deltoid ridge of the humerus. The anterior three-fourths of this insertion pass beneath a slip of the sterno-cleido-mastoid, which is adherent to the pectoral, and end by dividing into two; the outer slip becoming confluent with the origin of the inner part of the brachialis anticus, and the inner by ending similarly upon the pectoral. The posterior half is *inserted* obliquely into the deep fascia of the forearm, from the anterior side of the bend of the forearm to the middle of the posterior border of the ulna. It is also attached to the cartilaginous bar over the outer side of the forearm near the elbow-joint. The thoracico-abdominal part is a large strong triangular sheet with the base in the mesial plane. It *arises* by two divisions; the ventral from the linea alba 1 inch behind the xiphi-sternum, and from the outer half of the xiphi-sternum. This soon blends with the dorsal, which *arises* from the cartilages of the 2nd to the 11th ribs; from the 8th to the 11th ribs, opposite to the origin of the ventral division, it only springs from the cartilages; but anterior to the 8th rib it also has origin from the side of the meso-sternum, and blends with its fellow as far forwards as the 4th rib. Anterior to this, it does not blend over the meso-sternum; for the sternal part intervenes between the origins of the thoracico-abdominal parts of the opposite sides. The fibres pass towards the humerus, partly under cover of the sternal part; the posterior fibres ascend, the anterior are transverse. At the level of the 5th rib laterally, the outer division of the latissimus dorsi blends with it. After gaining these fibres along its outer edge, it blends with the sternal part and is *inserted* with it. The under surface of the insertion is tendinous.

As a guide to the descriptions of this muscle in *Phoca vitulina*, *Arctocephalus gazella*, *Otaria* and *Trichechus*, a statement of the names used for the various divisions may be useful, as anatomists differ much in their nomenclature.

In *Phoca vitulina* there are three parts—(1) the *Presternal*, (2) the *Sternal*, (3) the *Abdominal*.

[1] The deep fascia over the anterior surface of the forearm divides into two layers—the anterior one gives attachment to the panniculus, as has already been stated; the posterior is for the pectoral muscle.

[2] The fascial slip representing the clavicle is attached to the presternum internally, and passes outwards beneath the inner half of the presternal part of the pectoral, to end by joining the sterno-cleido-mastoid going to the humerus.

Professor Humphry mentions two divisions in *Phoca vitulina*—(1) the first or pectoral proper includes the presternal and sternal; (2) the second is the same as the abdominal.

In *Arctocephalus gazella* there are also three—(1) the *Presternal*, (2) the *Sternal*, (3) the *Thoracico-abdominal*. The last is so named because it covers the thorax and abdomen, and is not wholly abdominal as in *Phoca vitulina*.

Dr. Murie in the *Otaria* gives three divisions—(1) a *first division* (which embraces the presternal and sternal parts in *Phoca vitulina* and in *Arctocephalus*), (2) a *second* (representing the abdominal part in *Phoca vitulina* and the thoracico-abdominal in *Arctocephalus*), (3) a *third* (not found in *Arctocephalus* and *Phoca vitulina*, and called the sterno-scapular).

The same author in the *Trichechus* gives three divisions—(1) a thick fleshy *pectoralis major* (equivalent to the presternal and sternal parts in *Phoca vitulina* and *Arctocephalus*), (2) a *second layer* or *pectoralis minor* (which is the abdominal part in *Phoca vitulina* and the thoracico-abdominal in *Arctocephalus*), (3) a *third layer* (called the sterno-scapular by Dr. Murie in *Otaria*).

The muscle fibres are not arranged alike in the Phocinæ and *Arctocephalus*, but form muscular layers of very different shapes. The presternal and sternal parts in comparing their form can be combined, and this gives two masses for examination. The presternal and sternal parts in the Phocinæ form a large triangular layer, with the anterior and middle fibres transverse, and the posterior obliquely directed forwards; the base of the triangle springs from the whole of the presternum, meso-sternum, and xiphi-sternum. In *Arctocephalus* and in *Otaria* the same mass consists only of transverse fibres, and stretches from the presternum and meso-sternum directly outwards to the flipper. Judging by the drawing of the *Trichechus*, the configuration of the same division is more like that of the Phocinæ, for it approaches the triangular shape, and the posterior fibres are not directly transverse as in *Arctocephalus* and *Otaria*, but obliquely directed forwards as in the Phocinæ. The abdominal part in the Phocinæ approaches the triangular shape, and consists of an inner or mesial belt of fibres directed forwards and outwards, and an outer or lateral belt running along the lateral abdominal wall and a number of intermediate muscular bars or fingers filling in the triangle. All these fibres go to the axilla. In *Arctocephalus* the thoracico-abdominal part is a large badly formed triangle nearly like that of *Otaria* and *Trichechus*.

Humphry describes the second division (*i.e.*, abdominal part) of the pectoral muscle in *Phoca vitulina* as arising "from the linea alba, the pubes, and also from the margin of the ilium, covering the fibres of the external oblique which were seen running transversely between the iliac and pubic portions." This being a most interesting point in the anatomy of the pectoral muscle, I made a series of dissections to ascertain the exact condition, and in the large *Phoca* had special opportunity of investigating this among many other points, and wish to emphasise what was ascertained. A group of fibres did come from the linea alba, also one from the back of the leg, and an intermediate number of digitations from the fascia on the external oblique muscle whose hindmost ends did not pass a line drawn from 3 inches behind the xiphi-sternum to the inner side of the patella, so none reached the pubes. In this animal the digitations of some of the intermediate group of fibres of the abdominal part reached the outer side of the rectus sheath.

As no other writer describes a presternal part, but includes it with the sternal, I give my reason for so doing. In the Phocinæ some were fresh specimens, and in these there was a slight separation of the fibres at the junction of the presternum and meso-sternum; but in *Arctocephalus*, the specimens being at least ten years old and preserved in brine, which had hardened the flesh and cellular tissue, I could not be positive as to a natural division. However, as the presternal fibres in the Phocinæ and *Arctocephalus* are the only ones of the pectoral muscle which are not *inserted* into the humerus and forearm, but end among the fibres of the sternal part in the Phocinæ, and of the sterno-cleido-mastoid and sternal part in *Arctocephalus*, it shows how closely these præsternal parts are allied.

In *Otaria* the second division (*i.e.*, the thoracico-abdominal) is *inserted* partly by fascia, which joins the aponeurotic fascia of the forearm. In *Arctocephalus* there is no fascia going to that of the forearm.

In *Trichechus* the second division, deep layer or pectoralis minor (*i.e.*, the thoracico-abdominal part), is *inserted* directly into the whole length of the shaft of the humerus, so there is no blending of the second part with the first as in *Arctocephalus* and *Otaria*.

Neither in the Phocinæ nor in *Arctocephalus* have I made out the third and smallest division (sterno-scapular) described in *Otaria* and *Trichechus*, and Professors Vrolik, Humphry, and Lucae do not mention such a muscle in their researches on *Phoca*.

Dr. Murie inclines to the view that the two most superficial layers in *Otaria* are a divided pectoralis major, and not the minor; the third layer he classes as the sterno-scapular. In describing his *Trichechus*, he uses the names first layer or pectoralis major, second layer or pectoralis minor, and third layer. Although the name pectoralis minor is used by Murie, I do not think this muscle really exists in the Phocinæ and other Seals, for as the insertion acts as a guide in determining the identity of a muscle, and as there is a well-marked lesser tuberosity in the humeri of the Phocinæ, and a better representative of it in the *Arctocephali*, still no fibres of the pectoral muscle find their way to it, but all pass over to the deltoid ridge. If the pectoralis minor did exist, the insertion would be into the lesser tuberosity of the humerus, because the coracoid is inside the shoulder-joint in the seals.

The Lateral Thoracic Region contains the *Serratus magnus*, which covers the trunk and the neck. This muscle *arises* by five muscular slips from the ventral transverse processes of the five posterior cervical vertebræ behind the scalenus anticus, from the outer and posterior surfaces of the nine anterior ribs at the junction of the bones with their cartilages. The five lowest interdigitate with the external oblique; the slips from the first and second ribs are not divisible near their origin. From the insertion into the base of the scapula it is seen that the muscle is fixed in three ways. The five cervical slips are *inserted* into the vertebral border of the scapula, between the anterior angle and the cartilaginous plate, to 1 inch posterior to its anterior end. The four anterior thoracic digitations crossing from the trunk are *inserted* obliquely across the ventral surface of the cartilaginous plate between the cervical part ending 1 inch posterior to the anterior end of the cartilaginous plate, and the osseous posterior angle of the scapula. The five posterior ascending from the trunk are *inserted* into the vertebral border of the cartilaginous plate, and slightly into the ventral surface of it, extending as far forward as 1 inch posterior to the spine. These five digitations are attached in the opposite order of origin; the 5th goes into the posterior angle, the 6th is placed anterior to it on the scapula, and the 9th is the highest. In the large *Phoca vitulina* there were ten digitations from the trunk.

In *Arctocephalus gazella* it *arises* by sixteen digitations, almost as in *Phoca vitulina*. The fibres course to the base of the scapula. The six posterior digitations from the trunk form a strong bundle near the posterior angle of the scapula; this is partly tendinous on its outer side, and is *inserted* into the vertebral border of the cartilaginous plate at the posterior angle, posterior to the insertion of the rhomboideus dorsi, which sends a few fibres to it. The five cervical slips and the five anterior thoracic are *inserted* into the inner lip of the vertebral border, from 1 inch posterior to the anterior angle of the scapula to the posterior angle, and into the ventral side of the cartilaginous plate, with the exception of a small piece which is for the insertion of the rhomboideus dorsi, and joins with the insertion into the posterior angle. The cervical digitations are distinct, while those from the anterior thoracic region are not quite so, but touch each other from their origin to their insertion. The posterior slip interdigitates with the latissimus dorsi, the five anterior to this one with the external oblique.

The origins of the serratus in the Phocinæ and in *Arctocephalus* differ in the number of the digitations from the trunk; in the latter there are two more coming from the 10th and 11th ribs. In the Phocinæ it only interdigitates with the external oblique, whereas in *Arctocephalus* it interdigitates with it and the latissimus dorsi.

By the greater size of the cartilaginous plate in the Phocinæ a change in the two insertions is brought about. The plate in *Arctocephalus* is only a narrow bar, but in the Phocinæ it is very wide. In the Phocinæ the cervical slips fix themselves upon the anterior vertebral border of the bone and anterior end of the cartilaginous bar; the anterior thoracic slips follow the junction of the bar with the bone from the termination of the cervical slips to the posterior angle, and the posterior thoracic begin where the last ended, and follow the vertebral border of the plate to its anterior end. By this arrangement a circle of fibres surrounds the cartilage, and a clear space is left in the centre. The rhomboidei cervicis, capitis, and dorsi are fixed to it in this order from before backwards. In *Arctocephalus* the cervical and the anterior thoracic are attached to the scapula and ventral surface of this plate as far as the posterior angle, leaving uncovered a small part of the vertebral border of the plate near the posterior angle for the rhomboideus dorsi. The posterior thoracic slips go to the posterior angle. In *Otaria* it *arises* from ten ribs, and in *Trichechus* from eight.

The digitations of the cervical serratus are in a plane with the digitations of the levator anguli scapulæ, and are so combined in many Mammals that one muscle is the result. The slips are not so closely approximated in the Phocinæ and *Arctocephalus* as to prevent a natural division. Professor Humphry states that it forms a continuous sheet with the levator, and Dr. Murie says in *Otaria* "that the serratus digitations were tolerably fused together, so that they formed but one continuous sheet." In *Otaria* he makes special reference to its "two upper nuchal slips which are inserted quite on the dorsal surface of the scapula," and in the *Trichechus* explains that "the highest, as in *Otaria*, is more or less separate, and is inserted into the dorsum of the scapula between the angle and spine on the vertebral border." When the levator anguli scapulæ is not well developed and is absorbed by the serratus, and the fusion has not been absolute, then the serratus must be scrutinised closely to discover what has become of it. The difference in its anterior part in *Otaria* and *Trichechus* by the outer slips going to the dorsum of the scapula, and the want of perfect fusion of the slips, makes it doubtful as to the highest being serratus. The atlanto-scapular in *Arctocephalus* is the levator anguli scapulæ of Dr. Murie in the *Otaria* and *Trichechus*. To justify this observation, the myological researches of the various investigators on the Phocinæ in which there is no atlanto-scapular must be quoted. Professor Humphry describes a levator anguli scapulæ inserted into the base of the scapula. Professor Lucae in the same animal gives, in one of his plates, a levator with a similar insertion, and in my dissections of the Phocinæ and *Arctocephalus* I find in all a levator which corresponds to the nuchal slips called serratus in *Otaria* and *Trichechus*, so that I regard the nuchal slips as the levator in the *Otaria* and *Trichechus*.

It pulls the scapula away from the spinal column, the posterior fibres rotate it outwards, and the anterior fibres from the neck must pull the shoulder forwards.

The Muscles of the Shoulder.—In the Phocinæ are found the deltoid, subscapularis, subscapulo-capsularis, supraspinatus, infraspinatus, teres minor, and teres major.

In *Arctocephalus* the teres minor and subscapulo-capsularis are absent, but this animal possesses in addition an episubscapularis.

The *Deltoid* is placed upon the infraspinatus behind the scapular spine. It is in the form of a quadrant, and *arises* from the entire posterior border of the spine of the scapula, above the spinal origin of the infraspinatus; from the dense fascia between the outer termination of the spine and the shoulder-joint; slightly from the dorsal surface of the capsule of the shoulder-joint; from the scapula internal to the vertebral end of the spine and internal to the origin of the infraspinatus; from the dorsum of the cartilaginous plate to a small extent; and from a narrow surface between the infraspinatus and the dorsi-epitrochlear muscles. The fibres course towards the humerus, overlap part of the triceps, and cross the upper half of its dorsal surface; from the middle to the axillary end of the spine it receives some of the fibres of the anterior part of the trapezius, then passes over the shoulder-joint where the atlanto-humeral partly joins it along its anterior border. It is *inserted* into the lower half of the outer edge of the great humeral tuberosity (deltoid ridge).

In *Arctocephalus gazella* it lies posterior to the scapular spine, and is almost rectangular. It *arises* from the whole extent of the posterior lip of the spine, from the posterior border of it, from the capsule of the shoulder-joint dorsally, from the scapula by tendinous fibres between the spine and the vertebral border, from the vertebral border by muscular fibres, from the dorsum of the cartilaginous plate alongside of the vertebral border, and from the adjacent sides of both to the posterior angle. All the fibres incline to the outer surface of the humerus, a few to the outer end of the spine blend with a small group of the atlanto-scapular. It is *inserted* into the outer rim of the deltoid ridge, and into the dorsal part of the capsule of the shoulder-joint. The under two-thirds of the insertion is tendinous. From the corner of the muscle joining the lowest part of the deltoid ridge, a tendinous slip goes to the fibro-cellular bar lying upon the anterior border of the radius.

A glance at the scapulæ of the Phocinæ and *Arctocephalus* impresses one with their dissimilarity of mould. The spine, which is the boundary line between the supra- and infraspinous fossæ, is situated at the junction of the anterior third and the posterior two-thirds of the dorsum in the Phocinæ. In *Arctocephalus* it is at the junction of the anterior two-thirds and the posterior third (Pl. VII. fig. 2). The osteological differences between these two bones show clearly the variety in form, function, and development of the soft structures which are attached to them, and point to the likelihood of some muscles being present in the one and not in the other, which is the case. The form and position of the origin of the deltoid in the Phocinæ and *Arctocephalus* are markedly unlike. In the former it approaches the shape of a gun, with the stock at an acute angle to the barrel, in the latter it is like an old-fashioned scythe. The barrel of the gun and the handle of the scythe are the spinal origins. The stock of the gun is placed at the vertebral border of the scapula, and the butt rests upon the dorsi-epitrochlear muscle posteriorly, which is midway between the spine and posterior angle; the outer angle of the butt is between the infraspinatus and dorsi-epitrochlear muscles, and the infraspinatus only fills the upper half of the infraspinous fossa. In *Arctocephalus* the blade of the scythe goes along the vertebral border to the posterior angle, and is not much longer than the vertebral portion in the Phocinæ, because the spine is low down on the scapula. In *Otaria*, two layers are described on the left side, one on the right. In *Trichechus*, the first part is the same as in *Otaria*, but wants the slip to the supinator longus. In the Phocinæ it is supplied by the circumflex nerve, and by a twig from the suprascapular. In *Arctocephalus* by the circumflex.

As there are no clavicular and extremely few acromial fibres, there is no covering from the deltoid for the shoulder-joint anteriorly, and its action as an elevator of the fore-limb is *nil*. This want in the deltoid is atoned for by the fixation of some of the fibres of the anterior part of the trapezius to the deltoid and the humerus in the Phocinæ only. Lucae and Murie regard it as an external rotator, Murie adding also that it draws the humerus backwards. There must, however, be some slight elevating power through the anterior part of the trapezius.

The *Subscapularis* is a triangular muscle, and *arises* from the ventral surface of the scapula, with the exception of a small part near the neck, from the vertebral border to 1 inch posterior to the anterior angle; between which and that part of the vertebral border opposite the vertebral end of the spine, it lies to the outer side of the insertion of the serratus magnus; from here it follows the junction of the cartilaginous plate with the bone, taking origin from both along their line of junction to the posterior angle; and from the posterior angle for 1 inch along the axillary border. Anterior to the neck its fibres are united with those of the supraspinatus, and the origin from the posterior angle is tendinous. It converges and the under surface becomes fibrous ventral to the glenoid cavity, and the fibres from the posterior angle go almost transversely to the humerus. As the axillary border of the scapula is arched, the posterior half of the muscle does not lie upon the venter of the bone, but is next the teres major. It is *inserted* into the capsule of the shoulder-joint and into the lesser tuberosity of the humerus.

In *Arctocephalus* it *arises* from the concave surface of the venter of the scapula; from the cartilaginous rim close to its junction with the bone; from the posterior costa, with the exception of half an inch at the posterior angle, which gives origin to the teres major. On the surface next the bone there are three grooves corresponding to three ridges; from these latter there are no tendinous slips going into the substance of the muscle. The ventral surface has three deep furrows planted upon it; the first lies between the first and second ridges, the second between the second and third, and the third a little above the axillary border, whilst in its substance there are several tendinous slips. At the posterior angle the origin is tendinous, and this also gives origin to the teres major. The fibres converge towards the shoulder-joint; the anterior are in a line with the anterior border, and blend with the episubscapularis; the posterior, coming from the angle, are blended with the teres major; after leaving the angle they run parallel with its anterior border. Between the teres major and the scapula it lies upon the long head of the triceps. It is *inserted* into the venter of the capsule of the shoulder-joint, into the inner side of the lesser tuberosity, and into the humerus below the tuber for one-fourth of an inch, where it is behind the anterior insertion of the episubscapularis. In the Phocinæ it is supplied by three scapular nerves, along its upper border by a twig from the suprascapular, and below by another from the circumflex. In *Arctocephalus* it is supplied by the subscapular nerve and at the insertion by the circumflex. It rotates the limb inwards, but this powerful action is checked by the prominent lesser tuberosity coming against the glenoid.

The *Subscapulo-capsularis*[1] is a small muscular slip under cover of the subscapularis, and is found in the Phocinæ and not in *Arctocephalus*. It *arises* from the anterior part of the axillary border of the scapula near the glenoid, and from the ventral surface of the scapula, and it is *inserted* into the ventral aspect of the capsule of the joint, and into the humerus below the lesser tuberosity. In *Phoca barbata*, in addition, it takes origin from the dorsal surface of the axillary border.

No notice is taken by the authors frequently quoted of this small muscle in Seals. According to various anatomists it goes either into the capsular ligament or the humerus, but in the dissection of the Phocinæ it was seen going to both. It is supplied by the circumflex nerve.

The *Episubscapularis* is found in *Arctocephalus* and not in the Phocinæ. It is a cylindrical muscle overhanging the anterior border of the scapula, the subscapularis, and the supraspinatus muscles. It *arises* from the inner half of the arched anterior border of the scapula, by a tendinous band on the ventral side, and by muscular fibres on the dorsal edge, also by muscular fibres from the outer half of this border, from the anterior surface of the neck to the glenoid cavity; and where the neck is covered by the capsule from the anterior surface of it. It makes a bed for itself on the subjacent anterior portions of the supraspinatus and subscapularis, blending with both. In the substance of the muscle, about the middle of the anterior arched border, there is a flat strong tendon, and on both sides of this, throughout its whole extent, many of its fibres are attached. The tendon is *inserted* into the upper anterior surface of the lesser tuberosity of the humerus; and the fibres coming from the outer half of the arched border of the scapula which do not ascend to this internal tendon, go transversely outwards to the superior posterior of the lesser tuberosity, and into the superior surface of the capsule of the shoulder. At the insertion this tendon and these fibres are continuous, forming a hook over the lesser tuber; lastly, it is inserted by a flat bundle of fibres from the part which overlies the ventral anterior surface of the subscapularis, and after crossing its insertion goes into the small part of the lower inner side of the lesser tuberosity, below the insertion of the subscapularis, and into the inner border of the humerus above the teres major insertion. From Murie's accounts of the *Otaria* and *Trichechus*, I conclude that he inclines to the episubscapularis being a derivative from the supraspinatus and subscapularis, but from evidence gathered from the Phocinæ, I consider it as formed from the subscapularis. It is supplied by the suprascapular nerve. It tilts forwards and outwards the lower end of the humerus. It is principally for forcing the fore-limb forwards through the water, and is in place of clavicular deltoid fibres; it also turns the limb inwards, thus preparing it for the backward stroke.

The *Supraspinatus arises* from the supraspinous fossa to the outer side of the insertion of the levator anguli scapulæ, from the anterior border of the scapular spine, and from the capsule of the shoulder-joint. Anterior to the neck of the scapula it is fused with the subscapularis. At the vertebral side the muscle is a thin sheet, but anterior to the neck it is thick and fleshy. It is *inserted* into the outer surface of the lesser tuberosity, into the superior surface of the ligament stretching between the greater and lesser tubers, and into the upper end of the great tuberosity.

[1] Wenzel Gruber, *Abhandl. aus der menschl. und vergleich. Anat.*, 1854; also Macalister, Muscular Anomalies, Dublin, 1872.

In *Arctocephalus* it is a triangular muscle and *arises* from the supraspinous fossa, to within half an inch from the glenoid cavity. Overhanging it upon the anterior border is the episubscapularis, separated by a deep furrow. In considering this origin the configuration of the scapula must be grasped. The supraspinous fossa is divided into two by a well-marked ridge, or diminutive spine, anterior to which the suprascapular muscle is thick, whilst posterior it is thin; at the outer third of the ridge there is a trench between the fibres arising anterior and posterior to it, but no division in the fibres internal to this. From the ridge and the partial trench, it is seen that this muscle is a double one and consists of two parts, an anterior lying in front of the ridge, and a posterior behind it. The *anterior* part goes to the great tuberosity of the humerus, and is *inserted* into the capsule over the superior surface of the joint, into the pit on the anterior and upper surface of the upward prolongation of the great tuber, into its upper anterior half and into the posterior surface; a fasciculus crosses from the great tuber to the tip of the lesser tuber, and is *inserted* into the outer side of it, forming a narrow muscular bridge over the transverse ligament and the biceps; it joins the fibres of the pectoral below the great tuberosity. The *posterior* part lying posterior to the ridge and above the spine is *inserted* into the pit or impression on the outer side of the great tuberosity, above the pit for the infraspinatus, and into the capsule of the joint superiorly. In *Otaria* and *Trichechus* it has a single insertion.

Upon the great humeral tuberosity of the young *Arctocephalus* there are three depressions for tendons, comparable in this respect with the human great tuberosity. In the human subject these are for the supraspinatus, infraspinatus, and teres minor, but in the adult specimens the two lower are fused and the upper and lower extremities of this combined depression are deeply pitted, showing that the fibres going to either end act somewhat independently. As pointed out, the spines of the scapulæ in the Phocinæ and *Arctocephali* are in very different positions upon their respective bones. The accessory spine or ridge of bone in *Arctocephalus* bears the same relation to its scapula as the only spine in the Phocinæ. The origin of the posterior part of the supraspinatus in the former, disregarding the spines, is from the same site as the infraspinatus in the latter, and both are *inserted* into the same part of the major tuberosity. The actions of the posterior part are those of an infraspinatus, so it may be regarded as a transposed muscle; and the infraspinatus in *Arctocephalus* is functionally a large teres minor. If the infraspinatus were placed above the spine in the Phocinæ, and the spine changed to a lower latitude, then there would be almost the same arrangement of these muscles in both. In the Phocinæ it is supplied by the suprascapular nerve from the 6th cervical; in *Arctocephalus* by the suprascapular.

In the Phocinæ it carries the fore-limb forwards, and in *Arctocephalus* the anterior part raises the fore-limb with the episubscapularis and turns it slightly inwards. The posterior part with the insertion, like the human infraspinatus, is a feeble elevator of the limb, but a powerful rotator outwards, bringing the fore-limb backwards to the side.

The *Infraspinatus* lies beneath the deltoid and is similar to it in form. It *arises* from the posterior border of the spine of the scapula; from the scapula between the spine, and the origins of the triceps posteriorly, and the deltoid internally. It goes towards the shoulder; a little beyond the spine its fibres blend with the tendon of insertion of the supraspinatus. Over the dorsum of the neck of the scapula, it is between the supraspinatus and the teres minor. It is *inserted* into the outer side of the great tuberosity of the humerus; and into the capsule of the shoulder-joint, lower than the supraspinatus.

In *Arctocephalus* it is under cover of the deltoid, and is triangular in form. It *arises* from the dorsum of the scapula, anterior to the tendon of origin of the long head of the triceps, and the dorsi-epitrochlear muscles; from the posterior border of the scapular spine, beneath the origin of the deltoid; from the dorsal surface of the capsule surrounding the neck of the scapula. It crosses the dorsal surface of the shoulder-joint as a round tendon, is closely adherent to the capsule, and is *inserted* into a pit at the junction of the posterior border of the great tuberosity with the head of the humerus, below the pit for the posterior part of the supraspinatus. In *Otaria* it penetrates the capsular ligament, and strengthens it. In *Trichechus* it overlaps its large fossa. In the Phocinæ it is supplied by the suprascapular nerves from the 6th cervical. In *Arctocephalus* by the circumflex. In the Phocinæ and *Arctocephalus* it rotates the fore-limb backwards.

The *Teres minor* is a scanty muscular band which *arises* from a narrow line anterior to the long head of the triceps, and posterior to the infraspinatus. It is *inserted* into the capsule of the shoulder-joint; and into the anterior side of the great tuberosity of the humerus, below the infraspinatus. In *Arctocephalus* it is not found. In *Otaria* the fibres are lost upon the capsular head of the triceps, and in *Trichechus* it is rather indistinct, if present.

In *Arctocephalus* the infraspinatus has the same action as the teres minor in the Phocinæ, and I infer that the infraspinatus in *Arctocephalus* does the same work as the teres minor, and that the posterior part of the supraspinatus in the latter is functionally the same as the infraspinatus of the Phocinæ. In the Phocinæ it is supplied by the circumflex, and is a feeble rotator outwards.

The *Teres major* is a triangular muscle, lying on the posterior angle and dorsal surface of the scapula. The latissimus dorsi covers a portion of it. It *arises* from the scapula posterior to the origins of the dorsi-epitrochlear and the long head of the triceps, to one inch from the glenoid cavity; and from the dorsum of the cartilaginous plate. About the middle of the posterior surface it becomes muscular, and the lower margin of the tendinous surface of the inner half blends with the inner tendon of the latissimus dorsi. It is *inserted* into the inner border of the humerus below the subscapulo-capsularis for half an inch; and slightly into the great bicipital hollow.

In *Arctocephalus* it is rectangular and *arises* from the ventral surface at the posterior angle of the scapula, from the lower surface of the tendinous area which gives origin to the subscapularis anteriorly, from the posterior costa, and from the posterior angle by muscular fibres; a few fibres come from the posterior angle of the cartilaginous rim, and from the serratus magnus. The latissimus joins it along its posterior border; anteriorly it blends with the subscapularis outside of its origin for an inch. It is *inserted* into the middle third of the inner border of the shaft of the humerus, and slightly into the great bicipital groove, below the episubscapularis. In *Otaria* and *Trichechus* it is inserted from the middle of the shaft upwards to the internal condyloid ridge with the dorsi-epitrochlear and first head of the triceps.

With the assistance of the human scapula a better reading of those of the Phocinæ and the *Arctocephali* is obtained. In man there is an axillary border which has an adjacent surface on the dorsum of the bone, and this is cut off from the infraspinous fossa by a ridge running from the glenoid to the inferior angle. The adjacent surface is divided into two, the upper half for the teres minor, the lower for the teres major. This ridge is present in the Phocinæ and the *Arctocephali*, but is modified; in the former the glenoid third on the dorsum is well marked, over the remainder is faint, but on close examination can be seen and felt; and it ends at the vertebral border one inch anterior to the posterior angle. In the *Arctocephali* the ridge extends from the glenoid to the posterior angle, and is distinct; but the surface between it and the axillary border is limited. In the Phocinæ and *Arctocephali* the long head of the triceps and the dorsi-epitrochlear arise from the ridge; from the large surface in the Phocinæ posterior to the ridge only the teres major springs; as the corresponding surface for the same in *Arctocephalus* is limited, it has a linear origin one inch in length at the posterior angle. The insertion of the teres major is enormous, for it takes up about one-third of the length of the shaft. Professor Humphry and I do not find it going to the tuber major like Professor Lucae. The difference between *Arctocephalus* and *Otaria* is in the insertion, in the latter it goes to the internal condyloid ridge with the dorsi-epitrochlear and first head of the triceps. In the *Trichechus* it is similar to *Arctocephalus*. The mode of junction of the teres major and latissimus dorsi is interesting; over the posterior border of the teres tendon the inner part of the latissimus dorsi expands upon and is interwoven with the fascia over the dorsal surface of the teres, and the two thus associated go on to the humerus, the tendon of the latissimus lying next the bone. In the Phocinæ it is supplied by the subscapular, in *Arctocephalus* by the circumflex. In all the specimens it draws the humerus downwards, inwards, and backwards.

The Anterior Brachial Region in the Phocinæ and *Arctocephalus* is composed of the biceps and brachialis anticus. The coraco-brachialis is wanting.

The *Biceps* is a short muscular band lying on the internal surface of the humerus. It *arises* from within the capsule of the shoulder-joint by a strong short tendon from the rudimentary coracoid or beak above the glenoid cavity; and passes out of the capsule below the transverse ligament stretching from the greater to the two lesser tuberosities. It descends between the two tubers, and fills the bed of the wide bicipital groove; after dipping between the brachialis anticus and the pronator radii teres, it forms a tendon which is *inserted* into the radial tuberosity on the posterior border of the shaft. The external side becomes anterior at its attachment.

In *Arctocephalus*, besides the one tendinous head, it *arises* from the edge of the glenoid cavity on both sides of the beak, and is closely united with the under surface of the anterior part of the capsule above the head of the humerus. The tendon emerges from the capsule between the greater and lesser tuberosities, and passes below the tendon of the first part of the supraspinatus, and under the transverse ligament as in *Phoca*. It then continues down the humerus as a flat muscular band, partly tendinous on its under surface, filling the bed of the enormous bicipital groove. It dips between the pronator radii teres and the inner part of the brachialis anticus, to reach the bicipital tuberosity of the radius into which it is *inserted*. The external side is also anterior at the attachment into the radius.

The coracoid is separate in young Seals from the glenoid, and in them is found to form a considerable part of the glenoid cavity. If in the adult the coracoid were taken from the ovoid-shaped glenoid it would make a decided break in its shape. When the cartilage is attached to the glenoid it also covers a part of the coracoid. The glenoid and coracoid were inside the capsular ligament of the joint in the Seals dissected, and it is the coracoid that principally gives origin to the biceps.

In the Phocinæ it is supplied on the anterior lower surface by a small branch of the median nerve, and on the posterior surface by the external cutaneous. In *Arctocephalus* it is supplied by the musculo-cutaneous nerve. In all the specimens it flexes the forearm, and when the manus is in pronation it will turn it outwards.

The *Brachialis anticus* is situated on the outer surface of the humerus, and *arises* from its external surface behind the deltoid ridge, and by a bundle of fibres from the lower end of this ridge. It sweeps over the anterior border of the humerus; the posterior two-thirds of the muscle near its insertion goes between the humerus and the tendon of the biceps, and is *inserted* into the anterior border of the ulna below the coronoid process; the bundle of fibres from below the deltoid ridge ends by forming the anterior third of the belly of this muscle, and is finally *inserted* into the bicipital tuberosity of the radius, outside the tendon of the biceps.

In *Arctocephalus gazella* it is in two parts. The inner part *arises* from the deltoid ridge between its two lips, having the tendons of insertion of the pectoral and sterno-cleido-mastoid on the inner lip, and the cephalo-humeral and deltoid on the outer. It extends as high as the epiphysial line of the great tuber, and down to the junction of the outer lip with the inner. The outer part *arises* from the external surface of the humerus; and from the capsule of the shoulder-joint, which is behind the outer lip of the deltoid ridge, and in front of the external border of the shaft. The fibres of the inner part springing highest from the deltoid ridge of the humerus remain anterior to the insertion; the lowest are posterior. It is riband-shaped, with its anterior edge in the same plane as the anterior border of the radius; it passes between the biceps and the outer part to be *inserted* by a tendon which splits in two, behind the tendon of the biceps. The outer division of the tendon is attached to the capsule of the joint over the inner surface of the head of the radius, and into the tubercle of the radius on the outer side of the tendon of the biceps. The inner division of the tendon of the inner part goes behind the tendon of the biceps, and is *inserted* into the anterior border of the ulna below the lesser sigmoid cavity opposite the radial tuberosity. The outer part, with the exception of a small triangular portion at the upper end of the origin, is covered by the supinator longus; and the deltoid fills in this triangle. In front of the elbow-joint it crosses from the external surface of the humerus to the internal surface of the radius, and in doing this twists, so that the anterior fibres from the shaft are external and the posterior internal. It is *inserted* by muscular fibres into the inner surface of the capsule, over the head of the radius, higher up than the inner part; and by a tendon into the ulna outside the tendon of the inner part.

The few fibres taking origin from the lower end of the deltoid ridge in the Phocinæ, the anterior surface of it in *Arctocephalus*, and to its inner side in *Trichechus*, may be considered as the equivalent of the fibres from the surface internal to the deltoid ridge in man.

The deltoid impression of the human bone is only for the deltoid muscle. In the Seals it is an eminence, and acts like an additional surface, making compensation for the smallness of the humerus. In these animals it is a downward continuation of the great tuberosity, and is planted upon a thick vertical wall of bone in the Phocinæ and a thin translucent one in the *Arctocephali*. The inner edge of the surface in both is flush with the inner side of the vertical plate and has a straight edge; but on the outer side it overhangs the outer surface of the shaft, and has a slight projection near the middle of its surface in the Phocinæ, and in the *Arctocephali* a gradual expansion from the middle to its inferior extremity (Pl. VII. fig. 3). Roughly the eminence in the Phocinæ is rectangular, and in the *Arctocephali* triangular with the base downwards. The surface in the Phocinæ gives origin to a few fibres of the brachialis anticus and insertion for the supra- and infraspinati, teres minor, cephalo-humeral, atlanto-humeral, trapezius (anterior part), pectoral, and deltoid. This surface in *Arctocephali* gives origin to the brachialis (inner part), and insertion to the supraspinatus (anterior and posterior parts), infraspinatus, pectoral, cephalo-humeral, sterno-cleido-mastoid, and deltoid. These muscles for rotating the humerus have more leverage by being removed from the shaft by a vertical plate.

The brachialis anticus muscle in the Phocinæ is single, and divides into two for insertion into the radius and ulna. Lucae gives the division for the ulna as in combination with the biceps, but Humphry and I find it quite apart. In *Otaria* as in *Arctocephalus* it has two heads of origin, but in the former the outer head joins the inner head on the outer side of the elbow, whereas in *Arctocephalus* the head from the surface of the deltoid eminence divides into two, one going to each bone of the forearm, and the outer has also two divisions for both bones. In the Phocinæ it is supplied by the musculo-cutaneous and musculo-spiral. In *Arctocephalus* it is supplied by the musculo-cutaneous. It is a flexor of the forearm on the upper, and, like the biceps, will rotate the forearm outwards when the manus is prone.

The Posterior Brachial Region in the Phocinæ and *Arctocephali* consists of the *triceps*, which has four heads—(*a*) the *dorsi-epitrochlear*, (*b*) the *long head*, (*c*) *external head*, and (*d*) *internal head*. There is no subanconeus.

The *Triceps*, first head, or the *dorsi-epitrochlear*,[1] is a thin muscle partially covered by the deltoid, and *arises* from the dorsum of the scapula by a broad sheet-like tendon, extending from the vertebral border of the cartilaginous plate to a spot posterior to and in a line with the middle of the scapular spine. This tendon is continuous with the tendon of origin of the long head of the triceps, and it is placed between the origin of the infraspinatus anteriorly and the teres major posteriorly. Above the olecranon of the ulna it collects into a small muscular band, which runs over the border of the olecranon, near its junction with the posterior border on the internal surface of the ulna. After receiving a few fibres from the long head it is *inserted*, or rather moored by its lower edge, to the junction of the olecranon with the posterior border of the ulna, and to one inch of the posterior border below this junction. The band passes to the flexor minimi digiti, blends with it, and terminates at the junction of the middle and upper third of this muscle. In *Phoca barbata* the *insertion* overlapped both sides of the olecranon.

In *Arctocephalus gazella* it is of a triangular shape, and *arises* from the dorsal rim of the inferior costa of the scapula, by a sheet-like tendon which is one inch long, and extends transversely from the posterior angle to the middle of the dorsal rim of the posterior costa of the scapula. It is placed between the infraspinatus anteriorly, and the teres major and subscapularis posteriorly. It becomes cylindrical over the olecranon, slightly overrides both sides of it, and there receives a few fibres from the external head on its outer side, and is *inserted* into the olecranon from the middle tubercle to the posterior, and into the posterior and outer upper third of the flexor carpi ulnaris.

The difference in this muscle in *Phoca vitulina* and *Arctocephalus* according to my dissections is well marked. In the former the origin is far removed from the axillary border by the extensive surface for the origin of the teres major, which in the latter is adjacent to this border. The insertion in *Phoca* blends with the flexor minimi digiti, and in *Arctocephalus* with the flexor carpi ulnaris.

The statement by Professor Humphry that the muscle reaches the paddle finds no support from Lucae, and in none of the specimens did I see this; perhaps the flexor minimi digiti was included with it in his description. Lucae gives its insertion into the fascia of the front arm, &c.,

[1] This is Humphry's first division; Lucae (*op. cit.*, pl. ix. fig. 1) calls it the "triceps pars longa," and in his text "portio longa tricipitis."

but I made it out as blending with the flexor minimi digiti. In *Otaria* it *arises* from the inferior angle, but in *Arctocephalus* from the axillary border; the fibres in the former run to the forearm, but in the latter they blend with the flexor carpi ulnaris. *Trichechus* agrees with *Arctocephalus* in the origin, but the insertion differs, for it ends in the antebrachial fascia of the forearm, and is inserted into the olecranon by fascia only.

The second, or *long head* of the triceps,[1] is a triangular muscle, and *arises* between the origin of the teres minor anteriorly and the teres major posteriorly. The extent of its origin is from a spot immediately posterior to and in a line with the middle of the scapular spine to the glenoid cavity; the portion arising from the scapula is thin and chiefly tendinous; the remainder which *arises* from the neck is muscular, and covers the under surface of the neck as well as the lower half of the back. It also has origin from the capsule surrounding the neck. The lower half of this muscle lying next the external head is tendinous; it lies upon the internal and external heads, and is *inserted* into the olecranon below the middle head, into both of its sides and into the tendinous surface on the posterior of the external head.

In *Arctocephalus gazella* it is also triangular, and *arises* from the outer half of the dorsal rim of the posterior costa of the scapula, between the fibres of the subscapularis, which springs from the posterior costa, and posterior to the infraspinatus, which overlaps it. It stretches transversely from above the middle of the posterior costa to the under surface of the capsule of the shoulder-joint, from which it also has origin. The ventral surface is tendinous for the play of the teres major, while the dorsal is only tendinous near the olecranon above its insertion. As in *Phoca* it lies on the external and internal heads, when viewed from the inner aspect of the limb; and it is *inserted* into the anterior internal half of the border of the olecranon on the inner surface, which is opposite the anterior and middle tubercles of the outer surface; some of the fibres run amongst those of the internal head over the quadrilateral surface of the olecranon on the internal side, and it is tendinous on the outer surface near the olecranon. In *Otaria* and *Trichechus* it joins the common cubital insertion of the triceps.

The *third* or *external head*[2] *arises* from the capsule surrounding the head of the humerus, which is continuous with the posterior surface of this bone, and from the same position on the outer surface to midway between the anterior and outer borders, from the hollow between the head and the shaft, and very slightly from the humerus below this. It overlies the internal head, and is closely connected to the tendinous lower half of the long head which covers it: it then joins the anterior tendinous side of the long head, and is *inserted* by a small fasciculus into the outer side of the tip of the olecranon between the internal heads.

In *Arctocephalus gazella* it *arises* from the capsule of the shoulder-joint at the lower posterior surface of the glenoid cavity; from the capsule between this and the neck of the humerus; from the neck to the middle of the outer surface; from the capsule above the neck, and also from the external border of the shaft in its upper half. It has an opening, near its origin from the capsule on the external border, for the circumflex vessels. It divides above the olecranon into two parts; the inner is *inserted* into the tendinous portion of the long head above the olecranon and into the inner side of the olecranon, opposite to the anterior and middle tubercles to the outer side of the long head, and a slip from it joins the dorsi-epitrochlear; the outer is *inserted* into the superior

[1] This is Humphry's second division; Lucae's middle head; Murie's first division.
[2] This is Humphry's third division; Murie's (*Trichechus* and *Otaria*) second division.

surface of the olecranon between the inner and outer borders, as far back as the middle tubercle (Pl. VII. fig. 4, in *Arctocephalus australis*); some fibres blend with the other head over the olecranon.

The second division is nearly alike in *Otaria* and *Trichechus*, and its origin differs from that in *Arctocephalus*, for in the former two it *arises* from the back of the humerus, whereas in the latter it only comes from the external border.

The *fourth* or *internal head*[1] lies on the back of the humerus under cover of the external head. It *arises* from the posterior surface of the shaft of the humerus beneath the origin of the middle head, and from the posterior ligament of the elbow-joint. It is of a triangular form, but the base is next the elbow-joint, and the apex below the inner side of the head of the bone. It is *inserted* into the posterior ligament of the elbow-joint; into the sides and tip of the olecranon; and into the quadrilateral surface behind the sigmoid cavity.

In *Arctocephalus gazella* it *arises* from the posterior surface of the shaft of the humerus, from the capsule of the shoulder-joint, from the ligament as in *Phoca*, and is *inserted* into the quadrilateral surface behind the sigmoid cavity of the ulna. In *Otaria* and *Trichechus* its disposition is almost the same. It is the extensor of the forearm.

In *Arctocephalus* the musculo-spiral supplies the dorsi-epitrochlear, long, internal, and external heads, the latter also has a twig from the circumflex nerve.

The Flexor or Inner Surface.—In the Phocinæ the following are the muscles—anconeus internus, palmaris longus, flexor communis digitorum, flexor carpi radialis, pronator radii teres, flexor carpi ulnaris, abductor minimi digiti longus.

In *Arctocephalus*, instead of one palmar muscle there are three, and the abductor minimi digiti is not found. Neither in the Phocinæ nor *Arctocephalus* is there a pronator quadratus.

The *Anconeus internus*, called supinator quadratus by Lucae, is nearly double the size of the anconeus externus. It *arises* from the back of the internal condyle below the supracondyloid foramen, and is *inserted* into the inner side of the olecranon below the long head of the triceps.

In *Arctocephalus gazella* it *arises*, as in *Phoca*, from the posterior part of the internal condyle above the palmaris longus, and behind the pronator radii teres. It crosses from the internal condyle to the inner lip of the olecranon, and is *inserted* into it opposite the anterior and middle tubercles of the outer surface. The long head of the triceps and the deep palmar have a bed for it in their substance. It is present in *Otaria* and *Trichechus*. It is a short extensor of the elbow-joint, and also steadies it. It is supplied by the ulnar nerve.

The *Palmaris longus* in the Phocinæ is in two parts:—*a*. The first part *arises* from the posterior half of the hollow on the internal surface of the ulna, where the olecranon and the posterior border of this bone meet. It is situated at the origin below the anconeus internus, and higher up the shaft than the flexor carpi ulnaris. At the junction of the upper and middle thirds of the ulna it divides into two slips, one being anterior, the other posterior. The latter soon splits into two fine tendons, which are *inserted* into the deep fascia over the wrist. The anterior slip is also tendinous, and disappears beneath the palmar fascia; upon the under surface of this it widens and emerges on the opposite side as two fascial slips, which descend to the heads of the 2nd and 3rd metacarpal bones. Here they are attached to the sheaths of the corresponding tendons, and also to the tendons of the flexor sublimis for the 2nd and 3rd digits. It is with difficulty

[1] This is Humphry's fourth division; also Lucae's, and in his plate is the anconeus quartus.

removed from the palmar fascia, to which it is closely adherent. In *Phoca barbata* the origin was partly destroyed, but the fragment appeared the same; the insertion is similar. *b.* The second part is a narrow tendinous slip, and *arises* from the internal condyle between the flexor carpi radialis and the flexor communis digitorum (first head), and is *inserted* into the deep fascia over the ulnar side of the wrist.

Humphry does not separate this muscle into its divisions, but our descriptions are very much the same. Lucae's insertion is not anything like what Professor Humphry and I make it to be.

In *Arctocephalus* there are three palmar muscles—the Palmaris longus, superficialis, and profundus.

a. The *Palmaris longus*, the palmaris longus primus of Murie, has a fascial and a bony origin. It *arises* from the internal surface of the internal condyle by a tendinous slip, also by a muscular slip which is blended for a short distance with the flexor carpi radialis, and from the convex side of a fascial band for 1 inch, and blends with the superficial palmar for half an inch on the inner side. This slender muscle ends in a fine tendon at the junction of the upper third with the lower two-thirds of the radius, and at the lower end of the radius the tendon dips beneath the broad tendon of the deep palmar, upon the under surface of which it expands on both sides, forming a triangle with the apex as the continuation of the tendon; over the base of the 1st metacarpal it is moored to the under surface of the tendon of the deep palmar muscle, and ends over the 1st metacarpal.

b. The *Palmaris superficialis*, the palmaris longus secundus of Murie, is a slender broad layer of muscular fibres lying upon the deep palmar. It *arises* from the convex side of a fascial band, with the exception of that portion on its anterior side which gives origin to the palmaris longus. This band stretches from the internal condyle over the deep palmar to which it is closely bound, and ends upon the anterior edge of the dorsi-epitrochlear. Below the band on the posterior side its fibres are blended with the dorsi-epitrochlear for half an inch, and on the anterior with the palmaris longus for the same distance. It crosses the deep palmar muscle; and is *inserted* into the skin opposite the ulnar border of the base of the 5th metacarpal; the bulk of the tendon lies along the ulnar border of the 5th metacarpal, and is attached to the head of this bone, and to the ulnar side of the whole of the 1st phalanx.

c. The *Palmaris profundus* is the palmaris longus tertius of Murie, and has an extensive origin. It *arises* from the internal surface of the olecranon; from the inner edge of the quadrilateral surface behind the sigmoid cavity; from the capsule of the elbow-joint; from the internal concave surface of the ulna in its upper half, posterior to the ridge running down the shaft from the sigmoid cavity; and from the upper half of the posterior border of the ulna by an aponeurosis. At the level of the junction of the olecranon and the posterior border of the ulna on the surface of the muscle is a slender aponeurosis which covers its whole breadth, and as it descends upon the muscle towards the lower end of the shaft it becomes thick and strong. The muscle-fibres terminate abruptly on its posterior surface, parallel with the posterior border of the lower half of the ulna. This tendon is also common to the flexor carpi ulnaris. By its posterior border below, it is attached to the pisiform bone, and to the anterior border of the flexor carpi ulnaris; it gives a tendinous slip to the radial side of the base of the 5th metacarpal, and another strong broad one to the base of the 1st phalanx of the 5th digit; from the tendon to the 1st phalanx a slip joins the transverse ligament, *i.e.*, the metacarpo-phalangeal; the rest of the broad tendon crosses the wrist obliquely from the ulnar side of the forearm to the radial side of the carpus, and descends as an aponeurotic band of very considerable strength, covering the palmar aspect of the whole of the 1st metacarpal bone, and the radial halves of the 1st and 2nd phalanges of the pollex to the phalangeal cartilage. It passes over the tendons of the thumb, and is *inserted* into the radial side of the carpus, the 1st metacarpal, and the 1st and 2nd phalanges of the pollex; into the skin over the radial side of the 2nd phalanx of the pollex; into the phalangeal cartilage attached to the distal end of the 2nd phalanx of this digit, and it is firmly fixed to the cartilaginous bar, running from the elbow down the radial border of the radius, on the anterior side of the manus to the phalangeal distal cartilage of the 1st digit. Over the middle of the radial side of the 1st metacarpal, the deep palmar tendon gives a strong slip which goes down to the head of the metacarpal and the base of the 1st phalanx.

The insertion of the longus primus in *Otaria* and the palmaris longus in *Arctocephalus* are alike, so is the insertion of the longus secundus in the former, and the palmaris superficialis in the latter, only the tendon of the superficialis goes down to the 1st phalanx of the 5th digit instead of stopping at the distal end of the 5th metacarpal. The longus tertius in *Otaria* and the palmaris profundus in *Arctocephalus* are not so close; the latter is much more complicated, its origin being more extensive and the insertion being very different. In *Otaria* it ends along the radial side of the 1st digit. All are supplied by the median and ulnar nerves.

The *Flexor communis digitorum* is a combination representing and built up from—(*a*) the flexor sublimis digitorum; (*b*) the flexor profundus digitorum; (*c*) the flexor longus pollicis.

It *arises* by three heads. *a*. The 1st head[1] may be regarded as the *flexor sublimis digitorum*, for it *arises* from the internal condyle below the palmaris longus (part two), and from the internal lateral ligament. *b*. The 2nd head[2] resembles the *flexor profundus digitorum*, for it *arises* from the inner surface of the ulna posterior to the internal lateral liagment down to 1 inch from the wrist. *c*. The 3rd head[3] corresponds to the *flexor longus pollicis* as it *arises* from the posterior half of the middle third of the radius below the pronator radii teres, and from the interosseous membrane. The first and third heads are conjoined at the lower third of the forearm, and form one belly; the second head forms another, and these two bellies unite at the wrist, and thus a broad tendon of considerable strength is formed, which immediately divides into an anterior and posterior set of tendons; in the anterior set there are three slender ones, in the posterior five stronger. The *anterior* set is superficial and disposed like the flexor sublimis digitorum; the *posterior* is deep, and the first or outermost tendon, like the flexor longus pollicis, goes to the pollex, the remaining four are distributed like the flexor profundus digitorum. Of the superficial set, or flexor sublimis digitorum, the three tendons descend upon the surfaces of the deep tendons for the 2nd, 3rd, and 4th digits, opposite the middle of the metacarpal bones; they enter the sheaths, and over the bases of the 1st phalanges divide to give passage to the deep tendons, and then are attached to the sides and heads of the 1st phalanges of the 2nd, 3rd, and 4th digits. Of the deep set (five), the first tendon or flexor longus pollicis runs along the inner side of the pollex, inside the sheath, and is attached to the head of the last phalanx. From this tendon a smaller one springs, and unites with the sheath of the pollex at the head of the 1st metacarpal bone; it may be regarded as the only lumbrical. The remaining four tendons or flexor profundus digitorum

[1] Humphry's flexor sublimis digitorum = Lucae's flexor communis digitorum (strongest head).
[2] Humphry's flexor profundus digitorum = Lucae's flexor communis digitorum (second head).
[3] Humphry's flexor profundus digitorum = Lucae's flexor communis digitorum (third head).

go to the heads of the terminal phalanges of the four fingers; over the base of the 1st phalanges they run through the slits in the superficial tendons. Humphry gives the flexor sublimis digitorum as a distinct muscle with three tendons, but Lucae and I find that the three heads unite to form a common mass, and out of this superficially the sublime tendons come, but cannot be dissected out of this mass from their insertions to their origin.

In *Arctocephalus* it is also formed by three muscles—(*a*) the *Flexor sublimis digitorum*, (*b*) the *Flexor profundus digitorum*, and (*c*) the *Flexor longus pollicis*. The 1*st head* or *Flexor sublimis digitorum* is a short band, which *arises* from the internal condyle of the humerus, and from the internal lateral ligament. It is *inserted* into the anterior half of the flexor profundus digitorum, about the middle of the shaft of the ulna. It is tendinous on its surface. *b*. The 2*nd head* or *Flexor profundus digitorum* is covered by the sublimis in its upper half. It *arises* from the internal surface of the upper third of the ulna, anterior to the ridge, from the whole breadth of the ulna as far as the lower third of this bone, and from the internal lateral ligament which is continuous from the joint down the shaft. It terminates in a strong tendon which widens over the carpus. *c*. The 3*rd head* or *Flexor longus pollicis arises* from the whole of the inner surface of the shaft of the radius to its lower third, from the capsule of the joint, from the interosseous membrane, and from the anterior border of the ulna in its upper two-thirds. It descends over the carpus as a strong tendon, and joins the flexor profundus digitorum. The single tendon thus formed soon divides into five slips, the 2nd, 3rd, and 4th being double tendons which are anterior and posterior. The 1st or radial tendon divides into two slips. The outer runs down the middle of the 1st metacarpal bone and the 1st and 2nd phalanges, and is *inserted* into the head of the 2nd phalanx of the pollex. The inner descends along the ulnar side of the 1st metacarpal, and is *inserted* into the ulnar side of the base of the 1st phalanx of the pollex. These two pollical tendons come chiefly from the muscle, having origin similar to the flexor longus pollicis. The 2nd, 3rd, and 4th tendons, after splitting into anterior and posterior slips, descend over the middle of their metacarpal bones, and over the proximal ends of the 1st phalanges the superficial slips are split opposite the metacarpo-phalangeal articulations for the deep tendons; and descend to the bases of the 2nd phalanges, into which they are *inserted*. They almost cover the 1st phalanges on their inner surfaces, and are adherent to them. The 2nd, 3rd, and 4th deep tendons pass through the openings in the superficial tendons, and then become anterior to the short flexors, and are *inserted* into the heads of the terminal phalanges for the 2nd, 3rd, and 4th digits. The 5th tendon is single and is *inserted* into the head of the terminal phalanx of the 5th digit. The deep tendons terminate by dividing into three slips, a central strong and two lateral fine ones; the central slip terminates upon the terminal phalanx, the lateral pass from the sides of the central and end on the sides of the same phalanx. The lumbricals are absent in *Arctocephalus*.

In *Trichechus* the origin of the flexor sublimis digitorum is the same as in *Arctocephalus*, and it joins the head of the flexor profundus digitorum. The flexor profundus digitorum and the flexor longus pollicis are nearly alike, except that in *Arctocephalus* the flexor longus pollicis has an additional origin from the ulna. As in *Arctocephalus*, the flexor digitorum and flexor longus pollicis combine in the palm for the flexor tendons. From an examination of fig. 4 (Murie) picturing the inner aspect of the fore-limb, I find that the distribution of the tendons might be said to correspond. In Murie's paper there is a perforating tendon to the 5th digit, not represented in the plate. As in the Phocinæ only, it has a lumbrical muscle to the pollex.

In *Otaria* the deep and superficial flexors are very different from those of all the other species, since they do not unite in the palm. The flexor sublimis digitorum has two heads which join, and it divides into double slips for the 2nd, 3rd, and 4th digits, and a single for the 5th. The flexor profundus digitorum comes from the ulna and radius and divides into two tendons for the pollex, forming its short and long flexors, two short and long flexors for the index, and a single one for the 3rd digit ending like a short flexor. From this short account it is obvious that the names flexor sublimis digitorum and flexor profundus digitorum do not bring out the functions of these tendons, because both act as short and deep flexors. In the Phocinæ it is supplied by the median and ulnar nerves, in *Arctocephalus* by the median. It has the usual actions.

The *Palmar fascia* in the Phocinæ is a quadrangular piece of fascia attached on its outer border to the outer border of the lower end of the radius, and to the scapholunar bone. It extends to the posterior border of the radius, where the superior angle of this side gives attachment on the under surface to the anterior slip of part one of the palmaris longus.

The *Flexor carpi radialis arises* from the internal condyle between the pronator teres and the first head of the flexor communis digitorum. It passes over the carpus, and then the tendon divides into three. The outermost or anterior is *inserted* into the ulnar side of the base of the 1st metacarpal bone; the middle into the ulnar side of the base of the 2nd metacarpal bone; and the innermost or posterior into the base of the radial side of the 3rd metacarpal.

In *Arctocephalus* it *arises* as in the Phocinæ, but is placed between the origins of the pronator radii teres and palmaris longus; it is connected with the former for about half an inch. It is cylindrical; about the middle of the forearm it ends in a long, slender tendon which divides into three very short slips. These are *inserted* into the ligament between the trapezium and trapezoid bones; into the ulnar side of the proximal end of the 1st metacarpal, beneath the first flexor brevis muscle; and into the radial side of the proximal end of the 2nd metacarpal.

In *Arctocephalus* the *origin* differs slightly from that in the Phocinæ in its relations,and the *insertion* of the 1st tendon in the former is beneath the flexor brevis into the radial side of the 2nd metacarpal instead of the ulnar side. The 3rd tendon ends over the ligament between the scaphoid and the trapezoid bones, and is not long enough to reach the radial side of the 3rd metacarpal as in the Phocinæ.

The origins in *Otaria* and *Trichechus* are the same as in *Arctocephalus;* the insertion in *Otaria* is single, being only to the 1st metacarpal. In all, the insertion into the 1st metacarpal is constant, and is the largest and strongest when more than one tendon is present. This gives increased steadiness to the wrist-joint in flexion, which is necessary, because the pollex is not opposable but bound up with the other digits by the integument, and is finger-like in actions. In all the specimens it is supplied by the median nerve. It has the usual actions.

The *Pronator radii teres arises* from the internal condyle of the humerus, below the supracondyloid foramen, and is *inserted* into the inner surface of the radius, 1 inch from the lower extremity of the shaft, by a quadrilateral bundle of fibres; and into a very small extent of the inner side of the anterior border, above the supinator longus.

In *Arctocephalus* it *arises* from the condyle as in the Phocinæ, but is partly covered by the flexor carpi radialis, and is united with it for half an inch; and from the internal lateral ligament. It descends as a flat muscle along the internal surface of the radius; and is *inserted* into the anterior border of the middle of the shaft for about one inch. In *Otaria* and *Trichechus* it has a slightly different arrangement from that seen in *Arctocephalus.*

It receives no fibres from the inner side of the coronoid process, for the upper end of the internal condyle is at a greater distance from the coronoid and of greater length than in the human subject. The bones of the forearm being naturally placed midway between pronation and supination, a rotation of a quarter of a circle makes the hand prone. The mode of insertion in the Phocinæ and *Arctocephalus* is very different; in the latter it is as is in human anatomy, but in the former it is almost circular, and extends halfway across the inner surface of the radius near the lower extremity. This strengthens the statement as to the absence of a pronator quadratus, for the surface where it should be is partially occupied by the insertion of this muscle. In all the specimens it is supplied by the median nerve, and has the usual action.

The *Pronator quadratus.*—No evidence was got of its presence in the Phocinæ and *Arctocephalus*, although Humphry states that he found it but small, and Lucae inconsiderable. There is none in the *Otaria*, but in the Walrus it is fairly developed. If I had only dissected young specimens I should be sceptical as to its absence in the Phocinæ, but in an adult Seal no fibres were seen where the above writers have described it. The dissection in this specimen was done by turning aside the structures without removing any tissue.

The *Flexor carpi ulnaris arises* from the inner surface of the ulna where the posterior border joins the olecranon, and from the posterior border of the bone in its upper three-fourths, and is *inserted* into the pisiform bone, from which the tendon passes on expanding and attaching itself to the bases of the 3rd, 4th, and 5th metacarpal bones by joining the deep fascia adherent to them.

In *Arctocephalus* it *arises* from the inner side of the 3rd or posterior tubercle of the olecranon, to the slightest extent from the commencement of the posterior border of the ulna below the tubercle, and from the remainder of the upper half of the posterior border by an aponeurosis common to it and the deep palmar muscle. It lies posterior to the deep palmar, with which it is united so closely that no division is seen in the bellies of the combined muscles. It is covered anteriorly by the tendon common to the deep palmar, and posteriorly by the aponeurosis of origin from the posterior border of the ulna. About an inch from the lower end of the ulna it forms a strong tendon, which is *inserted* into the pisiform bone as in the Phocinæ, and into the strong fascia over the base of the 5th metacarpal. In *Otaria* and *Trichechus* it is very like the corresponding muscle in *Arctocephalus.*

All are agreed as to the pisiform being the chief point of insertion, but there are variations in the ending of the tendon. From human anatomy we learn that there is close relationship between the annular ligament and the flexor carpi ulnaris, and that the tendon terminates at the base of the 5th metacarpal, and this is nearly the arrangement I found in the Earless Seals; in the Eared forms I am not certain of the connection with the annular ligament. As the outer three digits in the Phocinæ give insertion to the flexor carpi radialis, and the bases of the three inner have this muscle fixed to them, the whole series of metacarpal bases have each a flexor of the forearm acting upon them. Owing to the posterior border of the ulna being arched with the concavity on the same side, and this muscle passing in a direct line from the two extremities, the manus and bones of the forearm form two sides of a triangle, with the pisiform as the apex. Hence this muscle must draw the hand to the inner side, and also turn it a little to the outer side, as well as flex the manus. In all specimens it is supplied by the ulnar nerve. It has the customary actions, and is in addition a powerful supinator of the manus.

The *Abductor minimi digiti longus.*—Humphry names it flexor minimi digiti; Lucae, abductor digiti V. It is not present in *Otaria* and *Trichechus*. It *arises* from the inner surface of the ulna where the olecranon and the posterior border meet, and passes down the posterior border of the ulna on the flexor carpi ulnaris; at the wrist it divides into two tendons—one is *inserted* into the skin over the palmar surface of the 5th metacarpal bone, the other is bound to the sheath and the deep fascia along the ulnar side of the 5th metacarpal, and ends opposite the ulnar side of the head of the 1st phalanx into which it is *inserted*. It is both an abductor and flexor of the manus, the flexing action commencing after the abduction is complete. It is supplied by the ulnar nerve.

The Manus.—The inner or palmar region consists of three groups of muscles. The First Group is composed of two adductors, found only in *Arctocephalus*:—

The *Adductor of the 2nd digit*, named superficial interosseous in *Otaria* and *Trichechus*, *arises* from the base of the 3rd metacarpal between the two heads of the flexor brevis of the same digit. It is *inserted* into the proximal extremity of the ulnar side of the 1st phalanx of the 2nd digit, and is superficial to the flexores breves which it crosses.

The *Adductor minimi digiti* is the adductor minimi digiti in *Otaria* and is absent in *Trichechus*. It *arises* from the middle of the ulnar side of the 4th metacarpal and from the deep fascia between the 4th and 5th metacarpals; after passing downwards and backwards it is *inserted* into the outer half of the shaft and head of the 5th metacarpal and base of the 1st phalanx.

The Second Group contains the *flexores breves*, which are the deep interossei in *Otaria* and *Trichechus*. In the Phocinæ the first *arises* from the ulnar side of the metacarpal of the pollex; and is *inserted* into the ulnar side of the 1st phalanx of the 1st digit. In *Arctocephalus* it is disposed as in the Phocinæ. The 2nd interrosseus in the Phocinæ is double and *arises* from the radial and ulnar sides of the 2nd metacarpal. The radial head is *inserted* into the radial side of the base of the 1st phalanx of the 2nd digit; the ulnar head into the ulnar side of the same digit. It has the same relations in *Arctocephalus*. The 3rd and 4th muscles in the Phocinæ and *Arctocephalus* resemble the last named. The 5th in the Phocinæ is single and *arises* from the radial side of the 5th digit, and is *inserted* into the same side of the base of the 1st phalanx of the same digit. In *Arctocephalus* I did not observe any muscle for the 5th digit. In *Otaria* these muscles are in pairs for all the digits but the 1st, which has only one. In *Trichechus* the 1st and 5th digits have only one each, the other digits two.

The Third Group embraces the following:—

The *Abductor brevis pollicis* is the M. flexor pollicis of Lucae, and is wanting in *Otaria* and *Trichechus*. In the Phocinæ it *arises* from the lower side of the process on the outer side of the scapholunar bone, and from the lower border of this bone to the outer side of the tendon of the flexor carpi radialis; and is *inserted* into the front of the radial side of the base of the 1st phalanx of the thumb. There is a sesamoid bone beneath its tendon.

In *Arctocephalus* it *arises* from the trapezium, from the upper and internal half of the 1st metacarpal, from the radial side of the base of the 2nd metacarpal, and from the carpo-metacarpal ligament. The greater portion is *inserted* into the ulnar side of the distal end of the 1st metacarpal, and the remainder into the distal extremity of the radial side of the 2nd metacarpal. Humphry does not mention this muscle, but Lucae describes it.

The *Abductor minimi digiti* is the flexor brevis minimi digiti in *Otaria* and is absent in *Trichechus*; in the Phocinæ it *arises* from the pisiform bone, and from the tendon of the flexor carpi ulnaris; and is *inserted* into the inner side of the base of the 1st phalanx. In *Arctocephalus* it *arises* from the tendon of the flexor carpi ulnaris, from the pisiform bone, and from the tendon of the palmaris profundus. It is well formed and is *inserted* into the ulnar side of the head of the 5th metacarpal; and into the same side of the entire length of the 1st phalanx. Lucae names it the M. flexor brevis digiti V. In *Otaria* Murie designates it the flexor brevis minimi digiti, and in describing *Trichechus* says "there is no trace whatever of the flexor brevis minimi digiti so well developed in *Otaria*, *Phoca fœtida*, and *Phoca vitulina*." The origin and insertion coincide with those of the corresponding human muscle, and the function is the same, being chiefly an abductor and a flexor. The human muscle sometimes has accessory heads from the flexor carpi ulnaris and the palmaris longus, and since a part of the origin in the Phocinæ is from the former, and in *Arctocephalus* from the palmaris profundus and the flexor carpi ulnaris, there is much to support the name abductor.

In *Trichechus* there is an opponens pollicis, and also a palmaris brevis.

The Outer or Extensor Surface of the Forearm.—In *Phoca vitulina*, *Phoca barbata*, and *Phoca hispida* the following muscles lie in this region:—Anconeus externus, supinator longus, extensor carpi radialis, extensor communis digitorum, tensor fasciæ, extensor carpi ulnaris, supinator brevis, extensor ossis metacarpi pollicis, extensor primi internodii pollicis.

In *Arctocephalus*, besides the above muscles, there is an extensor proprius pollicis, and out of the extensor communis is formed the extensor minimi digiti. The tensor fasciæ is absent. All the specimens want the dorsal interossei and the pronator quadratus.

The *Anconeus externus* is a narrow slip and *arises* from the back of the external condyle of the humerus, a little above the condyle; it is *inserted* into the outer side of the tip of the olecranon beside the inner head of the triceps, and into the upper half of the outer side of the quadrilateral surface behind the sigmoid cavity.

In *Arctocephalus* it *arises* from the posterior part of the supracondyloid ridge, and also, as in the Phocinæ, from the back of the external condyle; and is *inserted* into the olecranon on the external lip, between the 1st and 2nd tubercles. In *Arctocephalus* it did not run into the triceps so intimately as in the Phocinæ. It is an extensor and lateral supporter of the elbow-joint. It is supplied by the musculo-spiral nerve.

The *Supinator longus* is the most anterior of the extensors. It *arises* from the upper two-thirds of the external border of the humerus, above the musculo-spiral groove on the outer border. Below the head of the humerus it is covered by the external head of the triceps. After it crosses over the external surface of the shaft of the humerus, it lies along the anterior border of the radius, and is *inserted* into its anterior border, half an inch from the wrist, above the groove for the muscle of the pollex.

In *Arctocephalus* it *arises* from the external border as in *Phoca*, above, where the musculo-spiral nerve turns round the supracondyloid ridge, lying to the outer side of the extensor carpi radialis, from the neck of the humerus, and from the capsule of the shoulder-joint beneath the external head of the triceps. The extent of origin from the neck is from the external border to the outer border of the greater tuberosity. The fibres descend between the outer head (part one) of the brachialis anticus, and the extensor carpi radialis along the anterior border of the radius. At the middle of the anterior border it forms a round tendon, which is *inserted* into the external surface of the radius, to the outer side of the extensors of the pollex, at the junction of the epiphysis with the shaft. In *Trichechus* it is single, and *arises* from the deltoid ridge and shaft of the humerus. In *Otaria* it is double headed; the external head comes from the upper end of the external condyloid ridge and the internal from the deltoid ridge and joins the external head.

Vrolik, under Section 23, describes the *Extensor ossis metacarpi pollicis* as the supinator longus. Humphry describes it as inserted into the projecting margin of the radius and Lucae the same; Dr. Murie in *Otaria* into the outer side of the styloid process, and in *Trichechus* to the styloid process. It appears to me that these authors have not sufficiently defined the exact place of attachment to the radius. In the Phocinæ and *Arctocephalus* there is only one groove for the tendons to the thumb. In the former it is placed obliquely downwards and inwards across the anterior border of the radius; in the latter it runs down on the outer side of the anterior border; one-quarter of the groove in both is on the epiphysis. In the Phocinæ the supinator is inserted into the anterior border of the radius above the groove, and the same in *Arctocephalus*. It flexes the forearm, and supinates it when prone. It is supplied by the musculo-spiral nerve.

The *Extensor carpi radialis arises* from the external supracondyloid ridge, lies to the outer side of the supinator longus, and passes along the anterior border of the radius; above the wrist it passes below the tendon of the extensor ossis metacarpi pollicis, and then through the second division of the annular ligament; above the carpus it divides into three tendons. The outermost is *inserted* into the base of the radial side of the 1st metacarpal bone, the middle into the dorsal surface of the radial side of the scapholunar, and the innermost into the radial side of the base of the 2nd metacarpal bone.

In *Phoca barbata* there is a variation; half an inch above the extensor ossis metacarpi pollicis it divides into two tendons. The outer is *inserted* into the base of the 2nd metacarpal bone. The inner gives off from its outer side a slip, which goes to the dorsum of the trapezium, and then is *inserted* into the outer side of the 2nd metacarpal bone.

In *Arctocephalus* it lies to the outer side of the supinator longus above the elbow. It *arises* from the external condyle as in the Phocinæ, below where the musculo-spiral nerve turns round the external border of the humerus, slightly from the anterior surface of the capsule of the joint over the head of the radius, and from the external condyle. In the forearm it has the same relations as in the Phocinæ. Before passing beneath the extensors of the pollex, it divides into two tendons of equal size. The anterior or outer tendon is *inserted* into the ulnar side of the base of the 1st metacarpal. The posterior or inner into the upper third of the radial side of the base of the 2nd metacarpal. Vrolik, under Section 24, says of the extensor carpi radialis longus and brevis that both rise from the upper part of the outer margin of the humerus. The brevis is inserted into the lower part of the radius, and the longus into the outer face of the os navicularis. From the insertions the short one is the supinator and the long the extensor carpi radialis.

Humphry and Lucae describe two metacarpal insertions. *Otaria* has the longus and brevis as a common mass with two tendons. The insertions are similar to those in *Arctocephalus*. In *Trichechus* they are so united that they cannot be distinguished. The insertion is by a single tendon attached equally to the 1st and 2nd metacarpals. In *Phoca barbata* the muscle forms two tendons about the middle of the radius, in the other Phocinæ it is divided equally in the region of the carpus into three, and in *Arctocephalus* into two as in *Phoca barbata*. There is therefore an attempt to form two muscles in *Phoca barbata* and *Arctocephalus*, but as the origins in all the Phocinæ are from the supracondyloid ridge, and in *Arctocephalus* and *Otaria* from it and the external condyle, it is difficult to comprehend whether it is a single muscle with a divided tendon, or the longus and brevis united. The action of the extensor carpi radialis longus and brevis in human anatomy is to extend the wrist, but after this is done the longus can flex the arm. In the Seals both actions can be performed, and thus the function of this muscle is that of the longus and brevis.

The lower end of the radius in the Phocinæ and *Arctocephalus* has a characteristic difference. The scapholunar bone in the former has a very large radial tubercle, in *Arctocephalus* a small one, and in the latter the lower end of the radius articulates almost entirely with the scapholunar. In the Phocinæ the large tubercle seems to be formed at the expense of the scapholunar, for this bone only articulates with half of the lower end of the radius: hence the outer lower half of the radius is non-articular, the inner being the articular surface. It is supplied by the musculo-spiral nerve.

The *Extensor communis digitorum* is a double muscle consisting of two separate origins; these are named *primus* and *secundus*. *a.* The extensor communis digitorum primus is named by Vrolik M. digitorum extensores; by Humphry, extensor communis digitorum; by Lucae, mus. extensor quatuor digit.; and by Murie, extensor. It *arises* from the supracondyloid ridge, below the extensor carpi radialis. At the middle of the arm it forms a flat tendon, which passes through the third division of the annular ligament. Above the bases of the metacarpal bones the tendon expands and breaks into four tendinous slips, which pass down between the metacarpal bones to the radial sides of the four fingers. At the middle of the 1st phalanges the tendons begin to expand towards the ulnar sides of these bones, and at the heads of the 2nd phalanges the tendons cover the entire dorsum. They proceed to the bases of the 3rd phalanges, where they are *inserted*. The tendons adhere closely to the posterior ligaments of the joints of the digits. *b.* The extensor communis digitorum secundus. Vrolik appears to call it the extensores digitorum communes breves, Humphry the extensor secundus digitorum, Lucae the mus. abductor quatuor digitorum. It *arises* from the supracondyloid ridge below the primus, and from the external condyle. It slightly overlaps the primus; and a little below the middle of the forearm divides into four tendons, which pass through the fourth division of the annular ligament posterior to the primus. Two of the tendons pass outwards beneath the tendons of the primus, and run down the ulnar sides of the 2nd and 3rd metacarpal bones. The 3rd runs down the ulnar side of the 4th metacarpal bone, and the 4th divides into two, one going to each side of the 5th metacarpal. The tendons of the 2nd, 3rd, and 4th metacarpals are *inserted* into the heads of the ulnar sides of these bones, and into the dorsal surfaces of the proximal ends of the 1st phalanges, and also into their ulnar sides. The tendon of the 5th metacarpal splits into two as before stated; the anterior one is *inserted* into the radial side of the head of the 5th metacarpal, and into the dorsum and ulnar side of the proximal end of the 1st phalanx; the posterior into the dorsum and head of the 5th metacarpal.

In *Arctocephalus* it *arises* from the external supracondyloid ridge, and from the extensive lateral ligament beneath the muscle. It passes to the interosseous space and divides into two slips, which cross the extensor pollicis proprius. From these two slips are formed the outer slip or extensor communis digitorum, and the inner or extensor minimi digiti. The extensor communis digitorum divides into four tendons. The 1st descends along the ulnar side of the 2nd metacarpal bone; the 2nd along the dorsum of the 3rd; the 3rd descends upon the radial side of the 4th;

and the 4th runs down the radial side of the 5th metacarpal. The 1st, 2nd, and 3rd portions expand over the heads of the metacarpals, and continue expanding until they reach the heads of the 1st phalanges, to which they are strongly adherent. Then they pass over the posterior phalangeal joints as fine aponeurotic sheets, which go to the terminal phalanges, and are bound throughout their length to the bases of the phalanges and to the posterior ligaments over which they pass. They are *inserted* into the dorsal surface of the heads of the 2nd, and the bases of the 3rd phalanges of the 2nd, 3rd, and 4th digits to their radial sides. As has already been shown, the extensor minimi digiti is derived from the origin of the extensor communis digitorum. It divides upon the carpus into three tendons, the highest, the middle, and the lowest. The highest is the shortest, and is *inserted* into the radial side of the base of the 5th metacarpal. The middle is intermediate in size, and is *inserted* into the radial side of the middle of the 5th metacarpal, between the bases of the 4th and 5th. The lowest is the largest, and goes over the dorsum of the 5th metacarpal base as a narrow slip; and is *inserted* into the head of the 1st phalanx, and descends from this to the terminal phalanx as a thin fibrous sheet.

Vrolik in Section 25 points out that "close by the origin of the extensor digitorum a muscle peculiar to the Seal takes its rise," no doubt the secundus of the communis digitorum. Humphry and Lucae found two extensors, one above the other. In *Otaria* the common extensors arise by a common origin, but divide into three groups. The anterior, outer, or extensor communis digitorum divides into three tendons for the 2nd, 3rd, and 4th digits. The middle or extensor medii digiti has two tendons, one for the 3rd, and one for the 5th digit. The third, innermost, or extensor minimi digiti, has tendons for the 5th metacarpal and for the 4th digit. In *Trichechus* according to Murie the extensor communis digitorum has three tendons for the 2nd, 3rd, and 4th digits, which go into the distal ends of the 1st phalanges. The extensor medii digiti is also found, but adheres very closely to the extensor communis and ends in the interspace of the 4th and 5th digits in four or five short tendons. The extensor minimi digiti divides into two slips for the 5th metacarpal.

In all the Seals and the Walrus the extensors of the 2nd to the 5th digits of the manus are of the same type, each having an extensor mass subdivided into two sets of muscles. The Phocinæ have the two sets superimposed and they are described as primus and secundus. In *Arctocephalus* the two consist of the extensor communis digitorum and the extensor minimi digiti as in man. The *Otaria* and *Trichechus* have three muscles out of the two sets. The extensor communis being one set, the extensor medii digiti and minimi the other. In the Common Seal, Murie states that Duvernoy has noted that the index receives a tendon as well as the median digit, and to this muscle in question he applies the term "extensor propre de l'index," but Murie finds in *Otaria* and *Trichechus* no special indicator. The 1st digit in the Phocinæ gives attachments to two extensor tendons, and these are slips from the primus and secundus division of the common extensor. Neither of these can be called special indicators for they belong to the common group going to the other digits. The index in these animals is a collective unit in the manus, and its action is very much like that of the other digits, all being surrounded by the integument, as is seen by examining the combined actions of the extensors. In the Phocinæ the tendons of the extensor communis primus are placed along the radial sides of the phalanges, and when extending the digits will also adduct them, whereas the extensor communis secundus being on the ulnar side will extend and abduct. In *Arctocephalus* the extensor communis simply extends while the extensor minimi digiti extends and abducts; it therefore acts like the extensor communis digiti secundi in the Phocinæ. It may be as well to note that the Phocinæ have a tendon from the extensor primus to the 5th digit, as is seen in *Arctocephalus,* but not in *Otaria* and *Trichechus.* The actions are as usual.

The *Tensor of the posterior annular ligament,* named by Lucae tensor ligamenti carpi dorsalis communis, springs from the extensor communis digitorum secundus, near the external condyle, and consists chiefly of a narrow tendinous band. It is *inserted* into the middle of the upper edge of the outer or posterior annular ligament. In *Phoca hispida* and *Phoca barbata* it could not be made out owing to the condition of the specimens, but is most likely present in them. On referring to the accounts of *Otaria* and the Walrus it will be seen that in them the extensor minimi digiti and extensor medii digiti form one set of the extensors, and as the tensor comes out of the same set, I consider it to be the representative of the extensor medii digiti of the Sea Lion and Walrus.

The *Extensor carpi ulnaris* in the Phocinæ *arises* from the external condyle, from the outer surface of the ulna beside the articular facet for the radius; and from the ligament of the joint. It passes through the fifth division of the annular ligament; and is *inserted* into the middle of the ulnar side of the 5th metacarpal bone.

In *Arctocephalus* the anconeus externus partly covers its origin. It *arises* from the external surface of the olecranon, between the anterior and middle tubercles (Pl. VII. fig. 4); and from the outer edge of the quadrilateral surface behind the great sigmoid cavity of the ulna. It descends to the carpus on the inner side of the externus, and, after crossing the extensor proprius pollicis, is *inserted* into the base and head of the ulnar side of the 5th metacarpal, but chiefly into the head of the first phalanx on the ulnar side. In *Otaria* and *Trichechus* it is inserted only into the 5th metacarpal. It extends the manus, powerfully abducts it, stretching out the digits, besides aiding extension of the forearm. It is supplied by the posterior interosseous nerve.

The *Supinator brevis arises* from the external condyle of the humerus, and from the ligament of the elbow-joint on the external surface. It is *inserted* into the upper two-thirds of the anterior border of the radial shaft, into the anterior third of the inner surface down to the pronator teres insertion, and into the anterior two-thirds of the outer surface to the same insertion.

In *Arctocephalus* this muscle is hidden on the outer aspect of the radius by the downward expansion of the extensive lateral ligament. It *arises* from the posterior and external surface of the external condyle below the external lateral ligament, from the posterior aspect of the capsular ligament covering the posterior surface of the condyle, from the capsule over the outer side of the head of the radius, also from the outer half of the capsule covering the anterior aspect of the head of the radius, and slightly from the front of the capsule covering the anterior side of the external condyle. The fibres from the back of the condyle are mostly tendinous, and all are parallel to the radial shaft. It is *inserted* into the anterior half of the neck on its outer surface, into the external surface of the shaft of the radius, as far down as the lowest fibres of insertion of the pronator radii teres, that is about the middle of the bone; into the neck of the shaft of the anterior border to the insertion of the same muscle, and slightly into the inner border below the neck.

In *Trichechus,* as in *Arctocephalus* and the Phocinæ, it has only one head of origin, but in *Otaria* it has two heads, the additional one from the ulna below the coronoid process. It supinates the forearm and steadies the joint. It is supplied by the posterior interosseous nerve.

In *Arctocephalus* the *Extensor proprius pollicis* covers a considerable part of the flexor carpi ulnaris. It *arises* from the outer surface of the olecranon between the middle and posterior tubercles, from the ulna posterior to the ridge running down the shaft from the middle tubercle, and from the external surface of the ulna, where the ridge ends, to 1 inch from the epiphysial line. It has also fibres of origin from the fascial expansion of the external lateral ligament, which passes beneath it to attach itself to the lower end of the ridge of the ulna. It forms a flat strong tendon, and crosses obliquely forwards and outwards to the interval between the radius and ulna. At the level of the epiphysial line it enters the annular ligament, and passes over the posterior inferior corner of the lower end of the radius. It reaches the carpus and goes between the 1st and 2nd metacarpal bones; at the middle of the 1st metacarpal it begins to expand to the outer or anterior side, the tendon crossing the head of the metacarpal. Above the wrist it is crossed by the extensor carpi ulnaris, and over the wrist by the common extensors. Upon the base of the 2nd metacarpal it crosses the posterior tendon of the extensor radialis, and then descends upon the dorsum of the head of the 1st metacarpal, over which it joins the outer side of the extensor primi internodii pollicis. It is *inserted* into the base of the 1st phalanx of the pollex, and sends a fine aponeurosis to the terminal one. The posterior capsule of the joint of the 1st and 2nd phalanges of the pollex is chiefly formed by it.

This muscle is wanting in the Phocinæ, and comes under the heading "extensor pollicis et indicis" in Dr. Murie's papers on the Pinnipedia. In *Otaria* it *arises* almost from the same locality of the ulna, and is *inserted* into precisely the same part of the pollex as in *Arctocephalus*. The surface of the ulna which gives origin to this muscle in *Arctocephalus*, *Otaria*, and *Trichechus*, is occupied by the extensor primi internodii pollicis in the Phocinæ. It is supplied by the posterior interosseous nerve.

The *Extensor ossis metacarpi pollicis* is the abductor pollicis of Lucae. It *arises* from the external flat surface of the olecranon, beginning above the tip of the olecranon, and extending along its border to where the posterior border of the ulna begins; from the anterior upper half of the outer surface of the ulna; slightly from the external lateral ligament; from the outer surface of the interosseous ligament; and by a few fibres from the middle of the posterior border of the radius. After receiving the radial fibres it forms a flat tendon which descends obliquely downwards and forwards over the outer surface of the radius, crossing the extensor carpi radialis tendon above the wrist. It enters the first division of the annular ligament and runs in the groove on the anterior border of the radius above the styloid process, then over the palmar surface of the process or tubercle of the scapholunar bone; and is *inserted* into the radial or anterior side of the proximal end of the 1st metacarpal bone.

In *Arctocephalus* it *arises* from the external surface of the middle of the shaft of the ulna, anterior to the ridge which descends from the middle tubercle, below the origin of the extensor primi internodii pollicis, which is not covered by the attachment of the fascial expansion of the external lateral ligament, from the posterior surface of the interosseous membrane, and by a small surface from the external side of the posterior border of the radius in front of the ulnar origin. It passes obliquely downwards and forwards, over the external surface of the radius, under cover of the expansion of the external lateral ligament. Crossing the tendons of the extensor carpi radialis, it enters the first division of the annular ligament on the anterior border and external surface of the lower end of the radius, and runs along the side of the carpus to the outer side of the extensor primi internodii pollicis; and is *inserted* into the radial side of the base of the 1st metacarpal.

In *Otaria* "it takes origin from the outer surface of the olecranon, and from the ulna to as far as about the middle of the latter, and is *inserted* into the prominent and anterior or outer corner of the metacarpal of the pollex."

In *Trichechus* it is combined with the extensores primi and secundi internodii pollicis. This muscle in the Phocinæ covers that part of the ulna which, in *Arctocephalus*, gives origin to the extensor ossis metacarpi pollicis and the extensor primi internodii pollicis, in *Otaria* gives origin to the same muscles, and in *Trichechus* to the extensor ossis metacarpi, extensor primi internodii, and extensor secundi internodii pollicis. It is supplied by the posterior interosseous nerve.

The *Extensor primi internodii pollicis arises* from the posterior third of the outer surface of the olecranon; from the posterior border of the ulna in its upper half; and very slightly from the shaft where the extensor ossis metacarpi begins to cross the radius. One inch above the wrist it forms a tendon, which passes beneath those of the extensor communis digitorum secundus, and enters the third division of the annular ligament with and below the extensor communis primus. It is *inserted* into the base of the 1st phalanx of the thumb on the anterior or radial side; and into the head of the metacarpal.

In *Arctocephalus* the extensor digitorum and the extensor carpi ulnaris must be turned up before the origin of this muscle is seen. It *arises* from the external surface of the olecranon between the anterior and middle tubercles; from the edge of the quadrilateral surface in front of the anterior tubercle; from the sigmoid cavity of the ulna; from the concave outer surface of the ulna, as far as the origin of the extensor ossis metacarpi pollicis; from the external surface of the ligament of the capsule of the elbow-joint; from the interosseous ligament; and from the upper half of the posterior quarter of the breadth of the shaft of the radius. Its tendon crosses the radius, and goes through the same division as the extensor ossis metacarpi pollicis. Opposite the head of the 1st metacarpal it is bound to the palmar fascia, and is *inserted* into the radial side of the base of the 1st phalanx of the pollex, being joined to the extensor proprius pollicis.

Lucae gives the insertion into the base of the 1st metacarpal, but Humphry gives a different insertion into the back of the 1st phalanx of the pollex, which is the phalanx for the insertion of the extensor primi internodii pollicis.

In *Otaria* this muscle is wanting In *Trichechus* it is inseparably united with the extensor ossis metacarpi pollicis. That part of the ulna upon which this muscle is implanted in the Phocinæ gives origin in *Arctocephalus*, *Otaria*, and *Trichechus* to the extensor proprius pollicis. It is supplied by the ulnar nerve.

According to those works on the Pinnipedia that I have had an opportunity of reading, the outer surface of the ulna in the Phocinæ and *Arctocephalus* gives origin only to muscles for the pollex. The surface to which the fibres are attached, generally speaking, is the upper two-thirds of the shaft. In *Arctocephalus* the outer surface of the ulna is divided into two by a ridge commencing from the middle tubercle on the outer side of the olecranon, and becoming indistinct at the junction of the upper two-thirds and the lower third of the shaft (Pl. VII. fig. 4). In the Phocinæ there is a slight ridge dividing the external surface of the olecranon into two, which comes close to the posterior border of the ulna $\frac{3}{4}$ of an inch below the junction of the posterior border with the olecranon, runs down the shaft close to it, and ends at the middle of the shaft. These ridges separate the muscle fibres, which clothe the external surface of the shaft, into two groups of the same functional importance for the pollex. The posterior group gives origin to one muscle in all, and this is the extensor proprius pollicis in *Arctocephalus*, the extensor pollicis et indicis in *Otaria* and *Trichechus;* but as these three are exactly alike in their mode of insertion, practically they are the same, and all might be as correctly named extensor proprius pollicis. In the Phocinæ the muscle is called the extensor primi internodii pollicis, but only provisionally, for its origin is exactly as in all the others, but its insertion is half that of the proprius and half that of the extensor primi internodii, for a part of the insertion crosses the base of the 1st phalanx of the pollex, and the other half is continued down the radial side like the extensor primi internodii; thus it has a compound action.

The anterior group in the Phocinæ and *Otaria* is similar, forming the extensor ossis metacarpi only; in *Arctocephalus* two muscles come from this group owing to its division into an upper and a lower half. The upper half is the extensor primi internodii pollicis, the lower the extensor ossis metacarpi pollicis. In *Trichechus* there are three muscular elements—the extensor ossis metacarpi pollicis, the extensores primi et secundi internodii, all combined at their origin, and indistinguishable from the common mass of fibres. This affords evidence of a distinct portion of a bony surface being reserved for a muscle discharging a special function with respect to a certain digit. The area of origin in all these animals remaining constant and not increasing in size, whether there is a single tendon or more, is probably novel. It leads to the conception that there must be a method in the formation of distinct muscles out of common masses of fibres, though it may not always be traceable. These muscles have the usual actions.

Myology of the Hind Limb.

The Ilio-Femoral Region includes the psoæ and iliac muscles, with a varying set of muscles in connection with the former. The following shows the various accessory muscles found in each specimen. The meaning of the names is explained further on:—

The *Psoas magnus* or *primus* is present in the large *Phoca vitulina;* in the small *Phoca vitulina* with an ilio-femoralis et lumbalis anterior; in *Phoca barbata* with an ilio-femoralis et lumbalis anterior; in *Phoca hispida* with an ilio-femoralis anterior; in *Macrorhinus;* and in *Arctocephalus.*

The *Psoas minor* or *secundus* is found in all the above specimens and in the large *Phoca vitulina*, on the right side, with a lumbo-femoralis posterior.

The *Psoas tertius* is common to all but *Macrorhinus*, and it has an ilio-femoralis posterior.

The *Iliacus* is found in all the specimens.

Before entering upon the details of the psoæ, it is well to understand upon what grounds the names are given, as well as to point out what peculiarities each muscle possesses, and the similarities and dissimilarities in each dissection. As much interest in the anatomy of the Seals centres around this group of muscles the localisation of the fibres is of importance. Upon the lumbar vertebræ ventrally there are two longitudinal fleshy masses, each including a psoas magnus and parvus. As one of these muscles is attached in all the specimens, though with some modifications in detail, to the pectineal eminence, I regard it as the equivalent of the psoas parvus of human anatomy, called the secundus or minor in the text. The other muscle, lying to the outer side of the minor, has not the usual femoral attachment of the psoas magnus, but its position in the trunk and the want of the trochanter minor in the Phocinæ and *Macrorhinus*, indicate that the magnus must wander to some other point, and it has settled on the posterior ventral spine of the ilium. The names magnus and minor do not suit the magnitudes of these muscles in the Earless Seals, for the minor is by far the larger, and the major along side of it is small, but it is convenient to keep the names used in human anatomy. The tertius is a small muscle not to my knowledge previously described in the Seals, and called the iliacus by Dr. Murie in *Otaria*. It is located upon the junction of the lumbar with the sacral vertebræ under cover of the other two muscles, and is directed obliquely over the pelvic brim to the femur. It exists in all the specimens excepting *Macrorhinus*. The want of a psoas magnus to the femur is compensated for by fibres springing from the posterior ventral spine of the ilium, or from the pectineal eminence with, in some instances, a prolongation of fibres from the psoas magnus into this group, or a direct offshoot from the psoas minor. The name ilio-femoralis anterior is given when the fibres are only derived from the posterior ventral spine, and ilio-femoralis posterior when from the pectineal eminence. In two specimens (small *Phoca vitulina* and *Phoca barbata*) an addition is required to the name ilio-femoralis anterior. The psoas magnus in them gives fibres to blend with the ilio-femoralis anterior and then the name ilio-femoralis et lumbalis anterior may be adopted. Lastly, in the large *Phoca vitulina*, the psoas secundus gives a group of fibres directly to the femur, and this is called the lumbo-femoralis posterior.

The *Psoas magnus* is called the psoas major and ilio-lumbalis by Lucae; in *Phoca vitulina* it *arises* from the sides of the ventral surface of the 3rd, 4th, and 5th lumbar vertebræ to the inner side of the psoas tertius, which it covers and crosses, to be *inserted* only into the posterior ventral spine of the ilium. It has no ilio-femoralis anterior.

In the small *Phoca vitulina* most of the fibres are *inserted* into the posterior ventral spine of the ilium. It has an extension of its fibres forming an ilio-femoralis et lumbalis anterior. In Humphry's account of this muscle he points out that some of the fibres pass to the inner side of the thigh; this is the group which Lucae figures as the femoralis major and has not described.

In *Phoca barbata* this muscle has the same *insertion* and distribution as in the last species.

In *Phoca hispida* it is *inserted* into the anterior half of the posterior ventral spine of the ilium, and slightly into the adjacent inner half of the ventral border of the outwardly directed wing of the ilium. There is a great difference between this muscle and the corresponding one in the small *Phoca vitulina*, for not one of the fibres proceeds beyond the spine. It has, therefore, no lumbalis fibres from the psoas magnus, but it has an ilio-femoralis anterior.

In *Macrorhinus leoninus* it is *inserted* into the posterior ventral spine of the ilium, which is fused with the pectineal eminence.

In *Arctocephalus gazella* this is much the largest of the group. In the dorsal region it *arises* by a series of muscular slips, from the posterior halves of the last four dorsal vertebræ, from their intervertebral discs, and from the ventral surfaces of the ribs and the ligaments of the rib joints. In the lumbar region it *arises* from the whole of the ventral surfaces of the 1st, 2nd, 3rd, and 4th lumbar vertebræ, and from their intervertebral discs and transverse processes. It courses directly backwards, above the psoas minor, to the outer side of the tertius, becomes narrower, and is *inserted* into the posterior ventral spine of the ilium. There is no ilio-femoralis et lumbalis anterior, or ilio-femoralis anterior, in this animal nor in *Macrorhinus leoninus*.

The *Ilio-femoralis et lumbalis anterior*, in the small *Phoca vitulina*, is the ilio-psoas and ilio-femoralis of the text of Lucae, and the ilio-femoralis major and minor of his drawing. It is in part formed by a continuation onwards of some of the fibres of the psoas magnus, and by fibres springing from the posterior ventral spine of the ilium. A number of the superficial fibres of the psoas magnus pass over the spine, and run with a fresh set of fibres which *arise* from the posterior ventral spine. The fibres from these two sources proceed backwards and outwards, lying to the outer side of the psoas tertius, and are *inserted* into the lower outer third of the inner border of the femur.

In *Phoca barbata* it *arises* from the posterior half of the posterior ventral spine of the ilium, from the side of the sacrum, from the sacro-iliac ligament, and from the ventral surface of the ilium along the anterior or upper border to the spine. A few fibres of the psoas magnus run into it, and after receiving them it courses along the outer side of the psoas tertius, and unites with it near the supracondyloid ridge on the inner border of the femur.

The *Ilio-femoralis anterior* in *Phoca hispida arises* from the posterior half of the posterior ventral spine of the ilium, from the ventral surface of the sacro-iliac ligament, from the sacrum, and from the ventral surface of the ilium posterior to the spine. It passes to the lower end of the inner border of the femur, and is *inserted* into the supracondyloid ridge in front of the psoas tertius, and is partly blended with it. Lucae had obviously recognised this muscle, and though he names it in his plate ix., he does not describe it in the text.

The *Psoas minor* or *secundus* in the larger *Phoca vitulina*, as in the Earless Seals, is the largest muscle of this group. It *arises* from the ventral surfaces of the 14th and 15th ribs and their rib-joints, from the sides of the 14th and 15th vertebræ, from the ventral surfaces of the bodies of these vertebræ, and from the ventral surfaces of the transverse processes of all the lumbar vertebræ, and is *inserted* into the pectineal eminence. A similar insertion has been recognised by the authorities already named in the specimens they describe.

In the small *Phoca vitulina*, *Phoca barbata*, *Phoca hispida*, in *Macrorhinus*, and in *Arctocephalus* it is much smaller than the psoas major, and is a thin fusiform band, which *arises* by short tendons from the posterior aspect of the rounded tips of the transverse processes of the 2nd, 3rd, and 4th lumbar vertebræ. It crosses inwards ventrally to the psoas magnus and tertius, and is *inserted* into the pectineal eminence.

In the large *Phoca vitulina* the lumbo-femoralis posterior is found on the right side only. After dividing the tertius and turning the two ends aside, a muscular band is exposed, which is the direct continuation of the psoas secundus. This is a flat riband-shaped band of fibres from the psoas secundus passing over the insertion of this muscle into the pectineal eminence, and turning outwards upon the psoas tertius to the lower end of the femur on the inner border into which it is *inserted*. The secundus of the left side had no such distribution, and all its fibres ended in the pectineal eminence.

The *Psoas tertius* in the large *Phoca vitulina* is the most inferior, and passes beneath the psoas magnus over the pelvic brim to the lower inner border of the femur. It *arises* under cover of the magnus from the junction of the ventral surfaces and sides of the two last lumbar vertebræ. It lies upon the lumbo-femoralis on the right side and the iliacus on the left, and is *inserted* into the termination of the femoral ridge on the inner border of the femur at the lower end.

In the small *Phoca vitulina* it is a band of muscular fibres 1 inch broad, stretching from the lowest lumbar vertebra to the femur. It *arises* from the ventral surface of the hinder half of the last lumbar vertebra, from the anterior half of the 1st sacral vertebra, from their intervertebral discs, and from the anterior sacro-iliac ligament. It turns over the ilium between the anterior and inferior spines and the pectineal eminence, going beneath the tendon of the psoas minor which passes to the pectineal eminence. Hence it goes downwards to the lower end of the inner border of the femur, and is *inserted* into the supracondyloid ridge, occupying the lower third of the internal border of the femur above the condyle and below the ilio-femoralis et lumbalis anterior found in this specimen.

In *Phoca hispida* it *arises* from the ventral surface of the side of the body of the last lumbar vertebra, and from the intervertebral plates above and below (*i.e.*, anterior and posterior to this vertebra). It descends from the vertebral column over the iliac synchondrosis below the tendon of the psoas minor or secundus, and is *inserted* into the supracondyloid ridge as the last.

In *Phoca barbata* it *arises* from the last lumbar vertebra, but only from the lower or posterior part of its ventral surface, from the ventral surface 1st vertebra of the sacrum, from the intervertebral disc anterior to the last lumbar, and from the disc between the last lumbar and the sacrum. The course is the same as in the small specimen of *Phoca vitulina*, and it is *inserted* as the other muscles.

In *Arctocephalus gazella* it is situated to the inner side of the psoas minor, and *arises* from the sides and ventral surfaces of the lower border of the second last lumbar vertebra, from the upper half of the same part of the last lumbar, and from the intervertebral disc between it and the 2nd lumbar, and from the root of the transverse process of the last lumbar. From the sides of the vertebral column it descends, partly hidden by the large psoas minor. At the level of the insertion of the psoas major it passes beneath the tendon of the minor, and after crossing the capsule of the hip-joint turns round the inner surface of the femur. It is *inserted* into the inferior large surface of the small trochanter of the femur, behind the insertion of the iliacus and in front of the insertion of the pectineus.

In *Macrorhinus leoninus* there is no psoas tertius coming from the vertebral column, but there is an *Ilio-femoralis posterior*. It *arises* only from the entire length of the outer side of the pectineal eminence, reaching as far forwards as the tendon of insertion of the psoas magnus, which it slightly overlaps. It is *inserted* into the supracondyloid ridge on the inner border of the femur, just as are the ilio-femoralis anterior, the ilio-femoralis et lumbalis anterior, and the lumbo-femoralis posterior found in the various animals.

The *Iliacus*, as a separate muscle, was found in three specimens. From the distortion of the bony parts and the small size of the ventral surface of the ilium one might easily be led to suppose that there was no iliacus. This idea would seem not unwarranted, seeing that the femur has no trochanter minor in the Phocinæ and *Macrorhinus* (Pl. IV. fig. 4). But when one turns to a large specimen of a *Phoca*, good reason may be found for the identification of this muscle.

In the large *Phoca vitulina* it *arises* from the ventral surface of the ilium between the insertions of the psoas magnus and minor. This surface is equivalent to that portion of the ventral surface of the human ilium, which is immediately above the ilio pectineal eminence. It passes beneath the psoas secundus tendon on both sides, and the lumbo-femoralis on the right. The former is embedded in it on both sides, and the latter also on the right. The pectineal eminence being very prominent, and at its anterior end perpendicular to the ventral surface of the ilium, the fibres which arise from this surface are at right angles to those from the ventral surface of the ilium, so that it appears like two muscles. According to these two directions of the fasciculi, it is *inserted* in two ways; the fibres from the ilium into the anterior part of the inner border of the femur, the pectineal fibres into the femur posterior to the others. In *Phoca* the iliacus does not exist according to Duvernoy; Murie gives a description of it, and Humphry states that it was represented by a few fibres.

In *Macrorhinus leoninus* it *arises* from the outer half of the ventral surface of the ilium, and the inner half of the ventral border of the wing. It lies below the origin of the rectus toe th outer side of the insertion of the psoas magnus. It passes backwards and inwards, and joins the middle third of the outer side of the ilio-femoralis posterior. In all the specimens this muscle, when present, takes origin between the insertions of the psoas magnus and minor, but in *Macrorhinus* the magnus is posterior to the iliacus. Its name is due to the fact that it joins the ilio-femoralis posterior, and comes from the ventral surface of the ilium.

In *Arctocephalus gazella* it is a slender fasciculus, and *arises* from the ventral surface of the ilium between the ventral posterior spine and the pectineal eminence, and from the anterior or ventral sacro-iliac ligament. The psoas tertius lies upon it, and is adherent to its fibres, from origin to insertion. The course is the same as that of the psoas tertius, but the fibres of the iliacus are fixed to the capsule of the hip. It is *inserted* into the superior small surface of the small trochanter of the femur above the psoas tertius (Pl. VII. fig 7). In Murie's description of the iliacus, the lumbar and iliac fibres are made a common muscle. I made the dissection by cutting away the psoas tertius (Murie's iliacus) near its insertion and drawing it backwards, and found the iliacus fibres upon the ventral surface of the iliaum, having a different point of insertion into the lesser trochanter.

The muscles of the ilio-femoral region situated on the posterior and anterior spines of the ilium, and around the pectineal eminence along the inner side of the femur to the inner condyle, can only be differentiated by following closely the fibres from origin to insertion. The bulk of the muscles are not divided by well-defined fibrous septa as in many other Mammals, and the smaller muscles especially are in consequence difficult to isolate. The points of origin must be sought for and considered beforehand, otherwise many artificial muscle bundles would be formed and confusion result from divisions made. This has been most carefully attended to with this group, as they are so closely applied that no definite result could have been otherwise obtained. In the small specimens, the smallness of the space available for work, the fineness of the fibres, and the presence of a quantity of fat added considerably to the difficulty of the problem. However, sufficient evidence was obtained to put beyond doubt that a psoas primus, secundus, and tertius were present in all but *Macrorhinus leoninus*, which lacks the tertius, and that in all three there is a distinct iliacus. In the Phocinæ this muscle is supplied by the anterior crural nerve.

The interpretation of the muscles called "ilio-femoralis et lumbalis anterior" springing from the psoas magnus and the posterior ventral spine, "ilio-femoralis anterior" from the posterior ventral spine, "ilio-femoralis posterior" from the pectineal eminence, and "lumbo-femoralis" from the psoas minor presents no intricacy. All these are inserted into the inner border of the femur with trifling variations as to extent and locality. Some are directly connected with the psoæ, or are in close proximity to their insertions. From this we see that all these various origins maintain a connection with the psoæ, and that they are the representatives of it in the thigh.

The variations in shape and alterations in size of the ventral surface of the ilium have no doubt been the cause of the want of exactness and the difficulty in describing the iliacus. In *Arctocephalus*, which is a near relation of *Otaria*, the ventral surface of the ilium is well marked; in my specimen it was fully an inch long and half an inch broad. In the large *Phoca vitulina* it was also well formed, in a large *Phoca grœnlandica* it was half an inch long by half an inch broad. In the small *Phoca vitulina* three-quarters of an inch long by quarter of an inch broad. In *Phoca hispida* barely half an inch long by two lines broad, and in a specimen of *Phoca vitulina* in which the pubic bar and the ilium were not fused it was only a border. In *Macrorhinus* the ventral surface was increased by the broadening of the ventral border of the wing of the ilium, and the ventral surface and broad ventral border were not recognisable as such, for the one was continued into the other. Meckel, Humphry, and Murie agree as to there being an iliacus arising from the ventral surface of the ilium in *Phoca vitulina*. Murie believes the iliacus is present in *Otaria* and *Trichechus*, but describes it as coming from the spinal column as well as from the ventral surface of the ilium, and calls it a semi-divided iliacus. Instead of naming this an iliacus, I have named the spinal fibres psoas tertius, and the iliac fibres as the iliacus. In *Macrorhinus* only is there an iliacus without a psoas tertius. In the Phocinæ and in *Arctocephalus* the psoas tertius lies upon the iliacus, and in the small specimens is intimately fused with it.

The Ventral Femoral Region in the Phocinæ, *Macrorhinus leoninus*, and *Arctocephalus gazella*, is composed of the tensor fasciæ femoris, sartorius, rectus femoris, vastus externus, and crureus. The vastus internus and subcrureus are wanting.

The *Tensor fasciæ femoris* in *Phoca vitulina arises* from the fascia lumbo-dorsalis in its inner half, from the erector spinæ in its outer half. It forms a band, which descends between the anterior ventral spine and the posterior ventral spine of the ilium, just touching both. After crossing the iliac crest it sweeps backwards, forwards, and inwards. Above the external condyle of the femur it forms a tendon which is *inserted* into the deep strong fascia over the head of the tibia and fibula. The tendon extends from the middle of the head of the tibia to the middle of the head of the fibula, on the outer side, and into the lowest three-fourths of the edge of the patella. In *Phoca hispida* the origin is similar. It is *inserted* into the outer edge of the patella, into the outer edge of the ligamentum patellæ, and into the head of the fibula to the dorsal side of the ligamentum patellæ. In *Phoca barbata* it *arises* from the fascia over the erector spinæ only, and is *inserted* as in *Phoca hispida*.

In *Macrorhinus* it *arises* from the lumbo-dorsalis fascia, one inch and a half above the iliac crest, and from the erector spinæ. It descends over the anterior half of the crest of the ilium, joins the dorsal border of the tendon of the sartorius above the patella, descends along its outer edge to the tibia, and is *inserted* into the fascia over the head of the tibia, dorsally to the sartorius.

In *Arctocephalus gazella* it *arises* from the fascia lumbo-dorsalis, three-quarters of an inch from the spinal column opposite the middle of the space between the 3rd and 4th lumbar vertebræ to opposite the spine of the 5th. The muscular fibres commence at the edge of the erector spinæ. It passes backwards and forwards to the knee, crossing between the ventral anterior and posterior spines of the ilium, and is *inserted* by muscular fibres into the dorsal half of the patella, ending in the ventral border of the ligamentum patellæ. Lucae considers it as a muscle cover, otherwise his view is not different from the above. Murie does not notice it in the text or the drawings of *Otaria* and *Trichechus*. From the position of this muscle, reaching from the spinal column over the gluteal muscle to the outer side of the knee, it must act as a flexor of the thigh and a rotator outwards of the thigh and leg.

The *Sartorius* in *Phoca vitulina* is an elongated slip. It *arises* from the ventral anterior spine of the ilium, descends backwards, forwards, and slightly inwards, lying to the inner side of the tensor fasciæ femoris. It is *inserted* into the upper edge of the patella. In *Phoca hispida* it *arises* also from a small part of the lower lip of the iliac crest, and is *inserted* as in *Phoca vitulina*, but the fibres are also attached to the inner edge of the patella, into the ventral edge of the ligamentum patellæ, a few fibres descending along the inner side of the ligament to the head of the tibia. In *Phoca barbata* it has the same relations as in *Phoca vitulina.*

In *Macrorhinus leoninus* it *arises* from the lower edge of the ventral anterior spine of the ilium, which is a continuation of the outer lip of its crest, and from half an inch of the outer lip of the ilium. Its course is as in *Phoca vitulina*, but it is adherent to the rectus above the patella, and is joined on the dorsal edge by the tensor fasciæ femoris. The tendon is broad, and is *inserted* into the outer edge, and into the outer two-thirds of the superior edge of the patella. The tendon unites with that of the rectus and goes with it to the tibia.

In *Arctocephalus gazella* there was a second sartorius, much smaller than the proper one and posterior to it. The proper or anterior *arises* from the ventral anterior spine of the ilium, and from the ventral border behind the ventral anterior spine for a slight distance; it passes downwards and outwards, and is *inserted* into the inner edge of the patella, sending a fascial expansion to the fascia over the internal condyle to the head of the tibia. The posterior muscle *arises* from the middle of the venter of the ilium by a slender tendinous slip, descends to the knee, and is *inserted* over the internal border of the fascial expansion of the anterior one. Lucae only recognises part of the external oblique as its analogue. It appears in Murie's drawings of *Otaria* and *Trichechus* but not in the descriptions. It flexes the thigh, and may slightly adduct and evert it.

A very noticeable fact is the uncertainty as to the precise insertion of this muscle, its tendency to variation, and the fixity of the origin. Some may be in favour of regarding the tensor vaginæ femoris and the sartorius in the Phocinæ as offshoots from the external oblique, but the dissections appear to me to indicate that they are distinct from it. I look upon the external oblique as a progressive muscle, increasing in size and carried backwards in adaptation to the crawling movement of the Seals along the ground. In *Arctocephalus* where there is no crawling the external oblique follows the ilium and pubes. In the Phocinæ it is supplied by the anterior crural nerve.

The *Rectus femoris* in *Phoca vitulina* is a single-headed muscle, and *arises* from the ventral fourth of the anterior border of the outer surface of the ilium, from the outer surface between the anterior ventral spine and the origin of the gluteus minimus on the outer side, which is about the ventral half of the outer surface, and from below the capsule of the hip-joint, anterior to the middle of the acetabulum. Thus it springs from the outer surface of the ilium, from a surface bounded anteriorly by the anterior border of the ilium, posteriorly by the capsule of the hip-joint, where it is attached to the ilium on the dorsal side by the origin of the gluteus minimus, and on the ventral side by the ventral posterior spine of the ilium. The fibres form a rectangular band, which is partly behind the sartorius and the tensor fasciæ femoris. After passing downwards, forwards, and slightly outwards, it is *inserted* into the upper edge of the patella, and is united with the fibres of the vastus externus near the patella. In *Phoca hispida* it *arises* from the outer surface of the ilium ventral to the ridge between the ventral anterior spine and the middle of the anterior rim of the acetabulum. It does not arise from the ventral border, for the representative of the iliacus comes from the ventral posterior spine. It is *inserted* into the upper edge of the patella and is also joined above its insertion by a few fibres of the external vastus. In *Phoca barbata* it *arises* from the fossa of the posterior third of the outer surface of the ilium; and from the capsule of the hip-joint, but not from the anterior border of the ventral surface. It is *inserted* into the upper edge of the patella, and is also united to the fibres of the vastus externus near the insertion.

In *Macrorhinus leoninus* it *arises* from the external surface of the ilium, to the ventral side of the ridge running from the outer side of the ventral anterior spine to the middle of the acetabulum. Where the ridge is covered by the capsule it takes origin from it, and arises also from the outer half of the ventral surface of the ilium dorsal to the origin of the iliacus. Above the patella it forms a broad flat tendon, which is joined on its dorsal side above the patella by fibres of the external rectus, and is *inserted* into the upper edge of the patella.

In *Arctocephalus gazella* it *arises* from the external surface of the ilium: and from the capsule covering the front of the acetabulum. If a straight line be drawn from the ventral anterior spine to the middle of the anterior rim of the acetabulum, a triangular surface is mapped out, which is bounded ventrally by the ventral posterior spine, posteriorly by the rim of the acetabulum, on the inner side by the outer edge of the brim of the pelvis; and dorsally by the line from the ventral posterior spine to the acetabulum. Within this space is the origin of the muscle. It is *inserted* into the upper edge of the patella, and is joined on its outer side near the insertion by fibres from the vastus externus. Lucae has it as united to the cruralis, but I found it blended with the vastus externus. It is similar in *Otaria* and *Trichechus*.

As it is the reflected tendon in human anatomy that acts mostly upon the thigh, and this is the origin in the Seals corresponding to it, it is probably only a flexor of the thigh. It is relatively a much larger muscle than in human anatomy and will compensate for the vastus internus. In the Phocinæ it is supplied by the anterior crural nerve.

The *Vastus externus* in the Phocinæ and *Macrorhinus leoninus* is best seen in the last named animal, and extends along the outer border of the femur to the epiphysial line of the external condyle; *i.e.*, to the supracondyloid ridge, and is similar in all. It is placed upon the crureus and covers a considerable part of it; it *arises* from the capsule surrounding the neck of the femur, from the shaft between the inner termination of the great trochanter on the neck, from the whole length of the anterior edge of the great trochanter, slightly from the shaft below this, and from the external border of the femur in its upper half. It is blended with the crureus and is *inserted* into the upper and outer half of the patella, and into the capsule of the knee-joint, on a level with the middle of the outer edge of the patella. No fibres descend further down the capsule.

In *Arctocephalus gazella* it is a rectangular muscle, lying to the outer side of the rectus femoris, and partially overlapping the crureus. It *arises* from the front surface of the femur below the great trochanter; from the front of the neck of the same; from the capsule of the hip-joint, and from the external border of the shaft, almost reaching the external condyle. It is *inserted* into the outer upper half of the patella, and blends with the rectus femoris. Lucae describes a combined crureus and vastus externus. In *Otaria* it is attached to the whole anterior surface of the femur, as also in *Trichechus*.

In *Macrorhinus*, and in all the femora of the Phocinæ, there is an oblique ridge running from the top of the great trochanter on the front surface to the external condyle, which curves outwards in *Macrorhinus* to below the middle of the head of the femur before going to the external condyle (Pl. IV. fig. 4). In *Arctocephalus* the ridge is not well marked, but above the line on the femur for the capsular ligament of the knee in the middle of the shaft, a ridge from the top of the great trochanter runs down the upper third of the shaft in a line with this point (Pl. VII., fig. 7). This ridge marks off the vastus externus, even although the fibres of the crureus pass in below it for a distance. In the Phocinæ the vastus externus is supplied by the anterior crural nerve.

The *Crureus*.—In all the specimens there is a layer of muscular fibres without a natural division covering the front of the femur, which may be the combined vastus internus and crureus, but certainly is not the vastus internus only. For in *Arctocephalus* there is a large internal surface on the femur, and if it were covered by muscular fibres going to the patella, that would afford sufficient proof that it was the vastus internus. The fibres on the front surface, however, run from the ventral side of the internal condyle to the corresponding surface of the neck, and do not cover any part of the extensive internal surface of the shaft, therefore the group of fibres is more entitled to the name of crureus in *Arctocephalus* and still more so in the Phocinæ where there is no internal surface.

In the Phocinæ it *arises* from the anterior surface of the femur, from the intertrochanteric line. It extends down the shaft to the part which is covered by the capsular ligament of the knee-joint, and is *inserted* into the upper edge of the patella beneath the rectus, into the outer upper half of it (the muscular fibres descend no further), into the inner side of the ligamentum patellæ, into the head of the tibia on the ventral side, and into the capsule of the knee-joint.

In *Macrorhinus leoninus* it is similar, with the exception of its insertion into the inner side of the patella. The muscular fibres stop at the lower inner edge of it, and are *inserted* into the inner side of the head of the tibia by a tendon.

In *Arctocephalus gazella* it *arises* from the front surface of the femur, with the exception of the surface occupied by the vastus externus, and is *inserted* into the capsule of the knee-joint, and into the upper edge of the patella. In *Otaria* and *Trichechus* it is combined inseparably with the vastus externus.

Lucae describes the vastus externus and crureus as a combined muscle, thus recognising the presence of both; and I found them in all the dissections, including that of *Arctocephalus*. Although the vastus externus is not perfectly separate, the direction of the fibres is an aid to its recognition as a distinct muscle. In *Macrorhinus* the separation is further assisted by a tendinous surface upon the posterior portion of the externus, and here the distinction of it from the crureus was easier. In *Phoca* it was not so distinct, and less so in *Arctocephalus;* but in all it merited a special description. Dr. Murie describes in *Otaria* and *Trichechus* the internus and externus, and is doubtful about the crureus. As already explained, the vastus internus would go over the internal surface if it were present as it is in *Arctocephalus;* when this surface gives no origin to the internus, then the crureus must be crowded out by the two lateral muscles encroaching upon its surface of origin, for in the Phocinæ, where there is no internal surface, there is the same collection of fibres with the same insertion as in *Arctocephalus*, so I conclude that in *Arctocephalus* there is a crureus and vastus externus, whereas *Otaria* and *Trichechus* have a vastus externus and internus. The extensor of the leg, as the name implies, will extend it and flex the thigh upon the pelvis. The flexion of the leg only takes place in the Phocinæ when on land, but this muscle will be a powerful depressor of the hinder extremity in the water. In the Phocinæ it is supplied by a branch of the deep anterior crural nerve.

The INTERNAL FEMORAL REGION of the Phocinæ and *Macrorhinus leoninus* contains the pectineus, obturator externus, adductor longus, and adductor brevis.

In *Arctocephalus gazella* there are in addition the pectineo-superficialis vel femoralis, and adductor magnus.

The *Pectineus* in the Phocinæ is triangular and of small size. It *arises* from the ventral surface of the pubic bar behind the ilio-pectineal eminence; and slightly from the inner side of the bar. The psoas tertius crosses it and the obturator is above it. It passes across the head of the femur to the inner side of the posterior surface of the shaft; and is *inserted* into the capsule, and into the upper third of the inner surface of the back of the femur, extending across the femur one-half its breadth.

In *Macrorhinus leoninus* it *arises* from the posterior third of the ilio-pectineal eminence outside the pelvic brim, from the anterior quarter of the pelvic brim, and slightly from its outer surface, reaching as far as the capsule of the hip-joint. It passes downwards over the capsule, and is *inserted* into the upper third, and the inner half of the hinder surface of the femur. If a line be drawn from the middle of the inner border of the femur to meet the upper third of one drawn through the centre of the long axis over the back of the shaft, the attachment is into the triangular space below the neck inside the lines indicated.

In *Arctocephalus gazella* it is called "adductor brevis primus" by Murie. It *arises* from one-sixth of the ventral surface of the pubic bar, this part being ventral to the acetabulum and posterior to the pectineal eminence. It is covered at the origin by the pectineo-superficialis vel femoralis, and is *inserted*, after crossing the capsule of the hip-joint, into the back of the femur behind the small trochanter.

The *Pectineo-superficialis vel femoralis* is the same as the pectineus in *Otaria* and *Trichechus*. Upon the surface of the origin of the pectineus there is a band of fibres forming a distinct muscle, which goes to the lower end of the inner side of the shaft of the femur. It *arises* from the same sixth as the latter, but only from the crest of the os pubis, which is to the inner side of the pectineal origin. It is *inserted* above the internal condyle of the femur, at the junction of the front surface with the inner. This muscle may be looked upon as an accessory psoas, and may be named pectineo-femoralis, for the insertion is similar to the ilio-femoralis posterior in *Macrorhinus*. The pectineo-superficialis is regarded as the pectineus in *Otaria* and *Trichechus*. It is an adductor. The superficialis can flex the hip in addition. In the Phocinæ it is supplied by the obturator nerve.

The *Adductors* are wanting in the Phocinæ, but seem to be worked into the fibres of the very large obturator externus.

The *Adductor longus* in *Macrorhinus leoninus arises* from the posterior outer half of the pubic bar, from the outer surface of the ascending ramus of the pubis, with the exception of a margin near the symphysis, extending to the junction of this ramus with the descending ramus of the ischium, which is in a line with the middle of the acetabulum, and very slightly from the obturator membrane next the bone. It is *inserted* into the supracondyloid ridge below the psoas tertius, and above the epiphysial line on the inner border of the femur.

In a large specimen of *Arctocephalus gazella* this muscle could probably be divided into two. It *arises* from the outer hindward ventral half of the pubic bar, behind the obturator foramen, from all the surface between the origins of the obturator externus, and the gracilis and adductor magnus, and from the hindward quarter of the ischial bar to the origin of the quadratus femoris. It is *inserted* obliquely across the back surface of the femur, from the lower end of the great trochanter to the middle of the inner surface of the shaft of the femur, ending at the junction of the anterior surface with the inner. The adductor longus primus and secundus of *Otaria* form the adductor longus of *Arctocephalus*. In *Trichechus* the adductor longus has only one head. It adducts the thigh in *Macrorhinus*, but in *Arctocephalus* besides adducting, the fibres upon the posterior surface rotate it outwards, those on the inner surface inwards.

From the lower end of the great trochanter in *Arctocephalus*, crossing the back of the femur, and terminating at the middle of the junction of the posterior with the inner surface, is a ridge of bone resembling the linea aspera of human anatomy and giving attachment throughout its entire length to the adductor longus. This is a faint ridge in *Macrorhinus*, but it lies midway between the upper and lower ends of the great trochanter, and terminates in the middle of the back of the shaft at the junction of the upper third and lower two-thirds of the femur, the pectineus touching it. In *Phoca grœnlandica* there is a similar ridge to the last, but it ends at the middle of the inner border of the femur; the pectineus also lies above and on it. Humphry describes the adductors in a general way. The name as he uses it is not altogether unsuitable, for the muscles have this action. His adductor magnus I take to be the semimembranosus. Of his other two adductors, one is the pectineus and the other probably the ilio-femoralis.

The *Adductor brevis* in *Macrorhinus leoninus*. If the pubic bar be divided into fourths, the adductor brevis *arises* from the second fourth behind the pectineal muscle, near the ilio-pectineal eminence outside the brim of the pelvis, and slightly from the outer surface dorsal to this. It passes upwards and outwards, and is *inserted* into the middle of the posterior surface of the femur, outside the insertion of the pectineus. The exact spot is found by drawing a line from the lower end of the great trochanter, across the back of the femur, when the middle of this line is the insertion surface.

In *Arctocephalus gazella* it *arises* from the pubic bar outside the brim, and from the ventral half of it behind the origin of the pectineus. It lies between the adductor longus and the pectineal muscles. It is *inserted* obliquely across the posterior surface of the femur, from the lower end of the great trochanter to the insertion of the pectineus behind the small trochanter, and higher than the longus which is upon the linea aspera. Murie describes this muscle as a primus and secundus, but I think the primus is the pectineus and the secundus the above-mentioned muscle. What he gives as the pectineus is inserted into the internal condyle of the femur, and the primus below the neck and trochanteric fossa, which is the usual insertion of the pectineus. It rotates outwards and flexes the thigh.

The *Adductor magnus* is called primus and secundus by Murie and is only found in *Arctocephalus gazella*. It *arises* from the outer rim of the innominate bone, dorsal to the symphysis, extending to the commencement of the dorsal border of the ischial bar. It passes forwards and outwards from the pelvis to the knee, and is *inserted* into the lower half of the shaft of the femur at the junction of the inner with the front surface, across the internal condyle, into the tibia immediately behind it, and into the capsule of the knee-joint on the inner side. It adducts both the femur and the tibia. It is a single muscle in *Trichechus*.

The *Obturator externus* in the Phocinæ covers the outer surface of the obturator membrane. It *arises* from the outer surface of this membrane, from the outer surface of the pubic bar to half an inch posterior to the front of the obturator foramen, from the outer surface of the ischial bar, from the outer surface of the ischial tuber, and from the anterior half of the rami of the ischium and pubes, posterior to the obturator foramen. The fibres pass upwards and forwards below the capsule of the hip-joint in four slips, which are closely attached but easily distinguished. The ventral or first slip comes from the pubic bar, the dorsal or fourth from the ischial bar, and the other two from the surface of the large obturator membrane. It is *inserted* into the obturator pit, and into the outer half of the posterior or dorsal border of the great trochanter to the external border of the femur. The slip from the ischial bar may be looked upon as the quadratus femoris, but it is indistinguishably blended with the obturator externus. This conclusion is based upon the continuation upon the great trochanter of the insertion of the large obturator.

In *Macrorhinus leoninus* it is very different from the former three muscles in its origin. It *arises* in two parts. The *dorsal* part (or *quadratus femoris*) from the posterior half of the ischial bar to where it turns down, from the outer surface of part of the ischial tuber, slightly from the obturator membrane next the bar, and from the ischial bar posterior to the obturator foramen. It is partially blended with the anterior part, and the part along the dorsal border, forming a strong broad tendon, which gives off a tendinous slip from its ventral side. This slip joins the adductor brevis, and is *inserted* along with it. The larger remaining part of the muscle goes along the under surface of the neck of the femur, and is *inserted* into the whole of the dorsal or posterior border of the great trochanter. The *anterior part* (or *obturator externus proprius*) *arises* from the outer surface of the ischial bar from opposite the middle of the obturator foramen to behind the acetabulum, from the same extent of the pubic bar, but only from its dorsal half, from the obturator membrane lying next the bony origins, and from the posterior half of the concave surface behind the acetabulum. It crosses the joint-capsule, and is *inserted* by a strong tendon into the upper half of the posterior surface of the great trochanter. The insertion of this part is like that of the obturator externus, while the dorsal is similar to the quadratus femoris.

In *Arctocephalus gazella* it *arises* from the entire outer surface of the obturator membrane; slightly from the capsule of the hip-joint; and from the inner half of the pubic and ischial bars surrounding the foramen. It passes forwards and upwards, and is *inserted* into the digital fossa on the back of the great trochanter by a strong tendon. In *Otaria* it is inserted into the lesser trochanter. This muscle acts as a powerful rotator of the upper end of the femur. It rolls the thigh backwards and inwards to the side of the pelvis. Humphry describes the obturatores as large, and says the quadratus femoris is not a distinct muscle. I believe it is indistinguishably blended with the externus in the Phocinæ.

In the Phocinæ the digital pit is well marked, in *Arctocephalus* it is like a groove, and in *Macrorhinus* there is none. In the Phocinæ the obturator externus covers all the ischial and pubic bars and the obturator membrane to a little behind the foramen ovale. There is a slight attempt at division into four slips, the slip over the pubic bar resembling the origin of the adductor longus in the other Seals, and the ischial origin the quadratus femoris. In *Macrorhinus* the surface of bone and membrane corresponding to the surface covered by the fibres in the Phocinæ is shared by the obturator externus, quadratus femoris, adductor longus and brevis. In *Arctocephalus* the same divisions exist but are not so simple. The muscle around and over the obturator membrane in

Macrorhinus has divided into three masses, the longus occupying the pubic bar and adjacent membrane, the quadratus femoris, the ischial and adjacent membrane, and the obturator externus the front of the obturator foramen and the pubic and ischial bars on either side. The adductor brevis is isolated and is almost upon the pelvic brim, and there is a large space in the centre of the obturator foramen with no fibres. In *Arctocephalus* the obturator externus covers all the membrane and bone surrounding the foramen. The brevis is on the pubic bar and the longus is behind the brevis and runs round the posterior aspect of the obturator externus to the ischial bar, while the quadratus femoris is anterior to its termination. The function of this area of bone posterior to the acetabulum in the Seals is to give attachment to fibres which will rotate the femur outwards, adduct, and flex at the hip-joint. In *Arctocephalus* there are separate muscles for these various movements, in addition there is an adductor magnus, and each is separately *inserted* into the femur. In *Macrorhinus* there is no magnus, the brevis is insignificant in comparison with the same in *Arctocephalus*, and on the femur it is receding to the obturator extensor insertion. The longus is confined to the internal border of the femur, whereas in *Arctocephalus* it crosses obliquely the back of the femoral shaft. The quadratus femoris though separate at its origin in *Macrorhinus* is combined with the externus at the insertion. In the Phocinæ all the fibres of the externus go to the digital fossa near it. Though the origins in *Macrorhinus* are nearly like those in *Arctocephalus* the insertions are not, but slightly resemble those of the Phocinæ as regards the quadratus and obturator externus, and those of *Arctocephalus* as regards the brevis, and are like neither in the longus. The movements of the thigh in the Phocinæ are the most imperfect, and this combined mass is sufficient for them. In *Macrorhinus* a higher stage is reached as indicated by the separation into muscle bundles, and in *Arctocephalus* there is sufficient differentiation of the muscular mass to enable the animal to walk as well as swim.

The Gluteal Region of the Phocinæ and *Macrorhinus* contains the gluteus maximus, medius, minimus, pyriformis, obturator internus, and gemelli.

In *Arctocephalus* in addition to these there is the quadratus femoris.

The *Gluteus maximus* in *Phoca vitulina* is the most superficial muscle of the gluteal region, and is triangular in form. The base rests upon the vertebral spines and the apex upon the femur. The dorsal head *arises* from the crest of the ilium between the two lips, extending from the ventral anterior spine to the dorsal posterior spine; between the dorsal posterior spine and the spine of the last lumbar vertebra it takes origin from the fascia covering the erector spinæ, and also from the spines of the last lumbar, all the sacral, and the 1st caudal vertebra, by the fascia which is an extension backwards of the lumbar aponeurosis, from the tendinous expansion over the back of the sacrum, and from the dorsal sacro-iliac ligament. The ventral head is a narrow riband-shaped fasciculus about an inch broad. It *arises* beneath the great division opposite the level of the 3rd sacral vertebra, from the side of the dorsal sacro-iliac ligament. The fibres of the dorsal division pass from their origin to the great trochanter and the external border of the femur. Those coming from the crest of the ilium go backwards to the lower and outer part of the anterior border of the great trochanter. The portion lying between the dorsal posterior spine and the three sacral vertebræ passes almost horizontally outwards, and the remainder between the 3rd sacral and the 2nd caudal go forwards and outwards to join the femur. The dorsal part is *inserted* into the outer third of the anterior border of the great trochanter, goes obliquely across the great trochanter to the middle of its posterior border, and then passes out along the outer half of its posterior border, down the outer border of the shaft of the femur, to the lower end of the external supracondyloid ridge. The ventral part is *inserted* into the under surface of the dorsal part near the outer border of the femur, a few fibres gaining the femur. In *Phoca hispida* the gluteal muscle was in a very bad condition. It *arises* from the 4th sacral and 1st to 4th caudal vertebræ, and the insertion is as in *Phoca barbata*. In *Phoca barbata* it is smaller than in *Phoca vitulina*, and has three heads. The anterior head *arises* from the aponeurosis over the erector spinæ, by a band of muscular fibres springing midway between the dorsal posterior spine of the ilium and the 1st sacral vertebra, and from the dorsal sacro-iliac ligament. The second or posterior head *arises* from the posterior continuation of the same aponeurosis, which is attached to the spine of the 4th sacral vertebra, and the 1st, 2nd, and 3rd caudal vertebræ. The third or ventral head consists of a series of fibres springing from the side of the dorsal sacro-iliac ligament, opposite the level of the 4th sacral and 1st caudal vertebræ, beneath the posterior part. There is a space between the first and second heads and the erector spinæ, and the dorsal sacro-iliac ligament is uncovered by the gluteal muscles over the sacrum. The fibres from the first head pass back and out, those of the posterior part pass out and forwards over the great trochanter, and form one muscle by the anterior head joining the posterior. The three heads are inserted into the femur by the ventral or third head joining the under surface of the second, and sending a few fibres directly to the femur; thus two heads are left, the anterior and posterior, which are disposed like the dorsal head in *Phoca vitulina*.

In *Macrorhinus leoninus* there are three parts. The anterior part *arises* from the dorsal surface of the dorsal sacro-iliac ligament, and from the inferior lip of the crest of the ilium, and after joining the ventral part is *inserted* with it into the posterior half of the great trochanter. The ventral part lies beneath the posterior part, and *arises* from the ventral surface of the dorsal sacro-iliac ligament, and from the anterior surface of the 2nd and 3rd sacral vertebræ. It goes to the femur, and is joined, near the great trochanter on the anterior border, by the anterior part. The posterior part *arises* from the fascia over the 1st to the 3rd sacral spines and the 1st caudal, and from the dorsal surface of the dorsal sacro-iliac ligament. It passes transversely outwards to the femur, and is *inserted* into the outer border of the femur below the great trochanter and into the external condyle.

In *Arctocephalus gazella* there are two heads. The anterior *arises* from the fascia attached to the spines of the 1st, 2nd, and 3rd sacral vertebræ, goes outwards to the femur, and is *inserted* into the lower three-fourths of the posterior border of the great trochanter. The posterior *arises* from the fascia attached to the spines of the 1st, 2nd, and 3rd caudal vertebræ, and is partly overlapped by the anterior head. The fibres pass transversely outwards, and are *inserted* into the external border of the femur, into the capsule of the knee-joint, and into the head of the fibula.

Humphry and Lucae do not refer to the ventral part. In *Otaria* it has two parts, but there is only one in *Trichechus*. In the Phocinæ and *Macrorhinus* the iliac part rotates the femur inwards, tilts the lower end outwards, while the posterior part will rotate the femur outwards and flex the thigh. In *Arctocephalus* there are no iliac fibres, and consequently no rotation inwards and forwards.

The *Gluteus medius* in the Phocinæ is situated below the maximus, and *arises* from the lower lip of the crest of the ilium, from the external surface of the ilium immediately below the lower lip, from the sides of the laminæ of the 1st, 2nd, and 3rd sacral vertebræ below the dorsal sacro-iliac ligament, and from the ventral surface of the ligament below the 1st and 3rd sacral vertebræ. The anterior fibres pass backwards and outwards, the middle outwards, and the posterior forwards and upwards, just like those of the gluteus maximus, but on a smaller scale. It is *inserted* into the great trochanter of the femur. The anterior fibres are fixed to the middle of the front border of the great trochanter; from here the fibres are attached obliquely across the trochanter to the junction of the upper surface with the posterior border, where they fix themselves to the upper half of the posterior border of the great trochanter.

In *Macrorhinus leoninus* it *arises* from below the inferior lip of the ilium, and behind the ridge which extends from the ventral anterior spine to the middle of the acetabulum. It is *inserted* into the outer surface of the great trochanter above the tubercle on the superior side of the posterior border and the middle of the anterior border.

In *Arctocephalus gazella* it *arises* from the inferior lip of the crest of the ilium, and from the lumbar aponeurosis. The fibres pass backwards, and are *inserted* into the great trochanter from midway between the anterior border to the posterior inferior corner of it. In the Phocinæ and *Macrorhinus* it tilts the lower end of the femur outwards, rotates the trochanter inwards, and pulls the femur forwards. In *Arctocephalus* it draws the head of the bone inwards and forwards.

The *Gluteus minimus* in *Phoca vitulina* and *Phoca hispida* is beneath the medius, and *arises* from the outer surface of the ilium behind the ridges passing from the ventral anterior spine to the middle of the front of the acetabulum; this surface of origin is concave. It forms a narrow muscular rectangle which can be divided into three slips. It is *inserted* into the upper inner half of the front border of the great trochanter, and slightly into the surface of the trochanter adjoining. In *Phoca barbata* the origin is similar, but the *insertion* is into the outer half as well as into the inner half of the front border of the great trochanter.

In *Macrorhinus leoninus* it *arises* from the concave surface of the ilium behind the medius and dorsal to the ridge. It is *inserted* into the anterior border of the great trochanter in its upper half.

In *Arctocephalus gazella* it *arises* from the external surface of the ilium dorsad to the feebly marked ridge (already mentioned) and from the venter of the dorsal sacro-iliac ligament; and is *inserted* into the upper half of the front border of the great trochanter above the insertion of the gluteus medius. In all the action is to rotate the femur inwards and forwards.

The *Pyriformis* in the Phocinæ cannot be recognised apart from the gluteus medius until the dorsal sacro-iliac ligament is cut and turned aside. It *arises* from the ventral surface of the dorsal sacro-iliac ligament posterior to the 1st sacral foramen, and from the sides of the ventral surfaces of the 1st, 2nd, and 3rd sacral vertebræ. The fibres converge and are *inserted* into the upper third of the back of the great trochanter of the femur.

In *Arctocephalus* it closely resembles the same part in *Phoca*, but *arises* from the 2nd, 3rd, and 4th sacral vertebræ.

The *Gemellus superior* in *Phoca vitulina* and in *Arctocephalus* lies anterior to the tendon of the obturator internus. It *arises* from the dorsal surface of the ischial bar posterior to the acetabulum. The *Gemellus inferior* in *Phoca vitulina* and in *Arctocephalus* lies posterior to the tendon of the obturator internus. It *arises* from the internal surface of the ischium below the tuber extending to the origin of the obturator internus inferiorly, and the obturator internus tendon anteriorly. For the insertions of the gemelli in *Phoca*, see the obturator internus.

In *Arctocephalus* they are *inserted* into the great trochanter to the outer side of the obturator internus.

The *Obturator internus* in *Phoca vitulina arises* from the internal surface of the obturator membrane, and from the rim of bone around it, and forms a tendon which goes over the dorsal surface of the ischial bar in its groove. The two gemelli meet over, surround, and conceal the tendon of the obturator internus; and all three are *inserted* together into the posterior border of the great trochanter.

In *Arctocephalus,* after scraping away the gemelli and isolating the tendon, the muscle is found to *arise* from the obturator membrane, &c., as in *Phoca;* and is *inserted* to the inner side of the insertion of the gemelli into the posterior upper end of the great trochanter of the femur.

The *Quadratus femoris* is only found in *Arctocephalus.* It is triangular, and *arises* from the dorsal half of the ischial bar, posterior to the gemellus inferior and anterior to the origin of the semimembranosus. It passes forwards, outwards, and downwards, and is *inserted* by a tendon into the lower half of the posterior border of the great trochanter.

These three rotate the femur outwards, bringing the thigh near the pelvis.

In *Macrorhinus* the dorsal part of the obturator externus represents the quadratus. In the Phocinæ it is fused with the obturator externus and unrecognisable as the quadratus.

The Muscles from the Pelvis to the Leg.—In the Phocinæ, *Macrorhinus leoninus,* and *Arctocephalus gazella* the gracilis, semimembranosus (in *Phoca vitulina* it has an anterior and posterior part), semitendinosus (with two heads), and biceps (which has a long head, the biceps, and a short head named the sacro-peroneus) are present.

The *Gracilis,* also called symphysis tibialis in Lucae's plate, is a flat triangular muscle in the Phocinæ, stretching from the symphysis to the tibia. It *arises* from the symphysis pubis, and radiates outwards to the lower leg, the superficial fibres only arising not from the bone but from the linea alba. The posterior third of the latter is continuous with the fasciculi of the opposite side over the symphysis. The anterior two-thirds is anterior to the pubic arch, the muscle of the right side is beneath and overlapped by that of the left. It is *inserted* into the posterior two-thirds of the ventral surface of the tibia, and many of the fibres end in a tendon near the shaft. The tendon of insertion is combined with that of the semimembranosus and semitendinosus. In the substance of the gracilis, near the ventral border of the tibia and parallel with it, is a long narrow tendon running at right angles to its fibres. This is an indistinct white streak close to its anterior border, which gradually widens and strengthens to a strong broadish tendon at its posterior border; at the bend of the anterior surface of the astragalus it expands, forming, with the prolongations backwards of the combined tendons of insertion of the semimembranosus and semitendinosus, and gracilis, the plantar fascia.

In *Macrorhinus leoninus* it *arises* from the symphysis pubis by the fibres of its deep surface, from the linea alba in front of the pubis by the intermediate fibres, and by the superficial fibres from the ligament stretching between the pubic bones. The fibres opposite the pubes are blended with those of the opposite side. It is *inserted* into the posterior half of the tibia.

In *Arctocephalus gazella* it *arises* from the symphysis pubis, and from the ligament between the pubic bones. The superficial fibres are continuous with those of the opposite side, and none of the fibres reach further forward than the symphysis. It is *inserted* into the middle third of the ventral surface of the tibia, extending to the external border. It draws the leg inwards, and in *Arctocephalus* will turn the leg inwards when progressing on land. In *Otaria* a few fibres overlap the external oblique, but in *Trichechus* it has no fibres covering this muscle, and so is similar to *Arctocephalus*. In the Phocinæ it is supplied by the obturator nerve.

The *Semimembranosus* is named Musc. pubo-tibialis by Lucae; in *Phoca vitulina* it lies above the gracilis and is partially hidden by it. It is in two parts, the anterior and posterior. The anterior *arises* from the outer surface of the innominate bone posterior to the foramen, in front of the origin of the posterior part, and above the origin of the gracilis. It is *inserted* into the posterior two-thirds of the front of the tibia, its tendon combining with the gracilis. The posterior part *arises* from the outer edge of the innominate, between the tuber ischii, from which it also has fibres of origin, and the origin of the anterior part from the pubic bone. It is *inserted* into the tibia, anterior to the semimembranosus (anterior part), and extends forwards to one-fifth from the upper extremity of the tibia. In *Phoca hispida* the anterior part *arises* from the outer surface of the innominate bone, from the body of the pubis upwards to where the pubis and ischium fuse, and from the edge of the bone between the origin of the gracilis to the semimembranosus (posterior part). It is *inserted* into the posterior half of the ventral surface of the tibia, in conjunction with the semitendinosus and hinder three-fourths of the gracilis. The posterior part is placed above the gracilis. It *arises* from the outer dorsal half of the pubic bone, between the tuber ischii and the origin of the semimembranosus anterior part, slightly from the base of the tuber posteriorly, and from the edge of the bone between these two points. It goes outwards and forwards, and is *inserted* into the ventral surface of the tibia in its upper half, the fibres almost reaching the head of the shaft. In *Phoca barbata* both parts are similar to the last, except that the origin does not go up to the tuber ischii, and the insertion is smaller, not reaching so far forwards on the tibia, but falling short of the head by a quarter of the length of this bone.

In *Macrorhinus leoninus* it is almost the same as is the posterior part in Phocinæ. It *arises* from the outer surface of the innominate bone, posterior to the origin of the adductor longus and that part of the obturator externus which represents the quadratus femoris, extending backwards a little more than halfway between the symphysis and the ischial tuber. It is *inserted* into the anterior half of the ventral surface of the tibia, reaching almost to the head of the bone.

In *Arctocephalus gazella* it is closely allied to the posterior part in *Phoca vitulina*, *Phoca hispida*, and *Phoca barbata*. It *arises* from the posterior third of the outer edge of the pubic bar, which is behind the rudimentary tuber ischii, from the third of the posterior border of the innominate bone, which is the continuation of the sitting bone downwards, and slightly from the surface of the innominate adjoining the marginal origin. It is *inserted* into the front of the tibia in front of the semitendinosus, the fibres terminating a quarter of the length of the tibia from the head of the shaft, *i.e.*, it is *inserted* into the second fourth of the tibia from the head. Lucae describes it as one part in *Phoca*. In *Otaria*, what Murie names semitendinosus I call semimembranosus; this also applies to *Trichechus*.

In all the specimens the posterior part is present; in *Macrorhinus* and *Arctocephalus* the anterior part is wanting. The insertion of the posterior part in all is nearer the tibial head, the insertion in *Macrorhinus* almost touching it. The portion of bone giving origin to the anterior part in the Phocinæ is utilised in *Arctocephalus* for the adductor magnus, and in the latter it has wandered up the limb and divides its attachment between the femur and tibia. This is a case of the migration of a muscle, the anterior part of the semimembranosus in the Phocinæ having become an adductor muscle in *Arctocephalus* by changing to a more anterior position in the hind limb. The former adducts the thigh and leg and rotates the limb, and the latter adducts the leg and also rotates it. In the Phocinæ it is supplied by the obturator nerve.

The *Semitendinosus*, which is named Musc. coccygo-tibialis by Lucae and the semimembranosus by Murie, has two heads of origin. The dorsal head *arises* from the posterior half of the spine of the last sacral vertebra, from the spine of the 1st caudal vertebra, and is continuous anteriorly with the gluteus maximus. The ventral head *arises* from the side and ventral surface of the dorsal sacro-iliac ligament, and from the transverse processes and bodies of the 4th and 5th sacral, and the 1st and 2nd caudal vertebræ. The dorsal head is *inserted* upon the dorsal surface of the ventral head, half an inch from the caudal vertebræ. The ventral, thus strengthened, passes to the posterior two-thirds of the front of the tibia, into which it is *inserted*. In *Phoca hispida* the dorsal part was not seen, and the ventral part was also in a bad state of preservation. It appeared to *arise* from the 2nd, 3rd, 4th, and 5th caudal vertebræ, and to be *inserted* into the posterior two-thirds of the front of the tibia above the semimembranosus. In *Phoca barbata* the dorsal head, or gluteal slip, which is continuous with the hindmost fibres of the gluteus maximus, *arises* from the 2nd and 3rd caudal vertebræ; the ventral head *arises* from the 2nd, 3rd, 4th, and 5th caudal vertebræ. The insertion is the same as in *Phoca hispida*.

In *Macrorhinus leoninus* there are two heads of origin. The dorsal head *arises* from the spine of the 2nd caudal vertebra, under cover of the gluteus maximus, and from the dorsal sacro-iliac ligament, as in the others. The fibres are obliquely directed backwards and outwards. It is *inserted* into the posterior third of the second head near the commencement of the tendon, which is midway between the origin and insertion. The ventral head *arises* from the sides of the 1st, 2nd, 3rd, and 4th caudal vertebræ near the anterior surface of their bodies. Midway between its origin and insertion it forms a very strong broad tendon, which is *inserted* into the posterior half of the ventral surface of the tibia; the outer half covers the gracilis.

In *Arctocephalus gazella* it *arises* from the transverse processes of the 2nd, 3rd, 4th, 5th, and 6th caudal vertebræ, and from the sides of the bodies of these vertebræ between the transverse processes and their tubercles. It is *inserted* into the lower half of the ventral surface of the tibia. In *Otaria* and *Trichechus* it is *inserted* into the posterior half of the tibia like *Arctocephalus*. The action is the same as in the last muscle. Humphry, Lucae, and Murie do not refer to the double mode of origin. In the Phocinæ it is supplied by the obturator nerve.

The *Biceps*, or ischio-tibialis of Lucae, consists of two distinct muscles, and these are named the *Biceps* or long head, and the *Sacro-peroneus* or short head (sacro-fibularis of Lucae). In *Phoca vitulina* the long head is fan-shaped, and *arises* from the ischial tuberosity, and from the dorsal and outer surface of it by a pointed fasciculus. It spreads out or radiates towards the fibula. Over the peronei it extends from the head of the fibula almost to the malleoli. Here it is bound to the deep fascia covering the peroneal muscles, and terminates by joining the strong fascia over the outer muscles of the leg, which fascia is bound to the outer and ventral surface of the tibia. The portion at the lower end of the fibula joins the sacro-peroneus and is *inserted* with it. The short head or sacro-peroneus is riband-like, and *arises* from the under surface of the dorsal sacro-iliac ligament, from the sides of the 2d and 3rd sacral vertebræ. It goes obliquely backward and outward to the lower outer third of the fibula. It is *inserted*, after joining the former, into the posterior quarter of the dorsal border of the fibula along with the tendon of the long head. In *Phoca hispida* the long head is the same as in *Phoca vitulina*, and the short head or sacro-peroneus *arises* from the 4th sacral and 1st caudal vertebræ. In *Phoca barbata* the biceps (long head) is the same as in *Phoca vitulina*, and the sacro-peroneus *arises* from the 2nd and 3rd sacral vertebræ.

In *Macrorhinus leoninus* the long head of the biceps *arises* from the dorsal sacro-iliac ligament opposite the 1st caudal vertebra by a small slip, which blends posteriorly with the ventral part of the semitendinosus, and joins the origin from the tuber ischii 1 inch behind it; otherwise it is the same as in *Phoca vitulina*. The sacro-peroneus or short head *arises* from the ventral and lateral surfaces of the 2nd and 3rd sacral and 1st caudal vertebræ, and from the ventral and lateral surfaces of the dorsal sacro-iliac ligament. It is *inserted* as in *Phoca vitulina*.

In *Arctocephalus gazella* the long head of the biceps consists of three parts; all three *arise* from the sides of the sacral vertebræ. The fibres are transverse and go to the outer anterior surface of the tibia. The anterior part is slightly overlapped by the middle, but the fibres of the middle and posterior parts touch each other. Over the back of the fibula these three form a tendon which turns round the limb to the ventral border. This tendon forms also the deep fascia over the muscles of the leg, and is attached to the tibia, but it does not appear to go to the fibula. The sacro-peroneus or short head *arises* from the anterior surface of the 4th sacral and 1st caudal vertebræ, and is *inserted* by a small tendon into the dorsal border of the fibula, over the dorsal malleolus. In all the two heads bend the knee, roll the legs outwards, and adduct them. In *Otaria* and *Trichechus* the long head is in two parts. In the Phocinæ both the long and the short heads are supplied by the small sciatic.

The Leg.—The Outer Tibio-fibular Region in all the specimens has a tibialis anticus, extensor proprius hallucis, and extensor longus digitorum.

The *Tibialis anticus* in the Phocinæ and *Macrorhinus* is an elongated triangle with the base at the knee-joint. It is partly under cover of the extensor communis digitorum, and *arises* from the outer surface of the tibia in its anterior two-thirds, with the exception of a small triangular surface at the upper dorsal part of the head of the shaft, from the ligamentum patellæ, from almost the whole of the anterior two-thirds of the interosseous membrane, and by a small fasciculus from the outer surface of the fibula posterior to the fusion of the bones. Almost at the posterior third of the tibia it forms a strong tendon, which goes through the groove on the outer side of the posterior extremity of the tibia, beneath the annular ligament, and divides into two tendons of equal size. It is *inserted* into the proximal end of the metatarsal bone of the hallux on its tibial and outer surface, and into the ventral tibial surface of the internal cuneiform.

In *Arctocephalus gazella* it *arises* from the head and from the outer surface of the tibia in its anterior four-fifths. Near the annular ligament it forms a tendon, which passes beneath it, ventral to the extensor proprius hallucis, and crosses the tarsus, then expands and is *inserted* into the proximal tibial surface of the 1st metatarsal on its outer side. In *Otaria* and *Trichechus*, besides the insertion, there is also as in *Arctocephalus* a tendon to the entocuneiform bone. In the Phocinæ and *Macrorhinus* it flexes the ankle, depresses the pes, and turns it outwards. In *Arctocephalus*, besides having these actions, it will in walking raise the foot on to the outer edge. Lucae gives only one tendon of insertion, and that to the metatarsal. In the Phocinæ it is supplied by the musculo-cutaneous nerve (dorsal division).

The *Extensor proprius hallucis* in the Phocinæ and *Macrorhinus* lies along the dorsal side of the extensor communis digitorum, under cover of the peroneus longus. It *arises* from the whole of the ventral surface of the fibula, from a very slight margin of the outer surface of the interosseous membrane next the shaft, and from the ventral border of the shaft from the termination of the outer border to the junction of the middle and posterior thirds. It crosses from the dorsal side of the extensor communis to its ventral side, runs beneath the annular ligament between the tibialis anticus and the extensor communis digitorum, and goes over the tendon of the tibialis anticus to the ventral surface of the tarsus, then it ascends gradually to the outer surface of the distal end of the 1st metatarsal. It is *inserted* into the distal tibial outer surface of the same, into the proximal end of the 1st phalanx, and into the capsule of the joint between. In the Phocinæ it is supplied by the musculo-cutaneous nerve (ventral division).

In *Arctocephalus gazella* it is almost as large as the tibialis anticus in the same animal. It *arises* from the anterior two-thirds of the ventral surface of the fibula, from the anterior half of the dorsal border of the tibia, from a small triangular surface of the tibia posterior to its head, and between its short outer border and its dorsal border, from the fusion of the tibio-fibular articulation beneath the origin of the extensor longus digitorum, and from the interosseous membrane. It courses backwards between the tibialis anticus on its ventral side and the extensor longus digitorum on its dorsal; beneath the annular ligament it forms a tendon, which passes over the tibio-fibular joint and the tarsus, and runs along the dorsal side of the 1st metatarsal. It is *inserted*, after the expansion of its tendon, into the proximal end of the outer surface of the 1st phalanx. In *Otaria* it *arises* from the fibula and interosseous membrane, and to the proximal end of the proximal phalanx of the hallux. In the Phocinæ and *Macrorhinus* it extends the digit, and then flexes the ankle, and depresses and abducts the pes. In *Arctocephalus* it only extends and flexes.

The *Extensor communis* or *longus digitorum*, named by Lucae the extensor quatuor digitorum, in the Phocinæ and *Macrorhinus* is an elongated triangle situated between the tibialis anticus and the peroneus longus. The latter partially overlaps it on the dorsal side, and it partially overlaps the tibialis anticus, and crosses the extensor hallucis. It *arises* from the triangular surface of the tibia posterior to the superior tuberosity, marked off inferiorly by a faint ridge, *i.e.*, the short outer border which extends from the middle of the outer surface of the superior tuberosity backwards and upwards to the dorsal border of the tibia, from the tibia anterior to the fusion of the bones of the leg, from the capsule of the joint, and from the outer surface of the tibia and fibula where they fuse posterior to the origin of the peroneus longus. It forms a strong tendon, which passes backwards, crosses over the extensor hallucis, and goes beneath the annular ligament dorsal to the extensor hallucis at the posterior tibio-fibular articulation. Having traversed this, it crosses the ankle-joint and enters the groove on the middle of the outer side of the tarsus, which terminates over the proximal end of the 3rd metatarsal bone. Here it expands and divides into four tendons. The first or ventral passes obliquely over the ventral distal end of the 3rd metatarsal and expands upon the upper proximal end of the 1st phalanx of the 2nd digit. The second tendon passes back over the middle of the outer surface of the 3rd metatarsal, and expands upon it. The third crosses obliquely over the middle of the dorsal side of the 3rd metatarsal, goes backwards upon the ventral side of the 4th metatarsal, and expands upon the proximal end of the inferior side of the 1st phalanx. The fourth crosses obliquely backwards and upwards from the proximal dorsal end of the 3rd metatarsal, over the middle of the outer surface of the 4th metatarsal, and reaches the ventral distal end of the 5th metatarsal. These four tendons go backwards over the metatarso-phalangeal joints, expand upon the outer surfaces of the 1st phalanges of the four digits, and are *inserted* into the distal ends of the 1st phalanges of these digits, into the outer surfaces of the ligaments between the phalanges, and into the proximal ends of the 2nd phalanges.

In *Arctocephalus gazella* it is a long narrow muscle, and *arises* from the external condyle of the femur, by a small fasciculus posterior to the insertion of the gluteus maximus, which passes backwards over the capsule of the knee-joint, gaining fibres from it, from the outer sides of the head of the tibia and fibula adjoining the fused tibio-fibular articulation, also from the anterior half of the outer border of the fibula by a fine but strong aponeurosis ventral to and touching the tendon of origin of the peroneus brevis from the same border. Anterior to the malleolus it is a strong tendon, which passes beneath the annular ligament, traverses the shallow groove on the outer surface of the fibula, and the groove on the astragalus, lies on the outer surface of the tarsus between the cuboid and cuneiform bones, and expands and divides into four slips over the bones of the 3rd and 4th metatarsals. The first or ventral runs along the dorsal side of the 2nd metatarsal; the second along the middle of the 3rd metatarsal, the third along the ventral side of the 4th metatarsal. The fourth crosses the outer surface of the middle of the 4th metatarsal, and runs down the ventral side of the 5th metatarsal. At the metatarso-phalangeal articulation, the tendons begin gradually to widen; over the distal ends of the proximal phalanges they completely cover their outer surfaces; and after passing over the joints and sharing in the formation of the posterior ligament they are *inserted* into the proximal ends of the 2nd phalanges of the 2nd, 3rd, 4th, and 5th digits; from their attachments, fine aponeurotic sheets are prolonged onwards, and end unnoticeably over the phalanges. In the Phocinæ I did not find any origin from the femur, as described by Lucae. In *Otaria* and *Trichechus* there is no tibial origin. In the Phocinæ, *Macrorhinus*, and *Arctocephalus* it extends the digits, and flexes the ankle. In the Phocinæ it is supplied by the musculo-cutaneous nerve (ventral division).

The Fibular Region in all the specimens has the same muscles. The peronei longus, quinti digiti, and brevis.

The *Peroneus longus*, the peroneus primus of Lucae, in the Phocinæ and *Macrorhinus* is a longitudinal band of fibres. It *arises* from the small pit on the external condyle of the femur above the depression for the origin of the popliteus, from which it is separated by the intervention of the capsule of the knee-joint, which is attached to the femur between these two origins, and above it is the termination of the insertion of the gluteus maximus; also from the external surfaee of the capsule of the knee, from the outer surface of the fused tibio-fibular articulation, slightly from the adjacent surfaces of both bones and from the fascia above the muscle. It courses backwards over the tibio-fibular ankylosis, and lies in the hollow between the bones of the leg. About the junction of the middle with the posterior third of the fibula it ends in a strong tendon, which leaves the interosseous space and crosses obliquely backwards and upwards to gain the inferior groove on the outer surface of the fibula, then it follows the bed of this groove, which runs to the dorsal malleolus beneath the annular ligament. It passes over the tendons of the peronei brevis and quinti digiti which lie on the calcaneo-astragaloid articulation, and, entering the dorsal groove on the posterior outer corner of the os calcis, runs obliquely backwards, inwards, and downwards in the groove upon the dorsi-plantar surface of the cuboid bone. It goes beneath the ligament stretching from the plantar surface before the peroneal groove of the cuboid to the base of the metatarsal of the 5th digit, and finally enters the groove on the plantar surface of the cuneiform bones. It is *inserted* into the base of the proximal extremity, on the plantar and dorsal side of the metatarsal of the hallux, the ligaments of the foot forming a channel for it by bridging over the grooves. The high origin of this muscle from the femur will give support to the knee, and make up for the absence of the external lateral ligament.

In *Arctocephalus gazella* it is situated on the outer side of the leg, and *arises* from the external condyle of the femur, out of the same tendon which gives origin to the popliteus and plantaris muscles; and from the tibia and fibula at the tibio-fibular ankylosis, as in *Phoca*. It courses backwards between the extensor communis digitorum and the dorsal malleolus, turns outwards over the inner border of the fibula and gains the dorsal surface, enters the outer groove of this surface, runs over the tendons of the peronei brevis and quinti digiti, traverses the inner groove on the dorsal surface of the os calcis, and turns down into the groove of the cuboid bone, descending obliquely forwards over the cuneiform bones to the proximal extremities of the metatarsals. It is *inserted* into the dorsal proximal extremity of the 1st metatarsal bone. In *Otaria* and *Trichechus* it has origin from the femur, and is inserted into the head of the 1st metatarsal, and joins the fascia to that of the 4th. In the Phocinæ it extends the ankle and turns the dorsal border of the foot outwards; in *Arctocephalus* only it will raise the heel in walking. Humphry and Lucae describe no tibial fibres. In the Phocinæ it is supplied by the musculo-cutaneous nerve.

The *Peroneus quinti digiti* in the Phocinæ and *Macrorhinus* is a flat band-like muscle which *arises* from the outer surface of the peroneus brevis, upon which it is planted, and from the outer surface of the head of the fibula, dorsal to the peroneus longus. It passes backwards to the posterior end of the fibula, and is closely adherent to the peroneus brevis, from which it is with difficulty separated. About the lower third of the outer side of the fibula it forms a small tendon, which passes through the annular ligament behind the malleolus in front of the tendon of the peroneus brevis. It goes in this order over the inferior groove of the os calcis, and is *inserted* into the outer and dorsal surfaces of the distal end of the 5th metatarsal, and the proximal end of the 1st phalanx of the 5th digit.

In *Arctocephalus gazella* it lies on the peroneus brevis, and *arises* from the head of the fibula below the soleus, and from the anterior quarter of the dorsal surface of the fibula. It is adherent to the peroneus brevis, passes backwards in the inner groove on the dorsal surface of the fibula upon the tendon of the brevis, then it enters the groove of the os calcis which is on its outer surface, and proceeds backwards upon the dorsal side of the 5th metatarsal bone to be *inserted* into the proximal dorsal extremity of the 1st phalanx of the 5th digit, expanding before reaching it. In the Phocinæ it is supplied by the external popliteal nerve.

The *Peroneus brevis*, the peroneus secundus of Lucae, in the Phocinæ and *Macrorhinus leoninus* is the largest of the group, and *arises* from the outer surface of the head of the fibula; and from the anterior three-quarters of the outer surface of this bone, the fibres arising from the anterior half being dorsal to the outer border, and the remaining fourth of the muscle dorsal to the ventral border. Near the malleolus it forms a strong tendon, which goes with the peroneus quinti digiti but to its upper side through the annular ligament, and in this order enters the inferior groove on the os calcis, and is *inserted* into the dorsal surface and distal end of the 5th metatarsal.

In *Arctocephalus gazella* it is beneath the peroneus quinti digiti, and *arises* from the dorsum of the head of the fibula below the peroneus longus, from the whole extent of its outer border, and from the posterior three-fourths of its dorsal surface. It has the same course as the peroneus quinti digiti, and is *inserted* into the dorsal proximal surface of the 5th metatarsal bone, but before gaining the bone it broadens considerably. In *Otaria* it is very much the same as in *Arctocephalus*. In *Trichechus* the tendon does not expand so much as in *Otaria*. In the Phocinæ it is supplied by the external popliteal nerve.

In all the specimens the peroneus tertius and the peroneus quartus are absent.

In *Trichechus* are found the peroneus tertius and the peroneus quarti digiti, which latter is diminutive. The peroneus longus is an extensor of the ankle, the peroneus brevis and the peroneus quinti digiti are flexors and abductors of the foot, and the brevis and quinti digiti expand the toes.

The Inner Tibio-fibular Region consists of a superficial and a deep group of muscles.

The Superficial Group in *Phoca vitulina*, *Phoca hispida*, *Phoca barbata*, and *Macrorhinus leonins* is formed by the gastrocnemius and plantaris. In *Arctocephalus gazella*, besides the other muscles, there is the soleus.

The *Gastrocnemius* in the Phocinæ is a two-headed muscle, and the inner head is more than double the size of the outer. The inner head *arises* from the back of the femur above the internal condyle, reaching up the shaft to the junction of the internal border with the supracondyloid ridge, from the internal surface of the same condyle above the fossa for the internal lateral ligament, from the internal lateral ligament extending to the junction of the anterior third with the posterior two-thirds of the tibia, from the anterior third of the ventral border of the shaft ventral to the lateral ligament, and from the capsular ligament of the knee-joint. The outer head *arises* from the outer surface of the external condyle in common with the plantaris muscle, slightly from the outer half of the surface of the femur above the same condyle, and by a few fibres from the back of the head of the fibula. The two heads unite opposite the junction of the middle two-thirds with the posterior third of the tibia, and form a tendon which widens near the os calcis, and is *inserted* into the anterior aspect of the tuberosity of the os calcis.

In *Macrorhinus leoninus* the inner head *arises* as in *Phoca vitulina*, but covers more of the back of the femur, also from the front surface of the internal condyle up to the patellar facet of the femur. The outer head does not *arise* from the femur, but from the inner dorsal surface of the head of the fibula. The fibres of the inner head join those of the outer head at the anterior third of the tibia, and form a strong tendon, which is *inserted* as in *Phoca vitulina*.

In *Arctocephalus gazella* it is a single-headed muscle, and *arises* from the inner surface of the internal condyle of the femur below the fossa for the internal lateral ligament, from the internal lateral ligament, from the internal border of the tibia in its upper third, and from the capsule of the knee-joint. It crosses the leg from the dorsal to the ventral side; one inch from the os calcis it forms a tendon, which widens and is *inserted* into the os calcis to the outer side of the groove for the plantaris tendon.

Humphry and Lucae give no connection with the fibula; the bony attachments are the same in *Otaria* and *Trichechus*. In the Phocinæ and *Macrorhinus* it will powerfully extend the foot when swimming; in *Arctocephalus* it also extends the foot in the water, and raises the heel in walking. In the Phocinæ it is supplied by the great sciatic nerve.

The *Soleus* is found in *Arctocephalus gazella*, but not in the Phocinæ and *Macrorhinus*. It is a flattened elongated muscle, lying on the peronei brevis and quinti digiti. Near the head of the fibula it is a fine sheet, at the middle triangular, the apex being the origin, the base the free edge; over the posterior fifth it is a fleshy bundle. It *arises* from the dorsal surface of the head of the fibula by a thin tendon, from the whole length of the inner border of the shaft by a fine aponeurosis, and by muscular fibres from the inner surface of its posterior fifth, ventral to this border and dorsal to the interosseous membrane. The fibres pass backwards, and are *inserted* into the proximal surface of the tuberosity of the os calcis beneath the attachment of the gastrocnemius extending further back on the dorsal side of the bone, and on nearing the lower or posterior border of the fibula the inner surface becomes tendinous. It has the same action as the gastrocnemius. Murie gives an origin from the outer condyle of the femur which I did not observe.

The *Plantaris* in the Phocinæ lies below the gastrocnemius. It *arises*, as already mentioned, from the femur with the outer head of the gastrocnemius, and descends along the ventral side of the flexor longus hallucis, at the lower third of the leg it crosses to the dorsal side of the above muscle, and enters the plantar surface between the gastrocnemius and the flexor longus hallucis, below the backward prolongation of the tendons of the gracilis, semimembranosus, and semitendinosus which form the plantar fascia. Beneath this it widens, and is moored to the dorsal side of the larger combined tendon of the flexor longus hallucis and the flexor longus digitorum. Before reaching this tendon, the accessorius is *inserted* into its dorsal side (fig. II., p. 201). It sends one slip, behind its union with the combined tendon, to the distal end of the inner surface of the 5th metatarsal bone.

In *Macrorhinus leoninus* it *arises* alone from the same part of the femur as the outer head of the gastrocnemius and the plantaris in *Phoca vitulina*. It blends with the insertion of the gluteus maximus on its outer side at the origin. At the os calcis it enters the pes, as in *Phoca vitulina*, and joins the dorsal side of the conjoined plantar tendon of the flexor longus digitorum and the flexor longus hallucis (fig. IV., p. 202).

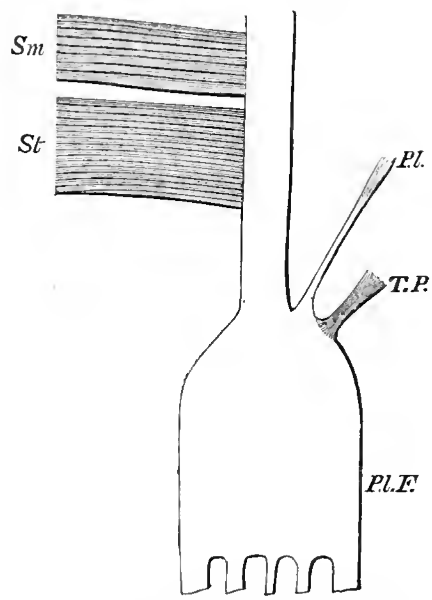


Fig. I.—The plantar fascia of *Arctocephalus*. *Sm*, semimembranosus; *St*, semitendinosus; *Pl.*, plantaris; *T.P.*, tibialis posticus; *Pl.F.*, plantar fascia.

In *Arctocephalus gazella* it is one-third the size of the gastrocnemius, and *arises*, in common with the popliteus, from the external border of the femur to the point of its tendon from the external condyle. It courses backwards, lying upon the soleus, partially covering the gastrocnemius, and is situated on the dorsal side of the leg. Near the ankle it forms a round tendon, which occupies the groove on the os calcis to the ventral side of the gastrocnemius. One inch posterior to the distal end of the os calcis it widens and divides into an anterior and posterior slip. The anterior joins the plantar fascia (fig. I.). The posterior divides into four slips, which are the superficial perforated tendons for the 2nd, 3rd, and 4th digits. In the Phocinæ it is supplied by the great sciatic nerve.

The Deep Group in all the specimens is alike. The muscles are the popliteus, flexor longus hallucis, flexor longus digitorum, with its accessorius and lumbricales, and the tibialis posticus.

The *Popliteus* in the Phocinæ is a triangular muscle with a round tendon. It *arises* from within the capsule of the knee-joint, from a shallow fossa situated below the termination of the external supracondyloid ridge on the lateral surface of the external condyle. The tendon of origin turns round to the back of the external condyle throughout its posterior surface. It crosses the back of the knee-joint obliquely from without inwards, and is *inserted* into the upper third of the ventral border of the tibia, into the inner part of the ventral tuberosity, into the whole extent of the dorsal side of the internal lateral ligament, and into the inner surface of the tibia anterior to the feebly marked oblique line posterior to this ligament.

In *Macrorhinus leoninus* the tendon *arises* below a slight depression on the lateral side of the external condyle; otherwise as in *Phoca vitulina*. It is *inserted* into the well-marked triangular surface anterior to the oblique line of the tibia; otherwise as in *Phoca*.

In *Arctocephalus gazella* it is larger than in the Phocinæ. It *arises* from the external surface of the external condyle by a strong round tendon, which forms part of the capsule of the knee-joint, and by the same origin as the plantaris from the femur. The latter origin at once becomes muscular and covers the round tendon. The two heads blend over the back of the knee-joint, and cross between the outer condyle of the femur and the head of the fibula. It is *inserted* into the anterior two-thirds of the inner surface of the tibia dorsal to the internal lateral ligament and ventral to the popliteal line. The internal lateral ligament only extends backwards to the middle of the shaft. It bends the knee and rolls the leg inwards.

There is in all the specimens a groove upon the external condyle of the femur for the tendon of the popliteus. The oblique line runs from the junction of the external and internal tuberosities on the inner surface of the tibia, backwards and downwards to join the ventral border of the tibia. This is very different from human anatomy, where it runs from the fibular facet of the tibia to the internal border. The oblique line in *Macrorhinus* is more like what is seen in man. In the Phocinæ the muscle is supplied by the great sciatic nerve.

The *Flexor longus hallucis* is the flexor digitorum of Humphry; in *Phoca vitulina* it is an elongated fusiform mass of fibre, and is the largest of the deep flexors of the back of the leg. It *arises* from the inner surface of the fibula, going backwards to its posterior extremity, from the inner surface of the head, and from the interosseous membrane. It just overhangs the ventral border of the fibula, and does not encroach far upon the interosseous space. The flexor longus digitorum touches its border and the tibialis posticus lies to its ventral side. Anterior to the inner surface of the ankle-joint it forms a tendon which is broad, flat, and strong; this runs in a groove on the backward projection of the astragalus through a fascial tunnel formed by the annular ligament. In *Phoca hispida* and in *Phoca barbata* the origins and *insertions* are similar to those in *Phoca vitulina*, but the development is much more perfect in the two former than in the latter, the bellies being much larger and more fusiform. It can with safety be said that the bellies were enormous for the size of these two animals.

In *Macrorhinus* it is like that in *Phoca vitulina*, but in addition there was a dense fascia over its anterior surface. The belly was the same as in *Phoca vitulina*, but only of moderate size.

In *Arctocephalus gazella* it *arises* from the inner surface of the head of the fibula, from the inner surface of the anterior fourth of the shaft, and by an aponeurosis from the tibia, which gradually passes from its dorsal border to the short inner border on the posterior two-thirds of the shaft. Near the ankle it forms a tendon, which runs beneath the annular ligament in the groove on the inner surface of the posterior extremity of the tibia, dorsal to the tibial groove, and at the posterior border of the os calcis blends with the flexor longus digitorum. The *insertion* comes after the insertion of the flexor longus digitorum in the Phocinæ and *Macrorhinus*.

In *Arctocephalus* the inner surface of the tibia differs from other Seals; for upon the posterior third of the shaft is a border intermediate between the ventral and dorsal borders, and it is to it that the origin of the flexor longus hallucis changes from the dorsal border. In *Otaria* and *Trichechus* it *arises* from the fibula only. In the Phocinæ it is supplied by the great sciatic nerve.

The *Flexor longus digitorum* is the flexor quatuor digitorum of Lucae. In the Phocinæ it is a triangular muscle, and *arises* from the triangular surface of the fibula to the dorsal side of the interosseous membrane behind the tibio-fibular fusion, and from the popliteal line on the inner

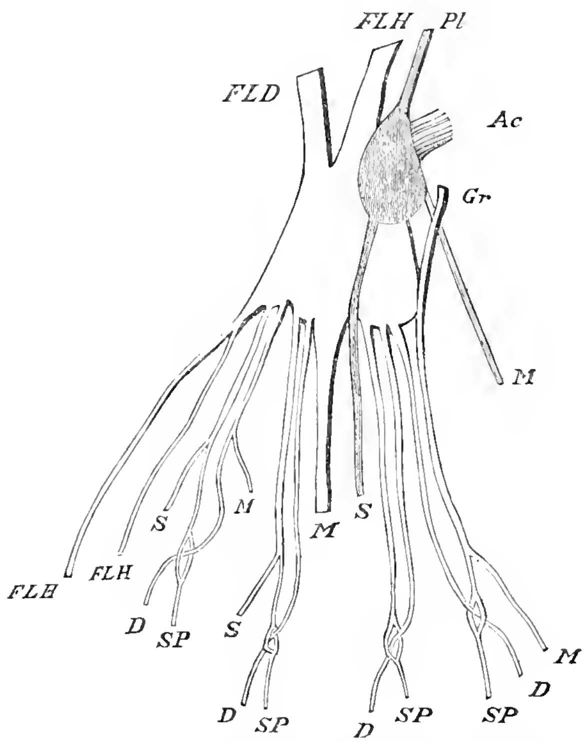


Fig. II.—Tendons of the foot in the Phocinæ. *FLD*, Tendon of Flexor longus digitorum; *FLH*, Tendon of Flexor longus hallucis; *Pl*, Tendon of the Plantaris; *Ac*, Insertion of the Accessorius; *Gr*, Tendinous slip from the plantar fascia, which is formed by the Gracilis, Semimembranosus, and Semitendinosus; *S*, Tendinous slips to the flexor tendon sheaths; *SP*, Flexor sublimis digitorum (perforatus); *D*, Flexor profundus digitorum (perforans); *M*, Tendinous slips to the metatarsal bones.

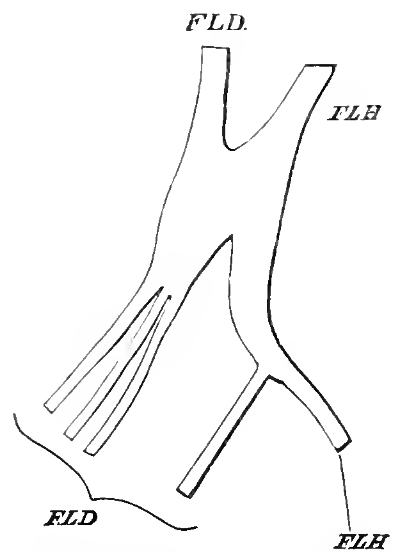


Fig. III.—Tendons of the foot of *Arctocephalus*. *FLD*, Flexor longus digitorum; *FLH*, Flexor longus hallucis.

surface of the tibia behind the insertion of the popliteus to the middle of the shaft. The tibialis posticus lies to its dorsal side, and the ventral border of the flexor longus hallucis behind. It forms a tendon which crosses to the dorsal border of the tibialis posticus, and enters the dorsal furrow in the large groove above the internal malleolus beneath its division of the annular ligament.

In *Macrorhinus leoninus* it is different, for there is a large popliteal line, and it *arises* from the whole of it. The ventral tuberosity of the tibia forms more of the internal surface than in the other Seals, for, while in the others the popliteal line forms part of the ventral border of the shaft, and the anterior end of the popliteal line terminates in the Phocinæ upon the inner dorsal side of the ventral tuberosity, in this case it ends upon the dorsal tuberosity.

In *Arctocephalus gazella* it *arises* from the posterior two-thirds of the ventral border of the fibula, from almost the same extent of the dorsal border of the tibia, from the inner surface of the

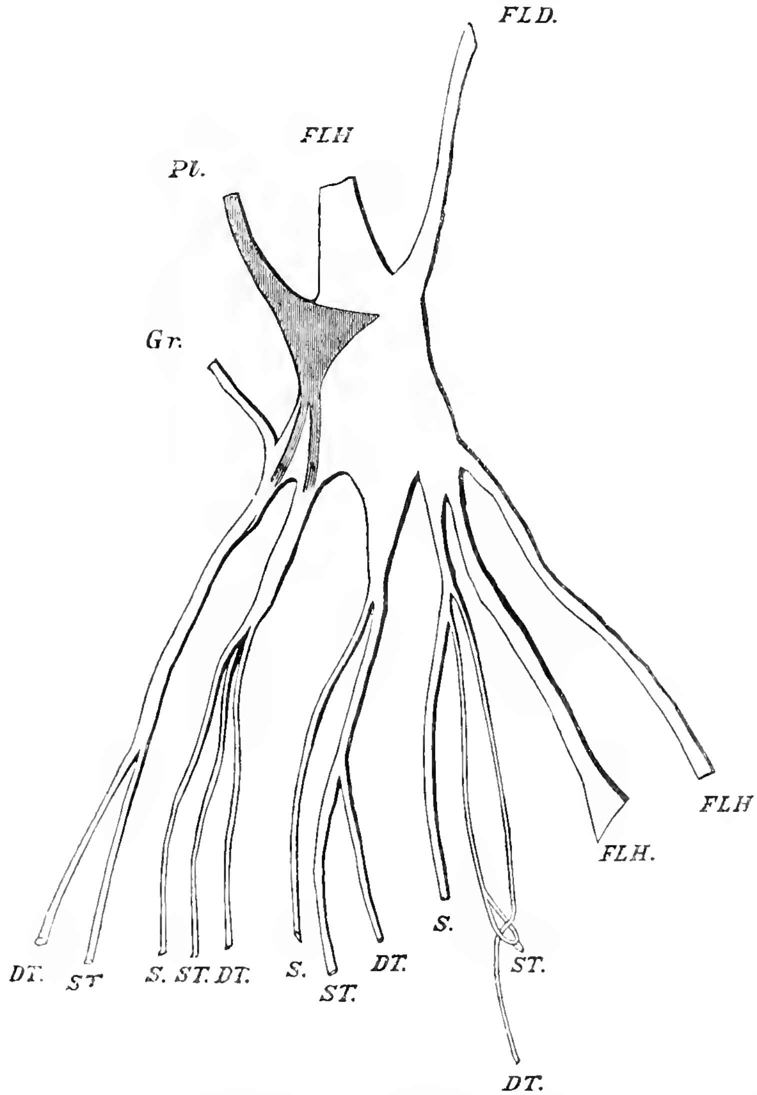


Fig. IV.—Tendons of the foot of *Macrorhinus*. *FLD.*, Tendon of Flexor longus digitorum; *FLH.*, Tendon of Flexor longus hallucis; *Pl.*, Tendon of the Plantaris; *Gr.*, Tendinous slip from the plantar fascia, which is formed by the Gracilis, Semimembranosus, and Semitendinosus; *S*, Tendinous slips to the flexor tendon sheaths; *ST.*, Flexor sublimis digitorum (perforatus); *DT.*, Flexor profundus digitorum (perforans).

shaft of the tibia between the intermediate and the dorsal borders to 1 inch from the ankle, and from the posterior two-thirds of the interosseous membrane. The muscle ends in a strong tendon, which traverses the groove of the astragalus and joins the tendon of the flexor longus hallucis. It *arises* in *Otaria* and *Trichechus* from the lowermost two-thirds of the shaft of the fibula and the lowermost third of the tibia and the interosseous membrane. In the Phocinæ it is supplied by a branch of the great sciatic nerve.

The union and insertion of the tendons of the flexor longus hallucis, and the flexor longus digitorum in the Phocinæ is as follows:—The tendon of the flexor longus hallucis is the largest in the sole; on its tibial side, 1 inch posterior to the os calcis, the tendon of the flexor longus digitorum unites with it. Upon its fibular aspect the plantaris tendon expands, and is fused with it by its outer surface. A slip from the plantar fascia of the gracilis, &c., blends with it along the dorsal edge; opposite the proximal extremities of the metatarsals this union of tendons and plantar fascia divides. The part which corresponds to the flexor longus digitorum gives off two slips. The ventral slip descends to the distal end of the terminal phalanx of the hallux, and is *inserted* there. The dorsal slip goes to the proximal dorsal side of the 1st phalanx of the hallux, into which it is *inserted*.

The rest of the tendons, which roughly are those of the flexor longus hallucis, break up in a more complex manner. For the 2nd digit two tendons spring out of the common one. The anterior is the superficial or perforated tendon, which gives off an anterior slip to blend with the sheath. The anterior superficial tendon splits over the proximal end of the 1st phalanx, and is *inserted* into the proximal end of the 2nd phalanx. The posterior or deep tendon gives off a posterior slip, which is *inserted* into the distal end of the metatarsal; then the deep tendon passes through the slit in the superficial tendon, and is *inserted* into the distal end of the terminal phalanx of the 2nd digit. For the 3rd digit there are three slips coming off separately. Two come off anterior and posterior to each other. The third is a large, strong slip, springing from the main tendon between the flexor tendons for the 3rd and 4th digits. This large slip is attached to the distal end of the 3rd metatarsal. The anterior slip divides into an anterior and posterior part. The anterior is *inserted* into the sheath, the other is the superficial tendon or posterior part, which is *inserted* like the other superficial tendons. The posterior part from the main tendon passes through the same slit as the last, and is *inserted* as in the former group. For the 4th digit, they are the same as for the 2nd digit, with a slight difference. There is no posterior slip from the deep tendon, and the anterior slip to the sheath is formed by the direct continuation of the plantaris tendon, which only fuses on its under surface with the great tendon. Those for the 5th digit have the same attachments. The difference in this group, as compared with the 2nd digit, is in the formation of the superficial or perforated tendon, which is formed from the plantar fascia of the gracilis, &c., and only joins the great tendon on its dorsal edge. This superficial slip gives off a small one to the distal end of the metatarsal of the 5th digit.

In *Macrorhinus leoninus* the combined tendon on the plantar surface divides into four slips. The ventral or internal one soon breaks into three. The ventral and middle slips of these three are for the hallux, and have the same course and *insertion* as in *Phoca vitulina*. The dorsal of these three is for the 2nd digit and forms an anterior and posterior tendon, which are the same as those for the 2nd digit of *Phoca vitulina*, without the posterior slip for the distal end of the metatarsal. In the 3rd digit they are similar to those in *Phoca vitulina*, without a slip from the combined tendon. In the 4th digit they are also similar to those in *Phoca vitulina*, but the plantaris muscle forms a greater part of the tendons. In the 5th digit the tendon is chiefly formed by the plantaris tendon and by the plantar fascia of the gracilis, &c. It comes off in one slip and divides into two, which have the same *insertion* as in *Phoca vitulina*, but there is no slit in the superficial tendon. All the slits of the other superficial tendons are lateral, and not antero-posterior as in the other Seals.

In *Arctocephalus gazella* the *insertion* of the combined flexor tendons out of the union of the flexor longus digitorum and the flexor longus hallucis forms a rectangular band, which divides at the base of the 2nd metatarsal bone into two broad tendons, the ventral and the dorsal portions. The ventral portion also divides into two, forming the flexor longus hallucis tendon and the first or inner flexor longus digitorum tendon. The ventral or flexor longus hallucis slip runs backwards to the terminal phalanx of the hallux, and after expanding is *inserted* chiefly into its proximal plantar surface, and into the whole of the plantar surface of this phalanx, by the prolongation of the tendon of insertion over the surface of the terminal bone. The first or inner flexor longus digitorum tendon, formed out of the dorsal part of the ventral division of the main tendon, is described with the following deep tendons. The outer or dorsal main portion breaks into three slips, that for the 5th digit coming off higher than the other two. The four long flexor tendons thus formed go backwards along the plantar sides of the 2nd, 3rd, 4th, and 5th digits to the distal phalanges; opposite the bases of the 1st phalanges they pass through the aponeurotic tunnels in the short flexors formed from the plantaris, becoming anterior to them, and are *inserted* into the phalanges as the tendon of the flexor longus hallucis.

The action of these combined muscles in the Phocinæ and *Macrorhinus* is to bring the pes to the middle line and to bend the digits. In *Arctocephalus* they will raise the heel in walking, otherwise they are the same.

There is an important difference in the relation of the flexor longus digitorum and flexor longus hallucis in the Phocinæ, *Macrorhinus*, and *Arctocephalus*. In the first two the flexor longus hallucis is to the dorsal side of the flexor longus digitorum from origin to insertion, but in the last the flexor longus hallucis is superficial to the flexor longus digitorum and crosses anterior to the ankle to the ventral side of the pes; and the flexor longus digitorum in the pes lies dorsal to it—the reverse of what is found in the Phocinæ and *Macrorhinus*.

While recognising the intermingling of the tendons of the flexors, I find it impossible to work out how far the tendons of the flexor hallucis and flexor longus digitorum cross each other to assist in forming the flexors of the digits, and therefore I have described only what is easily made out.

Humphry writes "in the case of the pollex the superficial tendon did not divide as in the other toes." In my dissections of the Phocinæ I find that the slip out of the combined tendon comes off singly, and very soon divides into two long slips, one being the flexor longus hallucis and the other the flexor brevis hallucis. The same author also explains that "the tendons of each muscle (flexor longus hallucis and flexor longus digitorum) contributed some fibres to each of the tendons (with the exception presently to be mentioned), but the deep tendons were derived mainly from the flexor longus pollicis, the flexor digitorum being distributed chiefly to the superficial tendons. The superficial tendon of the 4th digit was in one foot, and that of the 5th in both, derived from the plantaris." The flexor longus digitorum in the Phocinæ is not crossed by the flexor longus hallucis as in human anatomy, but they pass each other along their contiguous edges without crossing. The two tendons for the most part keep their own side in the pes. The flexor longus digitorum gives off the tendons for the hallux and 1st digit, the flexor longus hallucis for the 3rd, 4th, and 5th digits. I find that the plantaris forms the anterior slip for the sheath of the 4th digit and not the superficial tendon, and in the 5th digit the tendons were principally formed by the flexor longus hallucis, the plantaris giving a slip apart from the usual tendons to the distal end of the 5th metatarsal.

The *Plantar fascia* in the Phocinæ is formed out of the tendons of the gracilis, seminembranosus, and semitendinosus, which are prolonged into the foot, while the tendon of the plantaris muscle is interposed between it and the combined tendon of the flexor, and does not form a plantar fascia, but strengthens the common tendon, and forms part of the flexors of the digits. In the foot three layers are got from this modification, the first by the gracilis, &c., the second by the plantaris, and the third by the flexor longus hallucis and flexor longus digitorum.

The *Lumbricales* in the Phocinæ and *Macrorhinus* may be represented by the anterior tendons from the combined tendon going into the sheath of the digits.

The *Lumbrical muscles* in *Arctocephalus gazella* are five in number. The first lies between the long flexor tendons for the 1st and 2nd digits, coming out of the ventral main division. It *arises* from the adjacent sides of these tendons and forms a small tendinous slip, which is *inserted* into the distal dorsal side of the 1st metatarsal. The second *arises* from the surface and ventral side of the long flexor tendon for the 3rd digit, and is *inserted* by muscular fibres into the tunnel in the superficial flexor tendon formed out of the plantaris muscle. The third *arises* from the surface of the deep tendon for the 4th digit, and ends upon it near the distal end of the 4th metatarsal bone, like the last. The fourth *arises* from the dorsal side of the deep tendon for the 4th digit, passes beneath the deep tendon for the 5th digit, and is *inserted* by a small tendon into the ventral side of the distal end of the 5th metatarsal. The fifth comes from the tendon of a different muscle. The superficial tendon for the 5th digit from the plantaris gives origin upon its surface to a lumbrical muscle, which ends on the same tendon lower down. From the description of these slender fusiform muscular slips it will be seen that there are five, four from the combined tendons of the flexor longus digitorum and the flexor longus hallucis, and the fifth from the plantaris tendon. In *Otaria* there are six, the sixth is derived from the outermost tendon of the flexor longus digitorum, but there are no other differences.

The *Accessorius* is the M. caro-quadrata of Lucae. In *Phoca vitulina*, *Phoca hispida*, and *Phoca barbata* it is a triangular muscle, with its base directed outwards, and *arises* from the dorsal surface and posterior end of the os calcis to the inner side of the groove for the long peroneal tendon. The fibres pass inwards and obliquely backwards over the dorsal border of the hindward corner of this bone, forming a fine tendon which is *inserted* into the outer side of the tendon of the plantaris, before this muscle reaches the combined tendon. In *Macrorhinus leoninus* it was wanting, but most probably had decayed. In *Trichechus* it is absent, and was not noticed in *Otaria*.

The *Tibialis posticus* in the Phocinæ and in *Macrorhinus leoninus* is triangular, and lies to the outer side of the flexor longus digitorum. It *arises* from the inner side of the interosseous membrane, from the anterior two-thirds of the inner surface of the tibia, from the anterior third of the ventral edge of the fibula near the interosseous membrane, and from the inner side of the dorsal tuberosity of the tibia beneath the place of fusion of the tibia and fibula. It forms a strong tendon which passes beneath the flexor longus digitorum on its ventral side, and enters the ventral division of the groove on the outer surface of the distal extremity of the tibia.

In *Phoca*, near the tubercle of the scaphoid, it gives off a slip which becomes the middle slip of the abductor hallucis; to the inner side of the abductor slip it gives off another in which the sesamoid bone is found; and then is *inserted* into the tubercle of the scaphoid, spreading over its plantar surface, and into the entocuneiform bone. A few fibrous bands end upon the proxima end of the 1st metatarsal to the inner side of the flexor brevis hallucis. In the large *Phoca*, from beneath the inner head of the abductor hallucis, a slip from the tibialis posticus tendon proceeds backwards to the inner side of the flexor brevis hallucis, and ends on the ventral or inner surface of the 1st metatarsal. In *Macrorhinus* the tendon is *inserted* into the scaphoid tubercle, into the entocuneiform, and the 1st metatarsal; and gives off a strong slip to the abductor hallucis.

In *Arctocephalus gazella* it is of the same size as the flexor longus hallucis. It *arises* from the anterior fourth of the ventral border of the fibula, from the inner surface of its head, from the inner surface of the tibio-fibular fusion, from the anterior three-fourths of the inner surface of the tibia dorsad to the oblique line, and from the anterior fourth of the interosseous membrane. About 1 inch from the ankle it forms a tendon, which goes beneath the annular ligament in the groove near the ventral border of the tibia. After traversing it the tendon expands and is *inserted* into the anterior half of the 8th tarsal or entoscaphoid bone.[1] On nearing its insertion it gives off a tendinous slip (slip i.), which crosses the surface of this bone and joins the plantar fascia. It also sends a strong slip over the inner or ventral half of the bone which runs along the ventral plantar side of the 1st metatarsal; opposite the middle of the shaft this slip divides into two (ii. and iii.). The dorsal slip (ii.) is prolonged to the distal plantar surface of the 1st phalanx of the hallux. The ventral (iii.) is inserted into the distal plantar ventral side of the 1st metatarsal. In *Otaria* it is only *inserted* into the scaphoid; but Murie does not mention it in *Trichechus*. Lucae agrees with me as to its insertion in *Phoca*, and Humphry gives the same scaphoid and metatarsal insertions, but states "that a considerable portion of its tendon extended into the ligaments under the tarsus and into the tendinous structure which represents the short muscles of the hallux." In the Phocinæ it is supplied by a branch of the great sciatic nerve.

The human tibia upon the posterior surface has a ridge dividing it into two; the outer division is for the origin of the tibialis posticus. In all the specimens of Seals there is no ridge, and the inner surface is for the tibialis posticus. The part of the bone covered by the muscle in the Phocinæ is deeply scooped out, and gutter-like, the convexity being on the outer side, and in most of the specimens the shaft is semitransparent. This formation gives lightness to the bones of the leg but little diminution in surface. In *Macrorhinus* the inner surface is very slightly concave, and the shaft is triangular in transverse section, the apex of the triangle giving attachment to the interosseous membrane. In *Arctocephalus* the inner surface is only moderately scooped in its anterior third, and the shaft is triangular like the last. In all, the origin reaches the dorsal tuberosity of the tibia, for the popliteal line begins at the dorsal side of the ventral tuberosity, but in man the insertion of the popliteus prevents this.

The ventral surface of the tibia is apt to be included with the inner surface, unless a number of tibiæ are examined. The ventral border begins at the internal malleolus, runs along the shaft, and terminates at the junction of the outer two-thirds and inner third of the ventral tuberosity. The dorsal border runs from the external malleolus forwards to the junction of the external and internal tubercles on the outer side of the bone. The space between these two borders is the

[1] See Sir W. Turner's Report, p. 50. In the Phocinæ I found a sesamoid bone in the tendon of the tibialis posticus, but there was none in *Macrorhinus*.

ventral surface. The popliteal line, which begins about the middle of the shaft in all, runs forwards and ends at the dorsal side of the ventral tuberosity. A casual look at the bones might suggest that the concave surface giving origin to the tibialis posticus is the inner surface, but such is not the case. The small triangular surface for the popliteus also belongs to the inner surface. This is best seen in *Macrorhinus*, where the popliteal surface advances upon the inner to a greater extent than in the rest. In *Arctocephalus* the inner surface is more convex, and the popliteal line stands out like a ridge; this is still more evident in the Phocinæ. The popliteal line in the Seals only gives origin to the flexor longus digitorum.

In the Phocinæ and *Macrorhinus*, where the pes is always in line with the trunk, it will in the backward and forward motion of the paddle, assist in bringing the pes to the middle line, *i.e.*, adduct it, and turn the sole a little upwards, *i.e.*, pronate it. In *Arctocephalus* in walking it will extend the ankle, raise the inner side of the pes and the heel, besides giving the other movements when swimming.

PES.—The OUTER REGION in all the specimens has one muscle, the extensor brevis digitorum.

The *Extensor brevis digitorum* in the Phocinæ *arises* from the outer surface of the os calcis, ventral to the peroneal tendons, from the superior dorsal border of the os calcis, and slightly from the surface below the latter. It forms three muscular slips which end in two small tendons, the common extensor of the first running backwards between them. The ventral slip goes between the 1st and 2nd metatarsal bones, and is *inserted* into the ventral side of the proximal end of the 1st phalanx of the 1st digit. The dorsal slip goes between the heads of the 4th and 5th metatarsals, and is *inserted* into the proximal end of the 1st phalanx of the 3rd digit.

In *Macrorhinus leoninus* it is in two separate slips. The dorsal slip *arises* from the os calcis ventral to the peronei, and passes between the 1st and 2nd metatarsals, and is *inserted* into the proximal end of the ventral side of the 1st phalanx of the 2nd digit, and, by a small tendon from the side of this one, into the distal dorsal side of the 1st metatarsal. The ventral slip *arises* from the astragalus on its outer surface, and from the outer surfaces of the scaphoid and external cuneiform bones. The tendon passes back to the interval between the 4th and 5th metatarsals, and is *inserted* into the proximal dorsal side of the 4th digit.

In *Arctocephalus gazella* it is in two parts. The dorsal part has two heads of origin. The larger head *arises* from the dorsal surface of the os calcis and from the dorsal surface of the cuboid. The smaller head *arises* from the same bones, but to the ventral side of the large head. These two heads unite and are *inserted* into the proximal end of the 1st phalanx of the 2nd digit. The second part *arises* from the adjacent sides of the os calcis and astragalus, and from the cuboid, and is *inserted* into the proximal end of the 1st phalanx of the 3rd digit.

The INNER OR PLANTAR REGION has adductors, flexores breves of the phalanges, and abductors. In *Macrorhinus* the inner head of the flexor of the hallux and the abductor hallucis were the only two intrinsic muscles seen; the rest had evidently decomposed.

The Adductors.—In *Phoca vitulina* the adductor minimi digiti is found. In *Arctocephalus* there are the adductor hallucis, the adductor minimi digiti, and the adductor ossis metatarsi primi.

The *Adductor minimi digiti* in *Phoca vitulina arises* between the bases of the 3rd and 4th metatarsal bones, crosses the 4th metatarsal, and is *inserted* by a fine tendon into the tibial side of the base of the 1st phalanx of the 5th metatarsal.

In *Arctocephalus* the *Adductor hallucis* and the *Adductor minimi digiti arise* by a common origin from the plantar surfaces of the proximal ends of the 2nd, 3rd, and 4th metatarsal bones, and from the sheath of the peroneus longus by a tendinous sheet which is semi-circular. Along the posterior border of this tendon muscular fibres spring and take the form of a horse-shoe, the two limbs forming these two muscles. The tibial limb is the adductor hallucis and is *inserted* into the fibular distal end of the 1st metatarsal. The fibular limb is the adductor minimi digiti and is *inserted* into the distal tibial side of the 5th metatarsal.

In *Otaria* these muscles are regarded as superficial interossei, and their origins are more extensive than in *Arctocephalus*. In *Trichechus* (Murie) they are similar to *Otaria*. In *Trichecus* Cunningham says they form the plantar layer, and he figures the adductor hallucis as consisting of two parts—an adductor obliquus and an adductor transversus, but I did not find the transverse head of the adductor hallucis, and the adductor minimi digiti was not a separate fasciculus, as he figures it. The general plan of origin in the two specimens of *Arctocephali* was like Murie's drawings, the adductors being combined at their origins.

The *Adductor ossis metatarsi primi* in *Arctocephalus arises* from the anterior third of the tibial side of the plantar surface of the 2nd metatarsal, crosses to the 1st digit, and is *inserted* into the 1st phalanx on its fibular proximal side.

The Flexores breves.—These are named the deep interossei by Dr. Murie, and form the intermediate layer of Professor Cunningham. In *Phoca vitulina* and in *Arctocephalus* the muscles of the 2nd, 3rd, and 4th digits are double, of the 5th single, and the 1st digit is peculiar.

In *Phoca vitulina* they are feeble and *arise* from both sides of the plantar surfaces of the 2nd, 3rd, and 4th metatarsals, and from the tibial side only of the 5th. The muscle from the tibial side of the 2nd digit also has origin from the fibular proximal end of the 1st metatarsal. They are *inserted* into the proximal ends of the first phalanges of the digits, on the same sides from which they spring.

In *Arctocephalus* they are well developed. The origins and insertion are as in *Phoca vitulina*, with one exception—the muscle from the tibial plantar surface of the 2nd metatarsal is only from the posterior two-thirds of the shaft.

The *Flexor brevis primi metatarsi* or *flexor brevis hallucis*. In *Phoca vitulina* the outer muscle or outer head *arises* from the fibular side of the 1st metatarsal, and is *inserted* into the proximal fibular side of the 1st phalanx of the 1st digit. The inner flexor or inner head in *Otaria* is named the adductor hallucis, in *Trichechus* (Murie) the flexor brevis hallucis, and in *Trichechus* (Cunningham) this slip was not found. In *Phoca* it *arises* beneath the adductor hallucis from the outer posterior third of the scaphoid bone, upon the tendon of insertion of the tibialis posticus, and from the anterior outer third of the entocuneiform. It is a glistening tendinous band, with a reddish tinge at the anterior end, which passes backwards and inwards and is *inserted* into the inner side of the base of the 1st metatarsal.

In *Macrorhinus* the inner head *arises* from the outer posterior half of the scaphoid bone in common with the outer head of the abductor hallucis, over the middle of the entocuneiform bone the tendon splits into two equal portions—the inner is the abductor hallucis, the outer forms the flexor brevis hallucis. It is *inserted* into the proximal tibial plantar surface of the 1st metatarsal to the outer side of the abductor hallucis.

In *Arctocephalus* the outer muscle is the same as in *Phoca;* the inner *arises* from the tendon of the tibialis posticus, which is attached to the outer side of the anterior end of the entocuneiform bone, and from the anterior outer half of the same, and is *inserted* as in *Phoca.*

The flexores breves in *Otaria* consist of one single and four double muscles; as also in *Trichechus* (Cunningham). While Professor Cunningham alludes to no differences in their insertions, Dr. Murie gives the insertion in *Otaria* of the first interosseus into the fascia covering the metacarpo-phalangeal joint of the hallux, which is very like what I have stated. Excluding *Phoca,* we agree as to some change in the tibial side of the 2nd metatarsal. Murie in *Otaria* derives the tibial head of the 2nd muscle from the proximal ends of the 1st and 2nd metacarpals. The smaller moiety of this muscle, that next the hallux, has also a partial origin or attachment to the superficial layer of the interosseous fibres and hallucial metacarpal. Professor Cunningham, in describing the flexor brevis indicis, gives the origin of the tibial head from the base of the 1st metatarsal. In my account of this digit in *Arctocephalus* I describe an adductor from the anterior tibial third of the 2nd metatarsal.

The Abductors.—In *Phoca vitulina* these are the abductor hallucis, the abductor minimi digiti, and the abductor tertius quinti digiti.

In *Arctocephalus* the abductor hallucis, the abductor minimi digiti, the abductor tertius quinti digiti, the abductor ossis metatarsi quinti, and the abductor ossis metatarsi primi are found. In *Macrorhinus* the abductor hallucis only is described.

The *Abductor hallucis* in *Otaria* is named the flexor brevis hallucis, in *Trichechus* (Murie) the abductor hallucis, and in *Trichechus* (Cunningham) the inner head of the flexor brevis hallucis. In *Phoca vitulina* it originates by three separate slips, which are close to each other and attached posteriorly. The outermost *arises* from the scaphoid bone upon the tendon of insertion of the tibialis posticus, a little to the outer side of the inner head of the flexor brevis hallucis, which lies at a greater depth in the sole, and from the adjacent posterior surface of the os calcis; the middle from the tendon of the tibialis posticus before it reaches the scaphoid just anterior to its insertion; the inner by a slip which comes from the outer posterior side of the sesamoid bone of the tibialis posticus tendon. These three slips unite a little posterior to the sesamoid bone, forming a strong tendon, which is inserted into the inner distal plantar side of the 1st metatarsal. On both sides of the slip which comes from the tibialis posticus tendon, and on the outermost side of the middle two-thirds of the outermost tendon, there are a few muscular fibres.

In *Macrorhinus* it *arises,* in common with the inner head of the flexor brevis hallucis, from the outer posterior half of the scaphoid bone upon the tendon of insertion of the tibialis posticus before it reaches the scaphoid. It is a strong fibrous band which is directed backwards; midway between its origin and insertion, it is joined on the outer side by the outer head, and the two together are *inserted* into the proximal tibial plantar surface of the 1st metatarsal.

In *Arctocephalus* it *arises* from the tubercle on the posterior end of the sesamoid bone of the tibialis posticus, and is closely united with its tendon. It courses backwards along the tibial side of the 1st metatarsal, and is *inserted* into the distal tibial side of the 1st metatarsal and the proximal end of its 1st phalanx, receiving some fibres from the tibialis posticus, which pass over the sesamoid bone into it. Its almost tendinous nature, its close association with the tendon of the posticus, and its arising from the sesamoid bone, show that it has a similar function to the posticus.

In *Otaria* Murie does not describe this muscle.

In their descriptions of *Trichechus* Dr. Murie and Professor Cunningham differ. The former states that it *arises* by a long narrow belly, by a tendon from the extra bone outside the cuneiform, and is fleshy three-quarters the length of the hallucial metacarpal, being *inserted* by tendon and fascia over the metacarpo-phalangeal joint; the latter that it *arises* from a sesamoid bone which glides upon the tibial side of the internal cuneiform, and is *inserted* into the inner side of the base of the 1st phalanx of the hallux. Murie writes that it is fleshy, and Cunningham that it is tendinous, which he considers is probably owing to his specimen being a pup; and although Murie explains that this muscle in the Seal is entirely tendinous, I found muscular fibres in *Phoca*.

The *Abductor tertius quinti digiti* in *Phoca vitulina* is exposed after reflecting the tendinous structure concealing it. Murie has classed it as the 2nd head of the abductor ossis metacarpi quinti. It *arises* from the adjacent sides of the bases of the 4th and 5th metatarsal bones, and the tendinous structure covering these phalanges; after crossing the 5th metatarsal it is *inserted* into the fibular side of the head of this bone.

In *Arctocephalus* it is 1 inch long, with no fibres, and *arises* from the fascia completing the tunnel for the peroneus longus tendon. This origin is a small round tendon at right angles to the plantar surface. It is *inserted* into the tendon of origin of the abductor ossis metatarsi quinti. In *Otaria* it is one of the heads of origin of the abductor ossis metatarsi quinti.

In *Trichechus* (Murie) it is also named the abductor ossis metatarsi quinti. Its origin is the same as in *Arctocephalus* and *Otaria*, but the *insertion* is into the base of the 5th metatarsal bone. In *Trichechus* (Cunningham) the origin and insertion are similar to the former.

The *Abductor minimi digiti* in *Phoca vitulina arises* between the proximal ends of the 3rd and 4th metatarsal bones, and crosses obliquely outwards to the tibial proximal plantar side of the 1st phalanx of the 5th digit. In *Arctocephalus* it has two bellies. The first *arises* from the dorsal half of the plantar surface of the os calcis by muscular fibres, and extends longitudinally from the insertion of the gastrocnemius to the posterior tendon of this bone. The second belly *arises* from the base of the 5th metatarsal bone. The first belly is *inserted*, after forming a flat tendon, into the base of the 5th metatarsal beneath the second belly, which goes to the dorsal distal end of the 5th metatarsal, and is *inserted* into the outer or dorsal side of the flexor brevis minimi digiti. Murie's description of this muscle in *Otaria* differs from the above.

In *Trichechus* Murie states that it comes from the outside of the os calcis and not from the plantar fascia, while Cunningham says that it *arises* from the fascia covering the outer surface of the abductor ossis metatarsi minimi digiti, and is *inserted* into the outer side of the base of the 1st phalanx of the minimus.

The *Abductor ossis metatarsi quinti* in *Arctocephalus* is the flexor brevis minimi digiti (Murie), and the abductor ossis metatarsi minimi digiti (Cunningham). It is a small muscle, and *arises* from the os calcis to the outer side of the origin of the abductor minimi digiti by a slender elongated tendinous slip, which is closely united with the muscle just mentioned, and lies along its fibular edge. It is *inserted* into the distal fibular side of the 5th metatarsal to the fibular side of the abductor.

In *Otaria* the origin is double; the outer head is the same as described above; the inner I regard as the 3rd abductor of the 5th digit which is found in *Phoca*. In *Trichechus* (Cunningham) it exhibits the usual attachments, but Murie gives a different description.

The Facial Muscles of Expression.

These are arranged in the following groups:—The occipito-frontalis, the muscles of the ear, the muscles of the nose, the muscles of the eyelids, the muscles of the orbit, and the muscles of the mouth.

The *Occipito-frontalis* in *Phoca vitulina*.—The specimen from which the cervico-scapular panniculus is described had two V haped prolongations over the frontal region, which represented the occipito-frontal muscles. In another *Phoca* these fibres extended towards the middle line and touched each other, forming a complete occipito-frontalis. It is supplied by the facial nerve which ascends from the ear over the temporal muscle. In *Otaria* it is imperfectly formed.

The Muscles of the Ear.—There are three small muscles to the cartilaginous meatus in *Phoca vitulina*, two small pale fasciculi forming the protractors, and one a retractor.

The *Internal protractor* or *Attollens aurem arises* from the skin above the middle of the orbit and passes outwards and backwards, and is *inserted* into the inner and under surface of the cartilaginous meatus of the external ear at the junction of the skin with the cartilage. It is recognised by Humphry; in *Otaria* it is indistinct; in *Trichechus* the muscle is well developed, but arises posterior to the orifice of the meatus, and is therefore a retractor.

The *External protractor* or *Attrahens aurem arises* from the fibrous tissue over the articulation of the malar with the zygoma, and is *inserted* into the outer and under surface like the former. It is not noted by Humphry; in *Otaria* it is present but undescribed; in *Trichechus* it is distinct.

The *Retractor* or *Retrahens aurem arises* from the superior border of the zygoma extending from the osseous meatus, to midway between the articulation of the zygoma with the malar bone anteriorly and the osseous meatus posteriorly. It is *inserted* into the inner and under surface of the cartilaginous tube of the external ear. It is named the attrahens by Humphry; in Otaria it is feeble; in *Trichechus* it is a strong muscle.

The *Cartilaginous meatus* is 1 inch long and S-shaped, the attollens pulls the tube forward and opens it, the attrahens draws it forward and outwards, also opening it. The retrahens retracts the tube and flexes the anterior bend of the cartilage, thereby closing the meatus. They are supplied by the facial nerve.

The Muscles of the Nose.—The combined *Dilator et depressor nasi* in *Phoca vitulina* is rectangular. It *arises* from the fossa of the superior maxilla on the outer side of the infraorbital foramen, and from above the foramen, extending forwards to the third last molar tooth. The inferior division of the 5th nerve pierces it, and the fibres above the nerve form the dilator nasi, those below the depressor nasi. The former, after crossing the levator anguli oris and the constrictor nasi, is *inserted* into the side of the nose. The latter is *inserted* into the side of the nose inferior to the dilator, and into the upper lip, beneath the septum; some fibres join those of the opposite side, while a few are attached to the skin of the upper lip, coming off from the depressor portion in small slips. The nerve of supply is the facial.

In *Otaria* they are described separately.

The *Constrictor nasi* (named the compressor in *Otaria*) *arises* in *Phoca vitulina* superiorly from the whole length of the nasal cartilage, and is *inserted* into the premaxillary bone and muscle of the other side, partly under cover of the levator anguli oris. It is supplied by the facial nerve.

The *Levator labii superioris et alæ nasi* in *Phoca vitulina* is a rectangular muscle. It *arises* from the dorsal surface of the frontal bone which lies between the orbits, the same surface of the nasal bone, and the superior maxilla, nearly reaching the nasal orifice anteriorly. The fibres proceed downwards and outwards, and are *inserted* into the muzzle from the nose to near the angle of the mouth. It is supplied by the facial nerve.

The Muscles of the Eyelids.—The *Orbicularis palpebrarum* in *Phoca vitulina arises* from the tendo-palpebrarum inferior to the pulley for the superior oblique, from the palpebral ligament superior to it, from the frontal bone, and from the superior maxilla. The orbicular portion blends with the corrugator supercilii and the occipito-frontalis fascia, and is attached to the superior maxilla, to the ligament completing the orbit, and to the malar bone. The palpebral portion is feeble and is attached to the malar bone.

The *Tendo-palpebrarum arises* from the nasal process of the superior maxilla, and ends in the orbicularis palpebrarum, lying along the inferior surface of the tendon of the superior oblique.

The *Superior palpebral ligament* goes from the superior maxilla above the tendon of the superior oblique to the orbicularis palpebrarum.

The *Corrugator supercilii arises* from the frontal bone and is *inserted* into the under surface of the orbicularis and the occipito-frontalis.

The *Tensor tarsi arises* from the orbital surfaces of the frontal and superior maxilla three-fourths of an inch below the nasal process of the latter. It ascends and is *inserted* into the tendo-palpebrarum at the junction of the lid and the tendo-palpebrarum. It blends with the orbicularis.

The *Levator palpebræ superioris* in *Phoca vitulina arises* from the upper margin of the optic foramen external to the superior oblique. It passes forwards, expands, and is *inserted* into the upper eyelid. It is supplied by the 3rd nerve.

The Muscles of the Orbit.[1]—Besides the four recti and the two oblique muscles, there are two retractors and two depressors of the third eyelid.

The *Superior*, *Inferior*, *External*, and *Internal recti* muscles resemble the corresponding human muscles.

The *Superior oblique arises* from the inner, and slightly from the upper, surface of the optic foramen. It passes forwards along the inner wall of the orbit beneath the ligament for the upper eyelid through the pulley attached to the superior maxilla, and goes outwards to the eyelid and is *inserted* into the eyeball on the inner side of the insertion of the superior rectus. The tendon after passing through the pulley lies between the tendo-palpebrarum and the superior palpebral ligament, and pierces the upper eyelid to gain its attachment. The pulley is attached to the superior maxilla upon the margin of the orbit close to the articulation with the nasal process of the frontal bone, posterior to the nasal process of the superior maxilla. It is supplied by the 4th nerve.

The *Inferior oblique arises* from the orbital surface of the superior maxilla to the inner side of the inferior orbital foramen. It goes upwards and outwards round the eyeball, and is *inserted* into it inferior to the external rectus attachment. It is supplied by the 3rd nerve.

The *Superior external* and *Superior internal retractor* muscles *arise* from the outer side of the optic foramen, run along the optic nerve to the eyeball, and are *inserted* on the corresponding sides of the sclerotic beside the optic nerve.

The *Depressors of the third eyelid arise* together from below the optic foramen, widen out as

[1] Rosenthal's description of the muscles of the orbit differs considerably from mine.

they near the inferior margin of the third eyelid, pass on each side of the Harderian gland, and are lost in the substance of this lid. The cartilage in this eyelid is strongest in the centre, where it forms a strong vertical rod. The eyeball is surrounded by a fibrous case which lines the wall of the orbit, forming the periosteum, and on the outer side, where there is no osseous protection, the periosteum is continuous with the fibrous case along the sharp edge of the pterygoid and palate bones inferiorly, and the nasal and frontal superiorly.

The *Orbital ligament* completes the break in the circumference of the orbit. It is attached to the malar and temporal bones at their zygomatic articulation, and to the frontal bone above the orbit.

The Muscles of the Mouth.—The *Orbicularis oris* in *Phoca vitulina* surrounds the mouth, and, where it passes from jaw to jaw, is indistinct. It *arises* from the under surface of the inferior maxilla by fine fasciculi as far back as the 4th molar tooth. The fibres ascend round the angle of the mouth, and are *inserted* into the superior maxilla from the 4th molar to the articulation of the premaxilla; some of the fasciculi next the symphysis and the premaxilla circle round the mouth. It is supplied by the facial nerve.

The *Levator labii superioris proprius arises* from the superior maxilla, forming the margin of the orbit, and is *inserted* into the upper lip. It is supplied by the facial nerve.

The *Buccinator* muscle in *Phoca vitulina* is very small and composed of feeble muscular fibres. It *arises* from the superior maxilla from a line extending from the last molar backwards along the edge of the palate bone to midway between the root of the zygoma and the hamular process of the pterygoid, from the inferior maxilla, from a linear origin from above the inferior dental foramen to the last molar, and from the pterygo-maxillary ligament. It is *inserted* into the orbicularis oris. It is supplied by the facial and the 5th nerves.

The *Levator anguli oris* in *Phoca vitulina arises* from the junction of the nasal bone with the premaxilla, and from the protuberance of the superior maxilla. It is *inserted* into the canine fossa and into the skin of the mouth anteriorly beneath the infraorbital nerve and the dilator nasi. It is supplied by the facial nerve.

The Muscles of Mastication.

The *Masseter* in *Phoca vitulina* and in *Arctocephalus arises* from the whole of the zygomatic arch, and is *inserted* into the fossa of the lower jaw below the coronoid root to where the alveolar margin commences. It is supplied by the inferior maxillary nerve.

In *Otaria* there are two layers of fibres, a superficial and a deep set.

The *Temporal* muscle in *Phoca vitulina* and in *Arctocephalus* covers the side of the cranium, below the temporal ridge which traverses the parietal bone, running obliquely forwards from the middle of the occipital ridge to the root of the nasal process of the frontal bone. It lies between this line superiorly and the zygomatic arch inferiorly, and *arises* from the lower half of the parietal, from the squamous surface of the temporal bone, from the outer surface of the frontal inferior to the oblique line, from the outer half of the anterior orbital surface of the same, and from the superior tip of the alisphenoid. It converges and is *inserted* into the outer border, anterior border, and internal surface of the coronoid process of the lower jaw, covering the internal surface above a line drawn from the condyle to 1 inch behind the last molar. It is supplied by the inferior maxillary nerve.

In *Otaria* the fibres have two directions.

The *Pterygoideus internus* (Lucae's pterygoideus and Humphry's pterygoid) in *Phoca vitulina* and *Arctocephalus* is a strong muscle. It *arises* from the external surface of the pterygoid bone, and from the fossa on the outer side of the hamular process in *Arctocephalus* only, for this is absent in *Phoca*. It is *inserted* into the subcondyloid process of the lower jaw in *Arctocephalus* and in *Phoca*, beside the inner side of the ramus below the condyle, to midway between it and the angle of the jaw. The subcondyloid process is feeble in *Phoca*, but extensive in *Arctocephalus*. It is supplied by the inferior maxillary nerve.

In *Otaria* and *Trichechus* it has not been described.

The *Pterygoideus externus* in *Phoca vitulina* and *Arctocephalus* is a very small cylindrical bundle, and *arises* in the former from below the foramen rotundum, and in the latter from the bridge of bone connecting the alisphenoid with the external pterygoid plate over the foramen rotundum. In both it crosses transversely outwards and is *inserted* into the inner side of the condyle of the lower jaw. It is supplied by the inferior maxillary nerve.

This muscle has not been described by Vrolik, Humphry, Lucae, nor by Murie. I found it in all the specimens by dividing the symphysis and pulling the jaw gently outwards, when the bundle of fibres attached as above was seen.

The Muscles of the Neck.

The only superficial muscle is the *Sterno-mastoid;* in *Phoca vitulina* it is a riband-shaped muscle, and *arises* from the under surface and side of the anterior third of the presternum. It is joined to its fellow for one inch and a half anterior to the presternum by a fine aponeurosis, ascends to the mastoid process and is *inserted* into it at the root of the zygoma behind the insertion of the trachelo-mastoid. It is supplied by external branches of the cervical plexus and a twig from the spinal accessory nerve.

In *Arctocephalus* it is triangular with the base resting on the fascial slip representing the clavicle. It *arises* from the dorsal surface of the presternum and cartilage of the 1st rib, from the deltoid ridge of the humerus between the insertions of the pectoralis major on the inner side and the deltoid on the outer, blending with the origin of the inner part of the brachialis anticus below; and from the fascial slip representing the clavicle. This last origin is thin, and midway between the sternal and humeral origins is almost devoid of fibres, the deficiency being filled in with fibrous tissue. The humeral part blends with the cephalo-humeral muscle along its outer edge and the pectoral along its inner. The muscle runs forwards, narrows, and is *inserted* into the occipital ridge near the external auditory meatus anterior to the splenius. It is supplied by twigs from the external branches of the cervical plexus.

In *Otaria* the sternal end of the muscle represented in Dr. Murie's Memoir (pl. lxxiii. fig. 33) is like what I have described in *Arctocephalus*, and, as it extends outwards to the shoulder, it must have other attachments than the manubrium, which is all that Murie gives in his description.

In *Trichechus* it is as in *Otaria*, but a division into two parts is not described.

The Infra-hyoid Region includes the sterno-thyro-hyoid and the thyro-hyoid.

The *Sterno-thyro-hyoid* in *Phoca vitulina* is called the costo-thyreo-hyoideus by Lucae, the sterno-hyoid by Humphry, and the sterno-hyoid and sterno-thyroid by Murie. It is a long band with a triangular expansion from its outer side opposite the head of the humerus, the apex lying upon it. It is situated along the side of the neck upon the carotid artery and pneumogastric nerve, &c., and *arises* by muscular fibres from the outer surface of the cartilage of the 1st rib, from the outer surface of the lesser tuberosity of the humerus, from the transverse ligament going between the two tubers of the humerus, and from the fascia binding together the great vessels and nerves going to the flipper from the thorax and stretching from the 1st rib to the lesser tuber. At the level of the thyroid gland it splits into two parts, an anterior and a posterior. The deeper or posterior is *inserted* into the thyroid cartilage, the superficial or anterior into the hyoid bone; in the large specimen, the division was about midway between the origin and insertion. The part from the lesser tuberosity may be named the omo-hyoid. It is supplied by the communicans noni nerve.

In *Arctocephalus* it *arises* from the tip of the dorsal surface of the presternum, proceeds forwards, and about 1 inch posterior to the thyroid cartilage divides into a dorsal and ventral band. The dorsal is the sterno-thyroid, and is *inserted* into the thyroid cartilage, the ventral is the sterno-hyoid and is *inserted* into the hyoid bone. The nerve was destroyed.

The *Omo-hyoid* in *Phoca vitulina* is the part of the sterno-thyro-hyoid attached to the humerus, in *Arctocephalus* it is the outer margin of the sterno-mastoid. The Sterno-thyro-hyoid in *Arctocephalus* has an origin somewhat like the sterno-mastoid in *Phoca*. Humphry does not refer to the part forming the sterno-hyoid.

The *Thyro-hyoid* in *Phoca vitulina* and in *Arctocephalus arises* from the posterior part of the oblique ridge of the thyroid cartilage, and is *inserted* into the hyoid bone.

The Supra-hyoid Region.—In this region are the digastric, stylo-hyoid, mylo-hyoid, and genio-hyoid.

The *Digastric* in *Phoca vitulina* and *Arctocephalus arises* from the mastoid hollow and the tympanic bulla. About its middle, in *Phoca*, a superficial transverse tendinous division exists. It is *inserted* into the inferior surface of the angle and inferior border of the lower jaw to opposite the last molar tooth on the inner surface. It is supplied by the facial and by the mylo-hyoid branch of the inferior dental nerve.

In *Otaria* there is no tendinous intersection, but it is present in *Trichechus*.

The *Stylo-hyoid* in *Phoca vitulina* and *Arctocephalus* is a narrow transverse band, and *arises* from below the external auditory meatus, and is *inserted* into the hyoid bone. Humphry considers it to be a part of the digastric, and Murie does not describe it. It is supplied by the facial nerve.

The *Mylo-hyoid* in *Phoca vitulina* and *Arctocephalus* is a triangular muscle, which, with its fellow, fills in the intermaxillary space. It *arises* from the inner surface of the lower jaw above and a little behind the inferior dental foramen, and from the alveolar margin until opposite the last molar tooth, where the line of origin turns suddenly to reach the inferior border of the lower jaw. Thus far the origin is muscular, but at the symphysis it is tendinous. The fibres are *inserted* into a median fibrous raphé and into the body of the hyoid bone. The digastric intervenes between it and the lower jaw at the angle. It is supplied by the mylo-hyoid branch of the inferior dental nerve.

The *Genio-hyoid* in *Phoca vitulina* and *Arctocephalus* is a small rectangular muscle situated immediately beneath the inner border of the stylo-hyoid. It *arises* from the inner surface of the symphysis, and from the inferior margin of the lower jaw opposite the 2nd, 3rd, and 4th incisors. It takes a small turn to the middle line and meets its fellow, and is *inserted* into the inferior surface of the body of the hyoid bone. It is supplied by the hypoglossal nerve.

The Muscles of the Tongue.

The extrinsic muscles are the stylo-glossus, hyo-glossus, genio-hyo-glossus, and palato-glossus (see Soft Palate).

The *Stylo-glossus* both in *Phoca vitulina* and *Arctocephalus* is a small muscular band which *arises* from the ventral surfaces of the stylo-hyal and epi-hyal, and goes obliquely forwards over the end of the hyo-glossus, ending at the tip of the tongue. It is supplied by the hypoglossal nerve.

The *Hyo-glossus* both in *Phoca vitulina* and *Arctocephalus* is a quadrilateral band, and *arises* from the thyro-hyal, slightly from the basi-hyal and cerato-hyal. It extends along the under surface of the tongue to its tip beneath the stylo-glossus. It is supplied by the hypoglossal nerve.

The *Genio-hyo-glossus* both in *Phoca vitulina* and *Arctocephalus* is thin and triangular. It *arises* by muscular fibres from the inferior margin of the lower jaw, reaching from the symphysis to opposite the second last molar tooth, and is blended near the symphysis with its fellow. The posterior fibres go to the body of the hyoid bone and some to the pharynx; the middle to the middle of the tongue; the anterior to the front of the tongue. It is supplied by the hypoglossal nerve.

The Muscles of the Pharynx.

These are as usual, the inferior, middle, and superior constrictors, and the stylo-pharyngeus (for the palato-pharyngeus and salpingo-pharyngeus, see the Soft Palate).

The *Inferior constrictor* in *Phoca vitulina arises* from the side of the cricoid cartilage, &c., as in human anatomy, and almost hides the middle constrictor. It is supplied by the pharyngeal plexus, and the external and recurrent laryngeal nerves.

The *Middle constrictor* in *Phoca vitulina arises* from the posterior cornu of the hyoid bone, along its anterior surface, and slightly from the cerato-hyal, and is *inserted* as usual. It is supplied by the pharyngeal plexus.

The *Superior constrictor* in *Phoca vitulina arises* from the inner surface of the stylo-hyal and epi-hyal, and from the fibrous tube of the pharynx between the two tympanic bullæ. It is *inserted* into the median raphé of the pharynx and to the vertebral column between the two recti antici majores. It is supplied by the pharyngeal plexus.

The Muscles of the Soft Palate.

These are the levator palati, tensor palati, palato-glossus, palato-pharyngeus, azygos uvulæ, and salpingo-pharyngeus.

The *Levator palati* both in *Phoca vitulina* and in *Arctocephalus arises* from the tympanic bulla below and a little to the inner side of the Eustachian tube, and from the inferior surface of that tube. It passes beneath the salpingo-pharyngeus, and is *inserted* into the posterior part of the soft palate between the palato-pharyngei.

The *Tensor palati* both in *Phoca vitulina* and *Arctocephalus* is a round muscular bundle *arising* from the tympanic bulla on the outer side of the Eustachian tube, and from the outer side of this tube. It runs along the outer side of the pterygoid plate, and turns round the anterior aspect of the hamular process; then it spreads out as a fine tendon, fan-like, upon the aponeurosis of the palate anteriorly. It is supplied by the otic ganglion.

The *Palato-glossus* both in *Phoca vitulina* and *Arctocephalus arises* by a few scanty fibres from the anterior surface of the soft palate, and blends with the stylo-glossus.

The *Palato-pharyngeus* both in *Phoca vitulina* and *Arctocephalus arises* beneath the levator palati from the posterior surface of the soft palate by one head. It is *inserted* as in man.

The *Azygos-uvulæ* both in *Phoca vitulina* and in *Arctocephalus arises* from the aponeurosis of the soft palate, and is distributed as usual.

The *Salpingo-pharyngeus* both in *Phoca vitulina* and *Arctocephalus arises* from the hamular process of the pterygoid, which is feebly developed in the former, but strongly in the latter. It takes a backward course to blend with the stylo-pharyngeus.

Prævertebral Muscles.

The prævertebral Cervical Region contains the rectus capitis anticus major and minor, rectus lateralis, and the longus colli.

The *Rectus capitis anticus major* both in *Phoca vitulina* and in *Arctocephalus* is a long slip *arising* by three fasciculi from the ventral division of the transverse processes of the 3rd, 4th, 5th, and 6th cervical vertebræ. Its origins are between the inner slips of origin, and the outer slips of insertion of the longus colli. The anterior parts of the origins from the vertebræ are tendinous. It runs forwards, and is *inserted* at the inner side of the foramen lacerum posterius, and to the anterior three-quarters of the fossa on the ventral surface of the basi-occipital, anterior to the rectus capitis anticus minor. It is supplied by an anterior branch of the suboccipital nerve, and by the internal branches of the cervical plexus.

The *Rectus capitis anticus minor* in *Phoca vitulina* and in *Arctocephalus* is a small slip *arising* from the atlas behind the condyle, and to the inner side of its foramen at the anterior border of the lamina. It is *inserted* into the posterior three-quarters of the fossa on the ventral surface of the basi occipital. In *Arctocephalus* it also has an origin from the tip of the transverse processes of the axis, but the fossa is much deeper in *Arctocephalus* than in *Phoca*. It is supplied by the sub-occipital nerve, and by the deep internal branches of the cervical plexus.

The *Rectus lateralis* in *Phoca vitulina arises* from the anterior surface of the transverse process of the atlas outside the foramen, and is *inserted* into the inferior termination of the occipital ridge, into the paramastoid process, and into the outer quarter of the fossa to the inner side of this process.

In *Arctocephalus* it *arises* as in *Phoca*, but on the inner side of the foramen, and is *inserted* posterior to the foramen lacerum posterius and the origin of the digastric into the exoccipital bone. It is supplied by the suboccipital nerve.

The *Longus colli* in *Phoca vitulina* is a long muscular roll situated upon the anterior surface of the thoracic and cervical vertebræ. It consists of two parts, an anterior and a posterior. The posterior *arises* from the bodies of the 1st to the 7th dorsal vertebræ, from the intervertebral discs, from the ventral surfaces of the rib joints, and from the body of the last cervical vertebra. It ascends and lies to the outer side of the rectus capitis anticus major, and is *inserted* into the ventral divisions of the cervical transverse processes of the 2nd to the 6th cervical vertebræ, to the outer side of the origins of the rectus capitis anticus major. The anterior part *arises* from the inner sides of the ventral divisions of the transverse processes of the 3rd to the 6th cervical vertebræ, the origins from the anterior ends being tendinous. It lies to the inner side of the rectus capitis anticus major, and is *inserted* into the bodies and intervertebral discs of the vertebræ reaching to the atlas, the fibres from the 6th going to the 5th, from the 4th to the 3rd, from the 3rd to the 2nd and 1st cervical vertebræ. It is supplied by branches of the brachial plexus.

In *Arctocephalus* there are three parts. The posterior oblique *arises* from the bodies of the 1st to the 4th dorsal vertebræ, from the intervertebral discs, from the ventral surfaces of the rib joints, and from the body of the last cervical vertebra; and is *inserted* into the outer side of the ventral division of the 6th cervical vertebra. The anterior oblique lies on the outer side of the rectus capitis anticus major, and *arises* from the outer sides of the ventral divisions of the transverse processes of the 3rd, 4th, 5th, and 6th cervical vertebræ; and is *inserted* by three slips into the dorsal tubercles of the 3rd, 4th, and 5th cervical vertebræ, and the outer half of the ventral surface of the wing of the atlas. The vertical part *arises* from the inner surface of the ventral divisions of the transverse processes of the 2nd to the 6th cervical vertebræ. The fibres go forwards, and are *inserted* into the hypapophyses of the 2nd to the 6th cervical vertebræ.

In *Otaria* and *Trichechus* Dr. Murie describes two parts.

The LATERAL VERTEBRAL REGION includes three muscles in *Phoca vitulina*—the scalenus anticus, medius, and posticus. In *Arctocephalus* the scalenus medius is wanting.

The *Scalenus anticus* in *Phoca vitulina* is a short band of muscle, and *arises* from the anterior and outer surface of the 1st rib at its junction with its cartilage, and proceeds forwards to be *inserted* into the antero-posteriorly elongated hatchet-shaped ventral divisions of the transverse processes of the 4th and 5th cervical vertebræ by tendinous slips. A fasciculus from it blends with the tendon of insertion of the scalenus medius into the 3rd cervical. It is supplied by the branches of the brachial plexus.

In *Arctocephalus* it lies between the longus colli ventrally and the serratus posticus dorsally. It *arises* from the anterior border of the 3rd rib, anterior to the origin of the digitation of the serratus, from the same border of the 2nd and 1st ribs, but to the inner side of the digitations of the serratus. The muscle forms a flattened band, and is *inserted* into the tip of the ventral division of the transverse process of the 7th cervical, and into the ventral sides of the dorsal divisions of the transverse processes of the 3rd, 4th, 5th, and 6th cervical vertebræ.

The *Scalenus medius* in *Phoca vitulina* is larger than the last, and *arises* from the anterior triangular surface of the 1st rib near its vertebral end, lying behind and a little to the outer side of the anticus. It is *inserted* by a tendon into the ventral hatchet-shaped division of the 4th cervical vertebra, by a fasciculus into the under surface of the tendon of the posticus going to the 4th cervical vertebra, and into the posterior surface of the tendon of the same muscle going to the 3rd cervical vertebra by the same fasciculus, which is continued forwards from behind the tendon of the posticus to the 4th vertebra. In the large *Phoca vitulina* the muscular arrangement differs from the above: on the right side it *arises* from the anterior and outer surface of the 1st rib, extending from its junction with the cartilage nearly to the inner third of the rib. It runs forwards and is *inserted* into the root of the outer side of the ventral division of the transverse process of the 6th cervical vertebra by muscular fibres, into the posterior end of the ventral division of the 5th cervical vertebra by a tendinous slip, and likewise into the corresponding part of the 3rd and 4th cervical vertebræ. It is supplied by the brachial plexus.

The *Scalenus posticus* in *Phoca vitulina* is much the largest of this group, and *arises* from the posterior border of the 4th rib at the junction of the cartilage with the rib; and similarly from the posterior border and outer surface of the 3rd rib. The digitation of the serratus coming from the 3rd rib lies between these two points of origin. It is *inserted* into the ventral hatchet-shaped division of the transverse processes of the 3rd and 4th cervical vertebræ by two strong tendons. In the large *Phoca vitulina* the origin is similar, but the *insertion* is by tendons into the posterior of the ventral divisions of the transverse processes of the 3rd and 4th cervical vertebræ, these tendons being common to the scalenus secundus. It is supplied by the brachial plexus.

In *Arctocephalus* it lies in the cervical region and is of the same shape as the anticus, but smaller. It *arises* from the ventral tip of the transverse process of the 7th cervical vertebra, and is *inserted* into the ventral border of the transverse process of the atlas, dorsal to the anterior oblique portion of the longus colli, into the dorsal tip of the transverse process of the 3rd cervical, and into the dorsal divisions of the same processes of the 4th, 5th, and 6th cervical vertebræ.

The Muscles of the Thorax.

In *Phoca vitulina* we find the sterno-costalis anterior and posterior, internal intercostals, external intercostals, scalenus lumborum, levatores costarum, and triangularis sterni. In *Arctocephalus* the sterno-costalis posterior is wanting, otherwise the muscles are alike.

The *Sterno-costalis anterior* is Lucae's transversus costarum latus and Murie's supracostal. In *Phoca vitulina* it lies next the sternum, and is a flat slender layer of muscle which *arises* from the side of the presternum and mesosternum as far back as the 6th rib, and from the cartilages of the 1st to the 6th ribs at their junction with the sternum. It remains tendinous to 1 inch from the side of the sternum, then it becomes muscular, and ultimately divides into three digitations, the 1st being the longest. It is *inserted* into the outer surface and cartilage of the 1st rib, extending outwards to the digitation of the serratus, into the posterior border of the 2nd rib close to the digitation of the serratus, and into the same part of the 3rd rib.

In *Arctocephalus* it is a small triangular muscle, and *arises* from the sides of the 2nd, 3rd, and 4th sternebræ, from the cartilages of the 2nd, 3rd, 4th, and 5th ribs by a fine aponeurosis. The fibres run forwards and outwards, and are *inserted* into the posterior border of the cartilage of the 1st rib, and into the 2nd at the junction of the cartilage with the rib.

Lucae figures it attached to the sternum and the ribs, covering the tendon of the rectus (pl. vi. fig. 1), but describes it as going from the 4th rib to the 1st cartilage and rib, with its tendon united to that of the rectus.

In *Otaria* it lies to the sternal side of the scalenus anticus between the cartilages of the 3rd and the 1st ribs.

In *Trichechus* it extends from the 4th costal cartilage to the 2nd rib and 1st intercostal space.

The name supracostal given to this muscle by Dr. Murie is confusing, for thus we should understand that the muscle is the musculus rectus thoracis of Professor Sir Wm. Turner, and the supracostal of Mr. Wood and others.[1] In *Phoca* the rectus tendon is unbroken and reaches the cartilage of the 1st rib beneath the sterno-costalis; in *Arctocephalus* the rectus ends posterior to the origin of this muscle, but the fibres of the sterno-costalis anterior, as in *Phoca*, are obliquely directed outwards and not antero-posteriorly. In Murie's dissections it does not touch the sternum, but the situation and direction of the fibres in his plates are the same as in *Phoca* and *Arctocephalus;* so I do not regard Murie's supracostal as a part of the rectus which the name he uses indicates.

The *Sterno-costalis posterior* is the transversus tenuis of Lucae. It is only found in *Phoca vitulina*, and *arises* from the mesosternum at its junction with the cartilages between the 3rd and 7th ribs, and from the tendon of the rectus which passes forwards beneath it. On the right side it receives a muscular slip from the xiphisternum and then divides into three slips, which are *inserted* into the outer surfaces of the 1st, 2nd, and 3rd ribs. The first digitation is fixed outside the origin of the sterno-thyro-hyoid; the second and third beside the origins of the serratus, these two being crossed by the origin of the scalenus posticus. This part may not be quite separate from the anterior.

The *External intercostals* in *Phoca vitulina* commence close to the side of the vertebral column, and leave only a hollow for the levatores. They *arise* from the posterior part of the rib joints by a few fibres, at the outer side of the levatores they thicken, and then pass from the ribs in front backwards and outwards to the ribs behind. They extend from end to end of each rib.

In *Arctocephalus* they extend from the heads of the ribs to the middle of the costal cartilages.

The *Internal intercostals* in *Phoca vitulina* are quite close to the vertebræ, where the subcostals are wanting. They *arise* from the anterior part of the rib joints, and from the anterior borders of the ribs, and are *inserted* into the posterior borders of the ribs sternad to their origins, the fibres of the muscles almost meeting over the ribs. There is an aponeurosis between the two muscles, strongest near the column and almost disappearing about the middle of the bony ribs. In the last space the muscle lies only on the outer half of the rib, and begins at the outer edge of the scalenus lumborum.

In *Arctocephalus* they arise from the whole anterior borders of the ribs to their necks, and from the same borders of the cartilages. The fibres are *inserted* into the posterior borders of the ribs sternad to their origins, and end at the sternebræ.

The *Scalenus lumborum* is so named by G. H. Meyer in the human body.[2] In *Phoca vitulina* it *arises* from the transverse processes of all the lumbar vertebræ by an aponeurosis, and forms a triangular muscle with the apex posterior. It is *inserted* in its outer half into the posterior border of the outer half of the last rib; the inner half crosses over this rib and is strengthened by a few fibres from it; whilst the outer half of this portion goes into the 14th rib, the inner crosses over to the 13th rib, and ends on its posterior border.

In *Arctocephalus* it *arises* from the transverse processes of the 1st, 2nd, and 3rd lumbar vertebræ, forming a thin triangular sheet with the base forwards. It is *inserted* into the last three ribs. A portion of its fibres from the outer side is attached to each of the last two ribs, the remainder to the 13th rib, but the proportion in which the fibres are distributed differs from that in *Phoca*—

[1] Sir Wm. Turner, *Proc. Roy. Soc. Edin.*, vol. vi. pp. 268, 270, 1869.

[2] Lehrbuch der Anatomie, 1855.

over the ventral surface of the 15th rib the outer third of the muscle terminates, over the 14th rib the half of the remaining fibres, and over the 13th the rest.

Lucae makes no distinction between the true subcostals and the scalenus lumborum, but describes both under the name subcostalis vertebralis. The drawing by Meyer shows the scalenus lumborum terminating at the last rib, but in *Phoca* and *Arctocephalus* it is prolonged forwards to the under surface of the third last rib. In *Otaria* and *Trichechus* it has not been figured or described.

The *Subcostales* in *Phoca vitulina* usually commence at the 7th or 8th intercostal space; there are six or seven of them, and they lie next the vertebral column. Each *arises* from the ventral surface of the rib joint, from the posterior part of the vertebra in front of the one with which the rib articulates, and from the rib close to the joint. The fibres pass over the rib in front of their origin, and are *inserted* into the posterior border of the next. The last two muscles have the scalenus lumborum along their outer borders.

In *Arctocephalus* there are twelve of these; all *arise* from the posterior part of the body of a dorsal vertebra, and are *inserted* as in *Phoca vitulina*, having a rib intervening between the origin and insertion. The muscles are much narrower than in *Phoca*, and commence in the 3rd intercostal space.

In *Otaria* and *Trichechus* they are not mentioned.

The *Levatores costarum* both in *Phoca vitulina* and in *Arctocephalus* are a series of small triangular muscles, with their bases directed away from the spinal column. There are fifteen on each side of the back; they *arise* from the dorsal tips of the dorsal divisions of the transverse processes of the 7th cervical and the anterior ten dorsal vertebræ, and from the under surfaces of the anapophyses of the 11th, 12th, 13th, and 14th dorsal vertebræ. The anterior muscles are small and narrow, the posterior short and broad, and the intermediate much the longest. They are *inserted* into the dorsal surface of the rib below the originating point, then into the anterior border of the same rib for a little distance beyond this. In the large *Phoca vitulina* I found only fourteen.

The *Triangularis sterni* is Lucae's subcostalis sternalis; in *Phoca vitulina* it lies upon the inner side of the sternum and covers the internal mammary artery. It *arises* from the side of the manubrium reaching as far forwards as the anterior border of the 4th rib, from the junction of the cartilages with the sternum from the 4th to the 10th ribs, and from the anterior half of the side of the ensiform cartilage. The muscle is divided into a number of serrations; in this dissection there were nine on each side, six arising from the manubrium and three from the ensiform cartilage; those from the manubrium were much larger than those from the ensiform. Each serration from the manubrium extended from the posterior border of one rib to the back of the next behind. The posterior fibres are not so obliquely directed forwards and outwards as the rest; the anterior fibres are most oblique. The last serration from the ensiform cartilage crosses the cartilage of the 11th rib, and is *inserted* into the lower border of the cartilage of the 10th rib; the penultinate crosses the cartilages of the 10th and 11th ribs, and is *inserted* into the lower and inner surface of the cartilage of the 9th rib; the last but two crosses the cartilages of the 11th, 10th, and 9th ribs, and is *inserted* into the lower border and inner surface of the 8th cartilage. The other serrations are *inserted* into the under and inner surfaces of the cartilages of the 2nd to the 7th ribs, each serration crossing two ribs before reaching its attachment.

In *Arctocephalus* it *arises* from the anterior half of the sternum by fibres, and from the ventral sides of the 3rd, 4th, 5th, and 6th sternebræ by a narrow tendon. The fibres pass transversely outwards posteriorly, and slightly outwards and forwards anteriorly, and terminate laterally 1 inch to the outer side of the sternum. It is *inserted* into the cartilages of the 3rd to the 8th ribs, and into the fascia between them upon the intercostal muscles. These muscles are supplied by the intercostal or lumbar nerves.

The Muscles of the Abdomen.

In *Phoca vitulina* and in *Arctocephalus* these are the external oblique, internal oblique, transversalis, rectus abdominis, and cremaster. The pyramidalis and quadratus lumborum are wanting.

The *Obliquus externus abdominis* in *Phoca vitulina* is much the strongest of the abdominal group. It has fourteen digitations. The first *arises* from the outer and posterior surface of the 4th rib, interdigitating with the serratus magnus, and, after mingling with a few of the fibres of the first or anterior head of the scalenus posticus, is partially crossed by part of the same muscle from the 5th rib. The second digitation from the outer and posterior surface of the 5th rib interdigitates with the serratus and touches the origin of the posterior slip of the scalenus posticus, which passes beneath the digitation of the serratus from this rib. The third to the seventh spring from the outer and posterior surfaces of the 6th to the 10th ribs, interdigitating with the serratus magnus only. The eighth to the thirteenth digitations spring from the outer and posterior surfaces of the 10th to the 15th ribs, interdigitating with the latissimus dorsi. The digitation from the last rib is the largest of the series from ribs. The fourteenth digitation has no bony origin, but comes from the lumbar fascia, interdigitating with the latissimus dorsi, and is still larger than the thirteenth. The fibres from the first and second digitations run backwards and inwards and terminate near the inner edge of the rectus muscle, and are continuous with the fascia covering its posterior surface; those from the third and fourth have the same course, but form an aponeurosis near the inner edge of the rectus, and join the aponeurosis of the other side. From behind the ensiform cartilage to the symphysis pubis the muscle terminates in an aponeurosis upon the outer border of the rectus, the fibres of one side decussating with those of the other. The anterior digitations run obliquely backwards and inwards, the middle more so, and those fibres coming from the posterior ribs and the dorsal fascia are nearly antero-posteriorly directed. The muscle is thinnest at its anterior end and thickest at its posterior and dorsal side, and does not thin off at the side of the rectus but ends abruptly as a tendon. The dorsal border behind the last digitation overlies the lumbar fascia, and is kept in its position by the fascia over the surface of the muscle passing on to it. The dorsal edge of the muscle runs directly backwards to a little to the outer side of the patella, whence the posterior border runs obliquely backwards and inwards to the symphysis in a direct line from the patella. From the posterior border, midway between the outer edge of the patella and the symphysis, two strong flat tendons are developed; the outermost goes behind the cord and is attached to the brim of the pelvis a little more than 1 inch to the anterior side of the symphysis, its posterior border being posterior at the attachment. From the anterior border of this a thin triangular aponeurosis is attached to the brim of the pelvis, extending from the anterior part of the outer pillar to an inch and a quarter posterior to the pectineal eminence.

In *Arctocephalus* it *arises* by ten digitations from the posterior and outer surfaces of the 6th to the 15th ribs, each digitation ending about half an inch from the junction of the ribs with their cartilages. The last digitation also has origin from the lumbar fascia; the direction of the fibres is much the same as in *Phoca*. As most of the aponeuroses of the trunk had lost distinctness owing to the length of time the specimen had been in salt, I cannot enter into a description. From the last digitation the fibres pass directly backwards and reach the ventral anterior spine of the ilium, and are attached to it. The mesial fibres terminate upon the middle of the rectus muscle in the anterior two-thirds, and upon its inner edge in the posterior third. From the ventral anterior spine of the ilium the insertion remains muscular until it reaches the pectineal eminence, where it becomes tendinous, and is *inserted* into the pelvic brim, reaching the outer side of the rectus abdominis and forming the outer pillar of the external abdominal ring. The rest of this aponeurosis crosses over the cord and terminates upon the origin of the rectus. The five anterior slips interdigitate with the serratus magnus, the sixth, seventh, and eighth with the latissimus dorsi.

The *Obliquus internus abdominis* in *Phoca vitulina* is hidden by the external oblique, and has a slight resemblance to a quadrilateral figure. It *arises* by muscular fibres from the ventral border of the ventral anterior spine of the ilium to the inner side of the origin of the sartorius; from the brim of the pelvis by muscular fibres from the front of the attachment of the inner pillar of the external abdominal ring to the posterior part of the pectineal eminence; from the lumbar fascia between the last rib and the crest of the ilium by an aponeurosis; from the inner surfaces and tips of the cartilages of the 13th, 14th, and 15th ribs; and from the adjacent sides of the 11th and 12th ribs an inch from their terminations. The fibres of the muscle midway between the anterior ventral spine of the ilium and the last rib are almost all transverse; anterior to this they are directed upwards and inwards, and anteriorly end opposite the posterior end of the xiphisternum. The fibres are grouped into bands which are closely united, and between these bands the arterial supply for the abdominal walls penetrates. The muscle ends anteriorly and mesially as an aponeurosis and by fibres along its dorsal border; the anterior part of the aponeurosis crosses over the posterior half of the xiphisternum, and is *inserted* into the side of its anterior half and into the cartilages of the 10th and 11th ribs. The two strong broad anterior bands, *arising* from the lumbar fascia between which the transversalis partially arises, are *inserted* into the posterior border of the last rib, and into the inner surface and tips of the cartilages of the 13th, 14th, and 15th ribs, and by muscular fibres into the inner surfaces only of the 11th and 12th ribs. Behind the ensiform cartilage and anterior to the level of the 14th rib the tendinous termination passes behind the rectus and unites with the internal oblique of the other side; posterior to this and anterior to the posterior seventh of the rectus, the tendon passes over the rectus, and unites with the tendon of the external oblique above it; and at the posterior seventh of the rectus the muscle ends upon the rectus by small muscular digitations. The posterior border of the muscle crosses over from the anterior ventral spine of the ilium to the outer pillar of the external oblique, crossing the middle of the thigh; and the fibres rising from the brim of the pelvis turn outwards upon the thigh, and then curve to the middle line. The most posterior fibres turn over the cord and are attached to its outer fourth; and four fasciculi descend upon the testicle, and form the *cremaster*, being prolonged from the inner and curved side of the fibres which arch over the cord.

In *Arctocephalus* it *arises* by muscular fibres from the pelvic brim, beginning midway between the symphysis and the pectineal eminence; the fibres between the anterior part of the pectineal eminence and the anterior ventral spine of the ilium *arise* from the transversalis fascia; between this spine and the last rib the fibres anterior to the 4th lumbar spine spring from the lumbar fascia;

posterior to the 4th lumbar vertebra and anterior to the anterior ventral spine it has two fascial origins, from the dorsal surface of the erector spinæ, and from the tips of the transverse processes of the 5th and 6th lumbar vertebræ. The dorsal border has an oblique direction, sloping gradually from the 1st lumbar vertebra to the anterior ventral spine. The fibres springing opposite the 1st lumbar vertebra pass transversely beneath the digitations of the external oblique from the 13th rib, and are *inserted* into the posterior border of the 13th rib beneath that muscle; the fibres from the 2nd lumbar spine are similarly *inserted* into the 14th rib, and those from the 3rd lumbar spine like the last into the 15th rib. The greater portion of the last digitation of the external oblique is blended with the transversalis between the fibres from the 3rd and 4th lumbar spines. Posterior to the 3rd lumbar vertebra the fibres ascend and are *inserted* into the posterior border of the cartilages of the 13th to the 15th ribs and into the 11th and 12th cartilages by fascia. From the xiphisternum to midway between it and the pubes the fibres end upon the under surface of the rectus; posterior to this they turn over its ventral surface to end upon it; and the fibres from the pubes arch over the round ligament and also end upon the rectus.

The *Transversalis abdominis* in *Phoca vitulina arises* from the transversalis fascia between the front of the outer pillar and the anterior ventral spine of the ilium, from the lumbar fascia to the last rib, and from the inner surface of the cartilages of the 10th to the 15th ribs. The fibres are strongest anteriorly and thinnest posteriorly. It is *inserted* by muscular fibres into the side of the anterior surface of the ensiform cartilage, and blends over its posterior half with its fellow. Behind the ensiform cartilage it forms a tendon which unites with its fellow to the posterior third of the rectus, behind this it ends on the outer side of the rectus. Near the symphysis it terminates upon the transversalis fascia, and near the outer side of the same fascia it crosses over the cord near the internal ring.

In *Arctocephalus* it *arises* from the inner surface of the cartilage of the 11th rib in front of the tip of the 12th rib, from the same part of the 12th to the 15th ribs, from the lumbar fascia coming from the tips of the transverse processes of the lumbar vertebræ; and between the anterior ventral spine and the pectineal eminence it lies on the transversalis fascia. The fibres are far apart, especially near the pubes, and are *inserted* into the xiphisternum and the linea alba; midway between the xiphisternum and the pubes the fibres gradually shorten, and at the posterior fourth of the linea alba they just cross the infundibulum.

The *Rectus abdominis* in *Phoca vitulina arises* from the symphysis and slightly from the brim of the pelvis a little anterior to this. It runs anteriorly over the 11th rib and then along the side of the manubrium. Over the 5th rib it forms a broad thin tendon, which is *inserted* into the junction of the cartilages with the manubrium from the 1st to the 5th ribs. On the right side the tendon of the rectus was prolonged outwards from the junction of the 1st cartilage with the sternum to the humerus.

In *Arctocephalus* it is narrow anteriorly, and *arises* from the symphysis and the adjacent pubic bar. At the posterior fourth of the muscle it passes between the transversalis and the internal oblique, and midway between the xiphisternum and the pubes between the internal and external oblique. It is *inserted* by tendinous slips into the outer surfaces of the cartilages of the 5th to the 10th ribs. In *Phoca* and *Arctocephalus* the inscriptiones tendineæ are wanting.

This set of muscles is supplied by the ilio-inguinal, ilio-hypogastric, dorsal, and 1st lumbar nerves.

The Diaphragm.

In *Phoca vitulina* the diaphragm has a costal and a vertebral origin. The costal portion *arises* by a broad fleshy slip from the dorsal surface of the xiphisternum which stretches across its terminal expansion, from the posterior surface only of the cartilage of the 10th rib, and from the posterior and inner surfaces of the cartilages of the 11th to the 15th ribs. These costal origins interdigitate with the transversalis. The vertebral portion *arises* by two crura, the left crus by two tendinous slips, the posterior from the ventral surface of the posterior margin of the body of the 2nd lumbar vertebra, the anterior from the same part of the 1st lumbar; the posterior slip joins the outer side of the anterior opposite the middle of the 1st lumbar vertebra. The right crus also *arises* by two slips, the posterior from the ventral surface of the posterior part of the 2nd lumbar vertebra, the anterior from the back of the 1st lumbar exactly opposite the anterior slip of the opposite side, reaching as far forward as the back of the last dorsal; this slip is much larger than the slip of the opposite side. The lumbar artery of the right side has just sufficient space to pass between the slips, while the corresponding vessel for the left side is in the same relation to the short anterior slip but far removed from the posterior one. In addition the left crus also takes origin from both sides of the transverse process of the 1st lumbar vertebra by tendinous fibres, and both crura from the posterior border of the last rib. It has three openings which are nearly in the middle line. The one for the vena cava lies a little to the right of the mesial plane and most anterior, and is in the tendon of the diaphragm, and therefore is surrounded by fibrous tissue. The middle opening is for the œsophagus and is elliptical, the long diameter being antero-posterior; a small portion of the anterior end is tendinous, the rest is muscular. The third opening gives passage to the aorta, and is also elliptical, the long sides of the ellipse being parallel with the aorta; it is formed by the crura of the diaphragm which meet over the aorta, opposite the posterior part of the last dorsal vertebra, the left crus slightly overlapping the right, but the fibres not crossing each other. The central tendon is a large V-shaped slip of fibrous tissue. It begins on each side of the back about the middle of the penultimate rib as two fine fibrous streaks, which widen as they near the vena cava. These two streaks meet around this vessel, forming a fibrous ring which fills in the space between the opening for the œsophagus and the vena cava.

On the *dorsal margin* of the diaphragm there are two V-shaped slips of fibrous tissue let into its substance on both sides; the outer arches over the psoas secundus, the inner is between the tip of the transverse process of the 1st lumbar vertebra and the last rib. The apices of these V's are directed forwards, the abdominal fascia forming one side of these slips and the pleura the other.

The *muscular fibres* from the xiphisternum go straight to the tendon. The costal fibres run into the front side of the lateral slips of the central tendon, those from the ribs being most oblique, and those next the xiphisternum most transverse. The dorsal fibres take a straight course to the posterior side of the tendon; those from the transverse processes of the lumbar vertebræ pass towards the middle of the last rib, where they reach one side of the central tendon opposite where the last costal fibres reach its other side; between these two is one of the fibrous V's whose base is between the middle of the last rib and the transverse process of the 2nd lumbar vertebra.

The fibres are thus distributed round the openings:—Around the aorta on the under surface the crus of the left side slightly overlaps the right; on the upper surface they touch and run on.

Around the œsophageal opening upon the under surface the fibres from the crura meet at its posterior part, and pass on to the central tendon on each side of the vena cava; upon the upper surface the fibres from the right crus divide and run along each side of it, and end behind the vena cava. The vena cava is fibrous on the under surface of the diaphragm; the upper is not, but it receives a few fibres from the left side.

In *Arctocephalus* as in *Phoca* the diaphragm has a costal and a vertebral origin. The former *arises* by fleshy slips from the ensiform sternebra and not from the spade-shaped cartilage attached to it, posteriorly from the posterior surface of the 8th rib, and from the posterior and inner surfaces of the 9th to the 14th ribs. These also interdigitate with the transversalis. The latter origin consists of two crura, the left crus *arises* by muscular fibres from the body of the 1st and 2nd lumbar vertebræ and the disc between, and by tendon from the 2nd and 3rd lumbar vertebræ and the disc between. The right crus is larger than the left, and *arises* by muscular fibres from the 1st, 2nd, and 3rd lumbar vertebræ and the discs between, and by tendon from the 3rd and 4th lumbar; the crura expand and form an oval slip which fits into the back of the central tendon. The tendon is V-shaped, and the crura are attached to its dorsal side. The fibres from the ensiform cartilage and the ribs pass towards the anterior part of the tendon, those from the 14th rib meet the central tendon midway between the opening for the vena cava and this rib, and the gap between is filled in by fibrous tissue. The œsophagus is in the apex of the central tendon, the vena cava to the right, and the aorta between the crura.

In both specimens the left phrenic nerve pierces the diaphragm half an inch to the right of the vena cava; the right goes through the same spot on the other side, which is one and a half inch to the left of the vena cava, and they supply the muscle.

The Deep Muscles of the Back.

The muscles may be considered in the following groups:—The serratus posticus, splenius, erector spinæ, complexus and transverso-spinales, interspinales, intertransversales and interzygapophyses, and the short postero-cranio-vertebral muscles.

The *Serratus posticus* in *Phoca vitulina* is a very thin muscular band, and *arises* from the 2nd to the 5th dorsal vertebræ. The fibres course downwards and backwards, and are *inserted* by a short aponeurosis into the lower borders of the 5th to the 9th ribs, outside the tendons of the iliocostalis. In the large *Phoca vitulina* it *arises* by thin tendons from the same vertebræ and from the intervals between the vertebræ by thin aponeuroses, and is *inserted* into the posterior borders of the 6th to the 10th ribs by fine tendons. As it is not mentioned by Murie in *Otaria* and *Trichechus*, I conclude it is absent. It is supplied by the external branches of the dorsal spinal nerves.

The *Splenius* in *Phoca vitulina* is not a double muscle as in human anatomy, neither is it strap-shaped, but triangular. It is hidden by the cephalo-humeral, rhomboideus-capitis and cervicis, and *arises* from the ligamentum nuchæ, by muscular fibres in its posterior part, and by a fine aponeurosis in its anterior. It extends posteriorly from where the fibres of the rhomboideus cervicis begin to take a transverse course from the middle line of the neck, which is about one inch anterior to the vertebral anterior angle of the scapula, and terminates anteriorly at the back of the interparietal bone. A small fasciculus is continuous with the rhomboideus cervicis. The fibres course outwards and forwards, and are *inserted* partly by muscular fibres and partly by aponeurosis into the occipital ridge. It is supplied by the external division of the great occipital nerve, by a branch of the external division of the 3rd cervical, and by a branch from the suboccipital.

In *Arctocephalus* it has the same shape and relations as in *Phoca vitulina*, and *arises* from the ligamentum nuchæ, the 7th cervical vertebra, and the three anterior dorsal spines, and is *inserted* into the occipital ridge from the posterior termination of the sagittal suture, to the posterior margin of the external auditory meatus. It is blended with the trachelo-mastoid near its insertion. In *Otaria* and *Trichechus* a splenius capitis and colli are described. The former is the same as the splenius in *Arctocephalus*, and the splenius colli is the trachelo-mastoid in *Arctocephalus*.

The *Erector spinæ* in *Phoca vitulina* divides into the sacro-lumbalis, longissimus dorsi, transversalis colli, and trachelo-mastoid. In *Arctocephalus*, in addition to the above, the spinalis dorsi and colli are found.

In *Phoca vitulina* it lies between the caudal region and the last rib. Its aponeurosis extends from the sacral to the dorsal region as far as the 14th dorsal spine, crosses over the multifidus, forming its dorsal covering, and ends laterally on the middle of the dorsum of the erector spinæ posterior to the last rib. It is a massive roll of muscle anterior to the ilium, but posterior to this is in two small but distinct parts, corresponding to the sacro-lumbalis and the longissimus dorsi. Anterior to the ilium there is an indication of the existence of two muscles, for a partial fibrous partition is found running for a short distance into the fibres from the anterior dorsal surface of the sacrum. The erector *arises* in two parts, the division ultimately forming the longissimus dorsi from the rudimentary zygapophyses of the 3rd, 4th, 5th, and 6th caudal vertebræ, from the transverse process of the 1st caudal, from the ligamentous structures covering the dorsum of the sacrum between the zygapophyses and the transverse processes, and from the ligamentous partition on each side. It runs forward as the erector spinæ, lying next the zygapophyses of the lumbar vertebræ, and turns over the last rib. The division joining the fibres of the erector, and forming the sacro-lumbalis, *arises* from the transverse processes of the 1st, 2nd, and 3rd caudal vertebræ, and from the zygapophyses of the 1st and 2nd caudal vertebræ. This origin is bound to the outer side of the posterior sacro-iliac ligament, and runs into the erector anterior to the ilium, forming the partial septum already mentioned. This structure is supplemented by a tendon from the dorsal surface of the ilium, and by fibres from its anterior surface, from the same surface of the sacrum, and from the ligament between them, the three last origins being ventral to the septum. The longissimus portion of the erector from the caudal region is *inserted* into the dorsal posterior borders of the anterior zygapophyses of the 2nd, 3rd, 4th, and 5th lumbar vertebræ, into the anapophyses of the last dorsal and 1st lumbar vertebræ, into the outer surface of the lumbar vertebræ, by muscular fibres extending from the dorsal tips of the anterior zygapophyses to midway between these and the tranverse processes, and into the inner posterior third of the last rib. The sacro-lumbalis portion is *inserted* into the ventral halves of the outer surfaces of the lumbar vertebræ, into the outer surfaces of their transverse processes, and into the outer two-thirds of the posterior border of the last rib to within 1 inch from its outer end. The erector is under cover of the lumbar fascia.

In *Arctocephalus* the longissimus dorsi is not separable from the sacro-lumbalis as in *Phoca*, yet the formation of the two is partly evident in the lumbar region. The erector *arises* in the sacral region by an aponeurosis, from the spines of some of the caudal and all the sacral vertebræ, which passes forwards, and ends opposite the 8th dorsal vertebra, and covers the whole of the longissimus division in the lumbar region, and 1 inch of the sacro-lumbalis division next the ilium; also from the neural spines and zygapophyses of the caudal vertebræ, from the neural spines, zygapophyses, and transverse processes of all the sacral vertebræ, from the inner surface of the ilium, from the anterior surface of the sacrum, from the ligament between the ilium and sacrum, from all the lumbar vertebræ between the neural spines and the zygapophyses, and from the sides of these vertebræ between the zygapophyses and the ventral tips of the transverse processes.

The *Ilio-costalis* or *Sacro-lumbalis* in *Phoca vitulina* is the outer division of the erector spinæ. It is a long band running along the back, broadest and strongest at the posterior end, narrowest and tendinous at the anterior. Along its outer margin is a series of serrations, the seven posterior being muscular, the nine anterior tendinous. It is chiefly adherent to the outer surfaces of the ribs over which it lies, especially along their posterior and anterior borders. It is *inserted* by the digitations along its outer edge into the outer surfaces of the posterior seven ribs by muscular fibres, into the posterior borders of the anterior seven ribs by tendinous slips, and into the dorsal tubercle of the transverse process of the 7th cervical vertebra. In the large *Phoca vitulina* it also *arises* by tendinous slips from the angles of the 14th to the 5th ribs on their anterior borders. It is supplied by the posterior primary division of the spinal nerves.

In *Arctocephalus* it is an offshoot from the erector spinæ, and its origin can be partly traced to 1 inch anterior to the crest of the ilium. It is very narrow posteriorly, and expands gradually as it approaches the last rib, where it covers its inner two-thirds, while the anterior two-thirds of the muscle is narrow and tendinous on the dorsal surface, and terminates by giving off long tendinous slips. It is *inserted* into the dorsal surfaces of the 6th to the 15th ribs. Along its outer margin it has a number of tendinous digitations which are long at the anterior end, and short posteriorly. The most anterior goes into the dorsal tip of the transverse process of the 7th cervical, the rest pass to the dorsal borders of the 1st to the 12th ribs. The posterior slips are half tendinous and half muscular.

The *Musculus accessorius ad ilio-costalem* and the *Cervicalis ascendens* are wanting in both *Phoca vitulina* and *Arctocephalus*.

The *Longissimus dorsi* in *Phoca vitulina* lies to the inner side of the sacro-lumbalis, but is not quite so large or long, and is under cover of the fascia lumbo-dorsalis. It *arises* from the under surface of this fascia out of the erector spinæ, from the dorsal tips of the zygapophyses of some of the lumbar vertebræ, and from the anterior zygapophyses of all the dorsal vertebræ. It lies along the outer side of the zygapophyses, and is *inserted* by muscular fibres into the outer surfaces of the posterior five ribs, by tendons into the anapophyses of some of the dorsal vertebræ (posterior six), into the dorsal tips of the transverse processes of all the other dorsal vertebræ, which are homologous to the anapophyses, into the dorsal division of the transverse process of the 7th cervical vertebra, and by tendinous slips along its inner border into the dorsal surfaces of the anterior borders of the 6th to the 11th ribs. From the anterior zygapophyses of the 11th and 12th dorsal vertebræ two strong tendons arise, which divide equally between the multifidus and this muscle. Opposite the 6th rib a large piece of this muscle goes into the transversalis cervicis. In the large *Phoca vitulina* it is *inserted* in addition into the 9th, 10th, and 11th ribs on their posterior surfaces.

In *Arctocephalus* it is a long narrow band covered by dense fascia in its posterior half. This division of the erector runs into the neck, giving off a number of serrations from its under surface, the anterior ones long and chiefly tendinous, the posterior more muscular. They are *inserted* into the posterior borders of the 11th to the 15th ribs, into the zygapophyses and anapophyses of the 11th to the 15th vertebræ, into the anapophyses of the 1st to the 10th dorsal vertebræ, and into the tips of the dorsal tubercles of the transverse processes of the 3rd to the 7th cervical vertebræ. Some fibres of this muscle seem to take origin along the internal borders of the vertebræ.

The *Transversalis cervicis* or *colli* in *Phoca vitulina* is in part a continuation of the longissimus dorsi, and branches off from it at the 6th rib. It also *arises* by muscular fibres from the dorsal surfaces of the transverse processes of the 1st to the 5th dorsal vertebræ, to the inner side of the tendons of insertion of the longissimus dorsi into the same processes, which if developed would be the anapophyses, and from the anterior halves of the anterior zygapophyses of the 5th, 6th, and 7th cervical vertebræ and the 1st dorsal. It forms in conjunction with the part coming out of the longissimus dorsi a muscular band which advances towards the cervical region, and there lies between the digitations of the serratus magnus on its outer side and the trachelo-mastoid on its inner, and is *inserted* by five tendinous slips into the dorsal tubercles or divisions of the transverse processes of the 3rd to the 7th cervical vertebræ. In the large *Phoca vitulina* it *arises* in addition from the transverse processes of the 6th to the 10th dorsal vertebræ.

In *Arctocephalus* it is a prolongation of the longissimus, and can only be regarded as the part of the longissimus which lies in the region of the neck and is described with it, because there is no slip given off from it as in *Phoca*.

The *Trachelo-mastoid* in *Phoca vitulina* lies between the complexus and the transversalis cervicis. It *arises* from the anterior and posterior zygapophyses of the 3rd to the 7th cervical vertebræ, and the surfaces of the vertebræ between the articular surfaces. It divides into two parts; the portion arising from the 3rd, 4th, and 5th vertebræ is *inserted* into the posterior edge of the transverse process of the axis; the rest goes to the cranium, and is *inserted* into the mastoid process. It is supplied by the external division of the 2nd and 3rd cervical nerves.

In *Arctocephalus* it is called by Murie splenius colli, and *arises* from the 3rd, 4th, 5th, 6th, and 7th cervical vertebræ between the posterior zygapophyses and the hyperapophyses, and from the dorsal surfaces of the laminæ between each vertebra, and from the sides of the roots of the 1st, 2nd, 3rd, and 4th dorsal spines. The last two cervical origins blend with the complexus. It courses anteriorly below the outer border of the splenius, and is *inserted* by a narrow tendon into the inferior part of the occipital ridge behind the external auditory meatus posterior to the insertion of the splenius.

The *Spinalis dorsi* is only found in *Arctocephalus*. It lies between the neural spines and the longissimus dorsi; the dorsal surface is muscular as far back as the 12th rib, from this to the 14th rib it is tendinous and appears continuous with the longissimus; but, by scraping away the muscular fibres which arise from the neural spines, a set of tendons is reached which appears to be the aponeurosis of the longissimus, but can with a little care be parted from it. It *arises* by muscular fibres and by long tendinous slips; the fibres spring from the sides of the neural spines from the 9th to the 12th dorsal vertebræ, the long tendinous slips from the metapophyses of the 11th to the 14th dorsal vertebræ. The muscular fibres are sparse and thin at the posterior extremity, but deepen and expand anteriorly; the tendons of origin lose themselves on the under surface of the muscle. It is *inserted* by small tendinous slips into the sides and tips of the neural spines from the 1st to the 8th dorsal vertebræ; but the 1st, 2nd, and 3rd vertebræ also have fibres inserted into them. A large muscular slip is continued into the cervical region, forming the spinalis colli.

The *Spinalis colli* in *Arctocephalus* branches off from the spinalis dorsi between the 2nd and 3rd dorsal vertebræ, passes forwards, receives additional fibres from the posterior cervical spine, surmounts them, and ends on the neural spine of the axis. It is *inserted* into the anterior cervical spines as far forwards as the axis.

The *Complexus* in *Phoca vitulina* lies above the rectus capitis posticus major, and beneath the splenius capitis and trachelo-mastoid. It is a fleshy band, and *arises* from the zygapophyses of the 3rd to the 7th cervical vertebræ by fleshy digitations. The fibres proceed to the occipital region, and are *inserted* by tendon in its inner three-fourths and by muscular fibres in its outer fourth into the back of the interparietal element of the occipital bone, and into the occipital ridge, reaching nearly to the root of the zygoma. It is supplied by the internal branches of all the cervical, and a branch of the suboccipital nerve.

In *Arctocephalus* it *arises* from the hyperapophyses of the 3rd, 4th, 5th, 6th, and 7th cervical vertebræ, and the metapophysis of the 3rd cervical. It courses forwards upon the cervical laminæ, and is *inserted* by tendon into the occipital ridge to the outer side of the biventer cervicis.

The *Biventer cervicis* in *Phoca vitulina arises* by fibres from the anterior zygapophysis of the 7th cervical vertebra, from the posterior zygapophysis of the same, from the anterior and posterior surfaces of the 1st dorsal vertebra, and from the anterior part of the 2nd dorsal vertebra. There are three digitations of origin; at the spine of the axis it unites with the inner border of the complexus and is *inserted* with it. In the large *Phoca vitulina* it *arises* from the zygapophyses of the 1st to the 4th dorsal vertebræ, and joins the complexus opposite the spine of the axis. In a small male *Phoca vitulina* it was absent. The nerve supply is the same as that of the complexus.

In *Arctocephalus* it is long and riband-like. It *arises* from the roots and sides of the neural spines of the 2nd, 3rd, and 4th dorsal vertebræ to the inner side of the trachelo-mastoid, with which it is blended at its origin. It passes forwards to the inner edge of the complexus, and is *inserted* by fibres into the occipital ridge, between the complexus on its outer side and the sagittal suture on its inner.

The Oblique Rotator Muscle of the Spinal Column.[1]—This muscle is in two layers in *Phoca vitulina* and in *Arctocephalus*, and lies between the neural spines and the zygapophyses. These layers are of a totally different formation in these animals. In *Phoca* the superficial layer is an extensive muscular bundle extending from the caudal to the cervical region, and the deeper layer forms a set of triangular imbricated muscles. In *Arctocephalus* the superficial layer resembles the deeper layer in *Phoca*, and the deep layer is similar of the rotatores muscles in human anatomy.

The *superficial layer* of fibres of the oblique rotator in *Phoca vitulina* lies in the hollow between the neural spines and the zygapophyses, stretching from the caudal region into the cervical under cover of the lumbo-dorsal fascia. In the caudal region the origins are tendinous slips; the first slip *arises* from the rudimentary zygapophyses of the 4th and 5th caudal vertebræ and the dorsal surfaces of the laminæ between them, and is *inserted* into the side of the neural spine of the 4th sacral vertebra, the corresponding parts of the 1st, 2nd, and 3rd caudal, and also into the posterior part of the zygapophyses of the 3rd caudal; the second slip *arises* from the zygapophysis of the 3rd caudal vertebra, and is *inserted* into the sides of the neural spines of the 2nd and 3rd sacral vertebræ, and the laminæ between the 2nd and 3rd, and 3rd and 4th sacral vertebræ; the third slip *arises* from the zygapophysis of the 2nd caudal vertebra, and is *inserted*

[1] See for the use of this term Sir Wm. Turner's Introduction to Human Anatomy, revised edition, p. 76, 1882.

into the sacral portion of the multifidus. In the sacral region they *arise* by a tendinous slip from the zygapophysis of the 4th sacral vertebra, from the zygapophysis of the 3rd sacral by a very short tendinous slip, from the dorsal surface of the sacrum between the neural spines and the zygapophyses, and from the fascia covering it. The mass thus formed and strengthened by the caudal slip joins anteriorly the lumbar portion, and is *inserted* by muscular fibres into the neural spines and the contiguous dorsal surfaces of the sacral laminæ, and by tendinous slips into the neural spines of the 4th and 5th lumbar vertebræ. In the lumbar region the fibres *arise* by broad tendinous slips from the anterior zygapophyses of the 1st sacral and all the lumbar vertebræ, from the posterior zygapophyses and dorsal surfaces of the laminæ of all the lumbar vertebræ, and from the fibrous covering above the muscles. These fibrous slips from the anterior zygapophyses join the muscle on the under surface of its outer border. They are *inserted* by tendinous slips along its inner border into the posterior aspect of the dorsal tips of the neural spines of the 12th to the 15th dorsal vertebræ, into the corresponding part of the 1st, 2nd, and 3rd lumbar vertebræ, and by muscular fibres into the sides of the neural spines of the same vertebræ. In the dorsal region the fibres *arise* from the metapophyses of the 8th to the 15th dorsal vertebræ, from the dorsal surfaces of the laminæ as far forwards as the 8th or 9th dorsal vertebra, and are *inserted* in the same way as the lumbar portion, into the 1st to the 11th dorsal vertebræ. From the 10th to the 15th dorsal spines the fibres of the superficial layer are intimately connected with the longissimus dorsi, and have origin from the under surface of the dorso-lumbar fascia, as far forwards as the 14th dorsal vertebra. The tendons of origin from the 6th to the 15th vertebræ are shared between the longissimus and the multifidus; the cervical portion is an offshoot from the dorsal about the level of the 8th rib, and forms long slips which are *inserted* into the neural spines of the 3rd to the 7th cervical vertebræ.

The *deep layer* of fibres of the oblique rotator in *Phoca vitulina*. The first muscle *arises* from the 3rd to the 5th cervical vertebræ from the posterior zygapophyses, and is *inserted* into the posterior zygapophysis of the axis. The second *arises* from the posterior zygapophyses of the 4th to the 6th cervical vertebræ to the inner side of the 7th, and is *inserted* into the posterior border of the lamina of the 3rd cervical vertebra. The third *arises* from the same parts of the 5th to the 7th, and is *inserted* into the corresponding part of the 4th cervical vertebra. The fourth *arises* from the laminæ of the 6th and 7th cervical and the 1st dorsal vertebræ, and is *inserted* into the dorsal surface of the same portion of the 5th cervical vertebra. The fifth *arises* from the posterior zygapophysis of the 1st dorsal vertebra, from the dorsal surface of its lamina, and from the dorsal surface of the lamina of the 7th cervical, and is *inserted* into the dorsal side of the spine of the 6th cervical vertebra. The sixth *arises* from the transverse process of the 2nd dorsal, from the posterior zygapophysis of the 1st dorsal, and is *inserted* into the spine of the 7th cervical. In the dorsal region they are not so oblique as in the cervical region. One *arises* from the zygapophyses of the 2nd to the 4th dorsal vertebræ, and is *inserted* into the spine and lamina of the 2nd dorsal vertebra, and so on to the 10th dorsal vertebra, the last muscle only having origin from one vertebra. The cervical muscles are all oblique, the dorsal are oblique and transverse, and all are imbricated.

The superficial layer of the oblique rotator muscles in *Arctocephalus* is well developed. The cervical muscles are much longer than the dorsal, the first and most anterior *arises* by three slips, from the dorsal surface of the lamina and the posterior zygapophysis of the 3rd cervical vertebra, from the hyperapophysis of the 4th cervical, and from the same part of the 5th cervical vertebra. It is *inserted* into the back of the hatchet-shaped neural spine of the axis, into the posterior border of its lamina, and into the neural spine of the 3rd cervical vertebra. The second *arises* from the hyperapophyses of the 5th, 6th, and 7th cervical, ascends, and is *inserted* into the neural spines of the 4th and 5th cervical. The third *arises* from the hyperapophysis of the 7th cervical and the posterior zygapophysis of the 1st dorsal vertebra, and is *inserted* into the back of the neural spine of the 5th and the neural spine of the 6th cervical. The dorsal muscles are well marked in the anterior dorsal region, but are feeble near the lumbar, for the space between the transverse processes and the neural spines narrows considerably near the lumbar region. They are all formed on the same plan, and *arise* from the inner sides of the transverse processes of these vertebræ, and are *inserted* into the side of the neural spine opposite the most anterior vertebra from which they spring.

The deep layer of the oblique rotators in *Arctocephalus arises* from the anterior of the transverse processes, passes inwards, and is *inserted* into the roots of the neural spines and posterior borders of the laminæ of the vertebræ anterior to their origin.

The erector spinæ, sacro-lumbalis, longissimus dorsi, transversalis colli, trachelo-mastoid, and spinalis dorsi are supplied by the external branches of the posterior divisions of the cervical, dorsal, and lumbar nerves. The rotator muscles and spinalis colli by the internal branches of the posterior divisions of the cervical, dorsal, and lumbar nerves.

The *Supraspinales* were not seen in *Phoca vitulina* or *Arctocephalus*.

The *Interspinales* in *Phoca vitulina* and in *Arctocephalus* are most distinct in the cervical region.

The *Intertransversales* in *Phoca vitulina* and in *Arctocephalus* are found in the cervical and dorsal regions. In the latter they are between the dorsal divisions of the transverse processes.

The *Interzygapophyses* in *Phoca vitulina* and in *Arctocephalus*, in the lumbar region, are strong muscular slips. The supraspinales and interspinales are supplied by the internal divisions of the cervical, dorsal, and lumbar nerves. The intertransversales and interzygapophyses by the external divisions of the cervical, dorsal, and lumbar nerves.

The *Rectus capitis posticus major* in *Phoca vitulina* is riband-shaped and *arises* from the posterior three-fourths of the side of the tip of the neural spine of the axis by muscular fibres. It courses forward, and is *inserted* by a short tendon into the lambdoidal suture between the rectus capitis posticus minor and the rectus capitis posticus major accessorius behind the occipital ridge beneath the complexus. It is supplied by the suboccipital nerve.

In *Arctocephalus* it arises from the anterior two-thirds of the side of the hatchet-shaped neural spine of the axis, and slightly from the adjoining surface. It is *inserted* into the lambdoidal suture.

The *Rectus capitis posticus major accessorius* is present in all the specimens. It is a narrow muscular slip *arising* by muscular fibres from the anterior fourth of the side of the tip of the neural spine of the axis. This small bundle takes a turn outwards and ascends to the occiput between the rectus capitis posticus major and minor. It is *inserted* into the occipital bone a little posterior to the lambdoidal suture, to the inner edge of the rectus capitis posticus major, between the insertion of the rectus capitis posticus minor and the insertion of the superior oblique, and slightly into the back of the condyle of the occipital bone, posterior to the major. It is supplied by the suboccipital nerve.

In *Arctocephalus* it *arises* from the anterior and under surface of the neural spine of the axis, and is *inserted* into the occipital bone posterior to the insertion of the complexus, and between the superior oblique and the rectus capitis posticus minor.

The *Rectus capitis posticus minor* in *Phoca vitulina* is nearly rectangular, and its anterior end is the broader. It *arises* from the tubercle on the tip of the neural arch of the atlas, and from the thin dorsal surface of its lamina anterior to the foramen. It ascends, and is *inserted* into the whole of the surface of the occipital bone, behind the insertion of the major rectus accessorius in front of the foramen magnum, and as far out as the inner side of the condyle of the occipital bone. This insertion is extensive. It is supplied by the suboccipital nerve.

In *Arctocephalus* it *arises* from the anterior dorsal half of the atlas, between the neural spine and its foramen and the articular surface for the occipital condyle. It is *inserted* into the supraoccipital bone, posterior to the biventer cervicis internally, and the rectus capitis anticus major externally. It is bounded by the rectus capitis posticus and the complexus, and posteriorly by the foramen magnum.

The *Obliquus capitis inferior* in *Phoca vitulina* is a short rectangular muscle, and *arises* from the side of the neural spine of the axis beneath the major and accessorius muscles, from the whole of the dorsal surface of its lamina, and slightly from the dorsal surface of the posterior zygapophysis of this vertebra. It passes outwards and forwards, and is *inserted* into the concave posterior surface of the transverse process of the atlas ventral to its foramina. It is supplied by the suboccipital and the great occipital nerves.

In *Arctocephalus* it *arises* from the outer side of the neural spine of the axis, and the dorsal surface of the lamina to the inner side of the hyperapophysis. It is *inserted* into the concave surface on the posterior dorsal half of the wing-like transverse process of the atlas.

The *Obliquus capitis superior* in *Phoca vitulina* is the same shape as the last; it *arises* from the dorsal anterior surface of the condyle of the atlas, and from the dorsal edge of the transverse process of the same. It is *inserted* into the middle of the occipital ridge between the rectus capitis posticus major, and the rectus lateralis beneath the complexus. It is supplied by the suboccipital nerve.

In *Arctocephalus* it *arises* from the anterior surface of the atlas outside the foramen, and is *inserted* into the lower half of the occipital ridge, into the upper half of the paramastoid process, and the exoccipital bone.

The Muscles of the Tail.

I have only observed one muscle arising from the caudal region in *Phoca* and in *Arctocephalus*. This is named in the text of Lucae the abductor caudæ, while Murie calls it the levator caudæ externus. The levator caudæ of Lucae, and the levator caudæ internus of Murie, are simply prolongations backwards of the erector muscles of the back into the caudal region, and are described as part of these muscles. The ventrales caudæ of Lucae are the same as the pubo-, ilio-, sacro-, and infra-coccygeus of Murie, and are included in my description of the levator ani.

The *Abductor caudæ* in *Phoca vitulina arises* from the dorsal surface of the dorsal sacro-iliac ligament, and from the under surface of the transverse processes of all the sacral vertebræ, and is *inserted* into the same parts of the caudal vertebræ. It is supplied by the caudal nerves.

In *Arctocephalus* it *arises* from the dorsal anterior spine of the ilium, from the dorsal surface of the dorsal sacro-iliac ligament, and from the transverse processes of all the sacral vertebræ, and is *inserted* into the transverse processes of all the caudal vertebræ, partly by tendon and partly by muscular fibres.

Some of the Perineal Muscles.

The *Sphincter ani* in the female Phocinæ and the female *Arctocephalus* is a broad, strong band. It *arises* from the ventral mesial caudal region, and encircles the posterior end of the rectum and vagina, but in the male it only winds round the rectum.

The *Levator ani* in *Phoca vitulina* is a triangular muscle. It *arises* from the anterior inner wall of the pubes, ending half an inch anterior to the posterior margin of the obturator foramen; from one inch of the pubic bar at the anterior margin of the obturator foramen; between these two points of origin from the obturator fascia close to the ventral margin of the obturator foramen; from the internal surface of the innominate bone dorsal to the obturator nerve, and posterior to the sacro-iliac articulation; and from the lateral and ventral surfaces of the 2nd, 3rd, and 4th sacral, and 1st and 2nd caudal vertebræ. It forms several tendons and these proceed backwards; the innermost is *inserted* into the ventral mesial surface of the 5th caudal vertebra, the outermost into the ventral surface of the transverse process of the same vertebra, and the other three tendons into the ventral surfaces of the last caudal vertebra by passing backwards between the other two insertions. From the middle of the 2nd caudal vertebra to the back of the 4th sacral, many fibres pass down around the rectum and vagina, and proceed backwards beneath the sphincter for the vagina and rectum. The combined levators form a funnel-shaped tube which passes through the pelvic outlet surrounding the rectum and vagina.

In *Arctocephalus* it *arises* from the inner surface of the pubic bar above the pelvic brim, between the pectineal eminence anteriorly and the side of the symphysis posteriorly; from the inner surface of the ilium anterior to the obturator foramen; and from the ventral sides of the sacral and caudal vertebræ. The levators form a muscular tube as in *Phoca*, the posterior pubic fibres proceed backwards and encircle the vagina and rectum, but principally the former. Then they turn inwards upon the ventral side of the vagina, and end posteriorly among the fibres of the sphincter for the vagina and rectum outside the pelvis. The rest of the fibres run backwards along the caudal region, and are *inserted* into the ventral surfaces of the transverse processes of the caudal vertebræ.

The *Protractor of the prepuce*, in the Phocinæ between the symphysis pubes and the umbilicus, is a muscular band *arising* from the outer border of the rectus by three slips. These soon unite, proceed backwards, and are *inserted* into the side of the prepuce around the orifice, the fibres of both muscles meeting on its ventral surface.

The *Retractor vaginæ* in *Phoca* is a quadrilateral muscle. It *arises* half an inch ventral to the ischial spine from the posterior borders of the ischium and pubes, and descends upon the side of the vagina, being dorsally blended with the levator ani.

INDEX TO REPORTS ON MARINE MAMMALS.

This Index refers both to the Report on the Bones of Cetacea (Zool. Chall. Exp., part iv., 1880) and to the Report on the Seals. The references to the Report on the Bones of the Cetacea are distinguished by the Roman numeral i.; the references to the Seals by the Roman numeral ii.

PLATE I.

PLATE I.

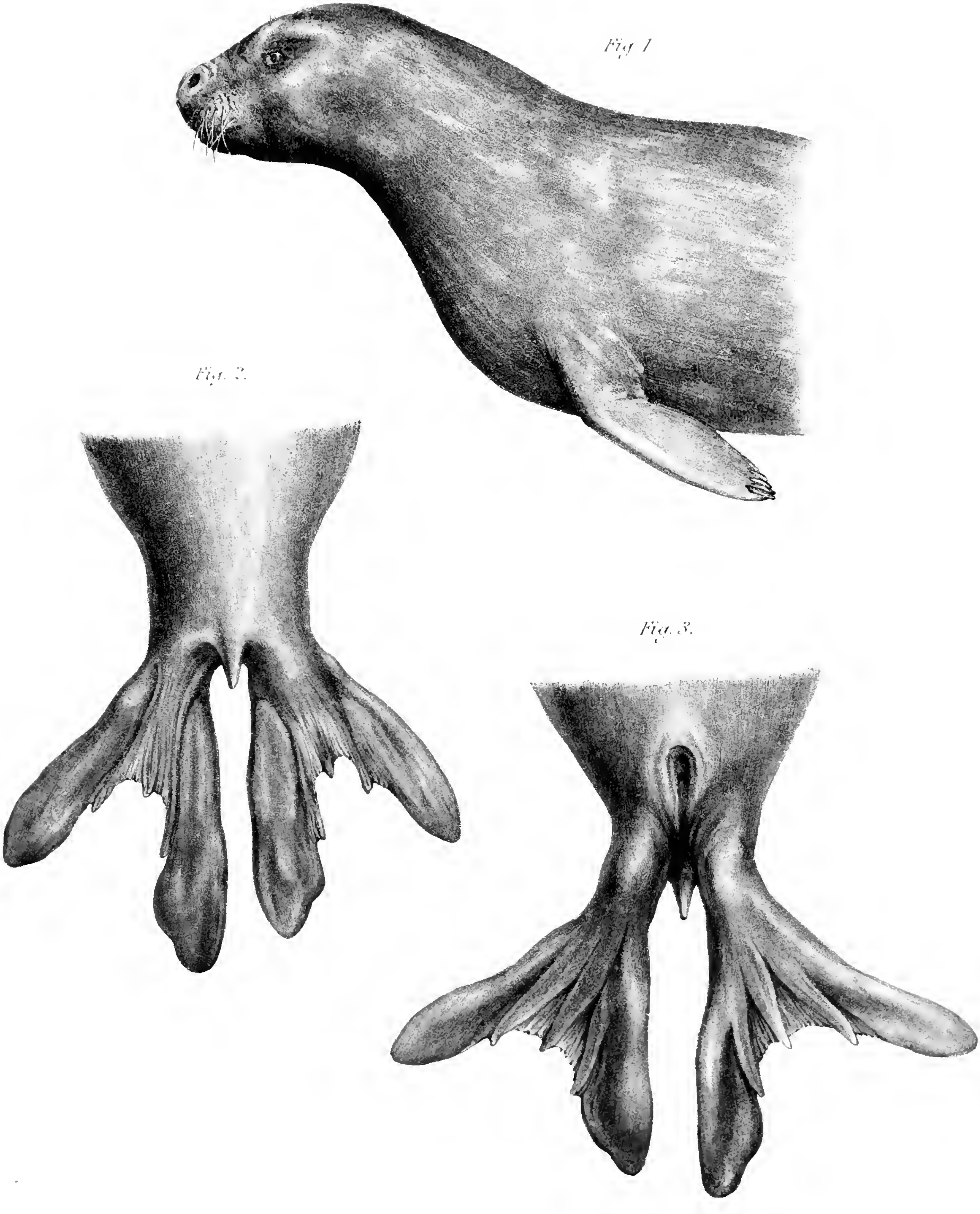
Elephant Seal.

Fig. 1. Profile view of head and anterior part of body of well-grown female *Macrorhinus leoninus*, from Christmas Harbour, Kerguelen.

Fig. 2. Dorsal aspect of the hind limbs and caudal region of the same animal.

Fig. 3. Ventral aspect of the hind limbs and vent of the same animal.

I am indebted to Arthur Thomson, M.B., for the drawings from nature from which these figures were taken.



Arthur Thomson M.B. pinxit

F. Huth, Lithr. Edinr.

ELEPHANT SEAL ♀.

PLATE II.

PLATE II.

Elephant Seal.

Fig. 1. Profile of skull of adult male (*h*) *Macrorhinus leoninus*, from Heard Island.

Fig. 2. Profile of skull of well-grown male (*e*), from Kerguelen Island. The skeleton of this animal has been described in Part I.

Fig. 3. Profile of skull of a large female (*f*), from Kerguelen Island.

Fig. 4. Profile of young skull, apparently a female (*h*), from Kerguelen Island.

Fig. 5. Anterior surface of atlas vertebra. This and the other vertebræ are from a male skeleton.

Fig. 6. Anterior surface of axis vertebra.

Fig. 7. Anterior surface of 3rd cervical vertebra.

Fig. 8. Anterior surface of 7th cervical vertebra.

ELEPHANT SEAL

PLATE III.

PLATE III.

ELEPHANT SEAL.

Fig. 1. Vertex view of skull of adult male (*h*) *Macrorhinus leoninus.*

Fig. 2. Vertex view of skull of a well-grown male (*e*).

Fig. 3. Vertex view of skull of a large female (*f*).

Fig. 4. Vertex view of a young skull, apparently a female (*h*).

Fig. 5. Side view of pelvis of a female (*c*), from Kerguelen Island.

Fig. 3

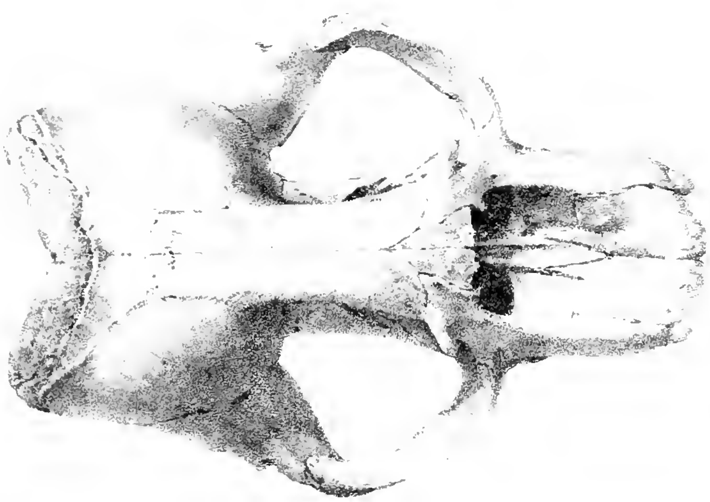


Fig. 2

Fig. 5

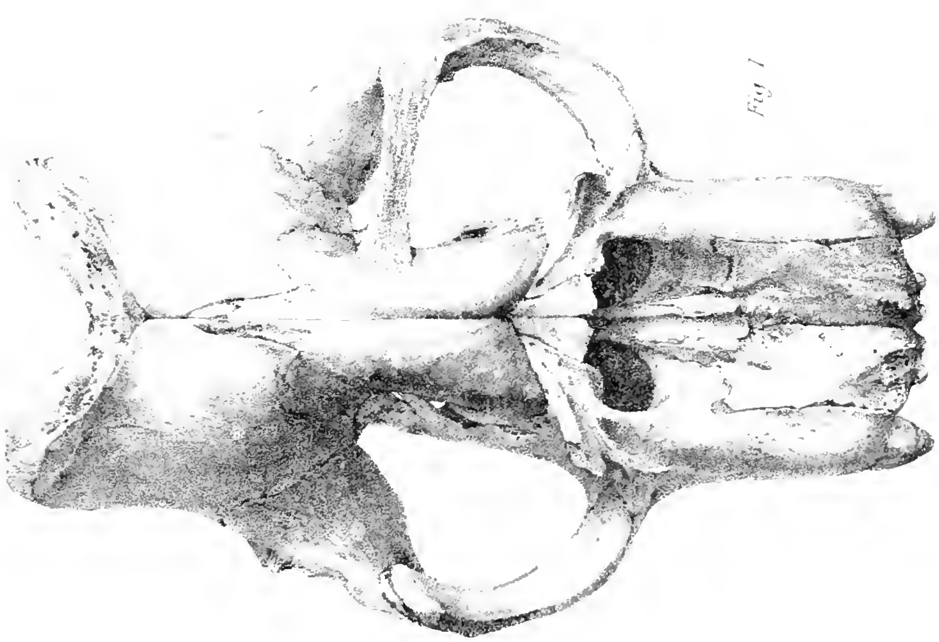


Fig. 1

Fig. 4

ELEPHANT SEAL.

PLATE IV.

PLATE IV.

Elephant Seal.

Fig. 1. Dorsum of the left scapula of a well-grown male *Macrorhinus leoninus*, from Kerguelen Island: the cartilage is still attached to the vertebral border.

Fig. 2. Anterior aspect of the right humerus of the same animal.

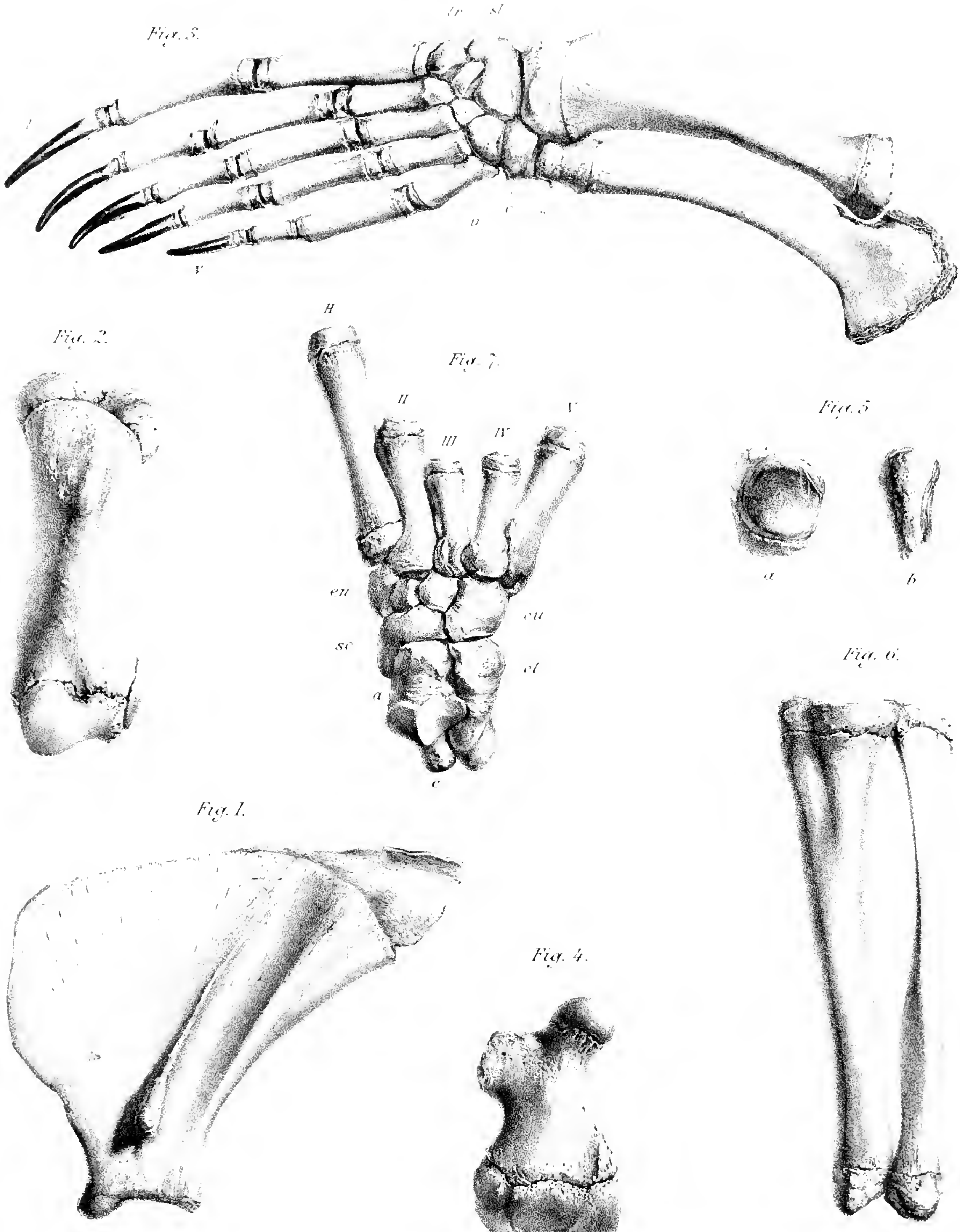
Fig. 3. Dorsal surface of the bones of the left fore-arm and hand of the same animal; *sl*, scapholunar: *c*, cuneiform; *p*, pisiform; *tr*, trapezium; *u*, unciform; P, pollex; V, minimus.

Fig. 4. Front of the right femur of the same animal.

Fig. 5. *a*, Articular surface of the right patella; *b*, the same bone in profile.

Fig. 6. The ventral surface of the left tibia and fibula of the same animal.

Fig. 7. Dorsal surface of the right tarsus and metatarsus of the same animal; *a*, astragalus, with *c*, its calcanear process; *cl*, os calcis with its calcanear process; *cu*, cuboid bone; *sc*, scaphoid bone; *cn*, opposite the three cuneiform bones; H, hallux; II., III., IV., V., metatarsal bones of four outer toes.



From Photo. and Nature

J. Huth, Lith.^r Edin.

ELEPHANT SEAL.

PLATE V.

PLATE V.

Weddell's Seal.

Fig. 1. Dorsal surface of the skull of *Leptonychotes weddelli*; *f*, supraoccipital venous foramen; reduced.

Fig. 2. Profile view of the lower jaw of the same skull; reduced.

Fig. 3. Series of upper and lower post-canine teeth of the left side; natural size.

Fig. 4. Dorsal surface of the bones of the right anterior extremity of the same animal; *p*, the pisiform bone; *sl*, scapholunar bone; *tr*, trapezium; P, pollex; V, the minimus.

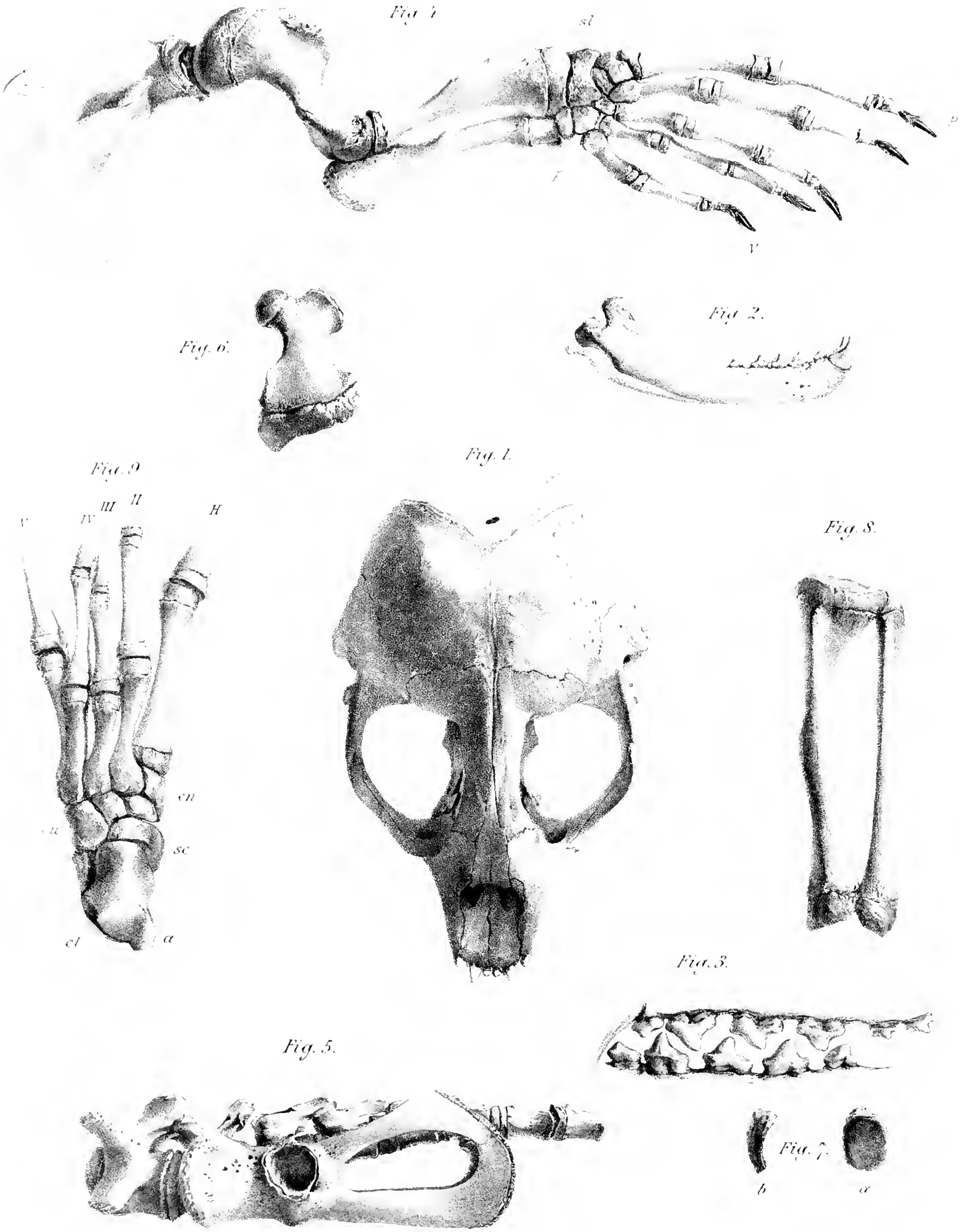
Fig. 5. Left side of the pelvis with the last lumbar and the more anterior caudal vertebræ.

Fig. 6. Anterior surface of the left femur.

Fig. 7. *a*, Articular surface of the left patella; *b*, the same bone in profile.

Fig. 8. Ventral surface of the left tibia and fibula.

Fig. 9. Dorsal surface of the left pes of the same animal; *a*, astragalus with its calcanear process; *cl*, calcanear process of os calcis; *cu*, cuboid; *sc*, scaphoid; *en*, opposite the ento-cuneiform; H, the hallux; II., III., IV., V., the four outer toes.



WEDDELL'S SEAL.

PLATE VI.

PLATE VI.

FUR-SEALS, SOUTH AMERICA AND KERGUELEN ISLAND.

Fig. 1. Profile view of skull of adult male *Arctocephalus australis*, from the Messier Channel.

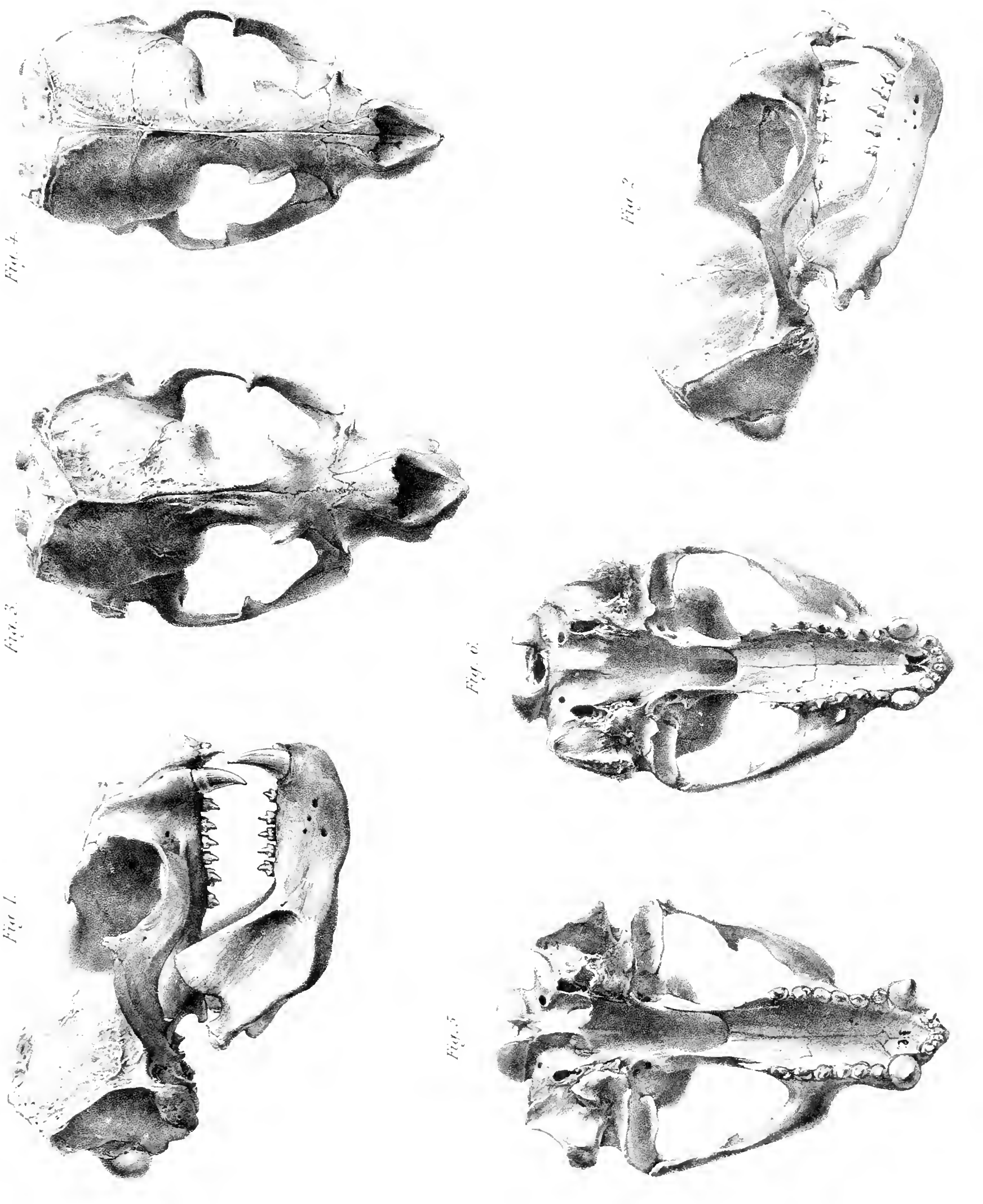
Fig. 2. Profile view of skull of *Arctocephalus gazella*, from Kerguelen Island, probably a male, but not adult.

Fig. 3. Vertex view of the skull of the same *Arctocephalus australis*.

Fig. 4. Vertex view of the skull of the same *Arctocephalus gazella*.

Fig. 5. Inferior surface of the skull of the same *Arctocephalus australis*.

Fig. 6. Inferior surface of the skull of the same *Arctocephalus gazella*.



Phot. and Nature

FUR SEALS, SOUTH AMERICA & KERGUELEN ISLAND.

PLATE VII.

PLATE VII.

Fur-Seal, South America.

Fig. 1. Profile of left side of the series of cervical vertebræ of male *Arctocephalus australis*.

Fig. 2. Dorsal surface of right scapula.

Fig. 3. Front of right humerus.

Fig. 4. Radius and ulna of right fore-arm.

Fig. 5. Palmar surface of right carpus and metacarpus; P, pollex; V, minimus; *p*, pisiform; *sl*, scapholunar bone; *tr*, trapezium; *c*, cuneiform.

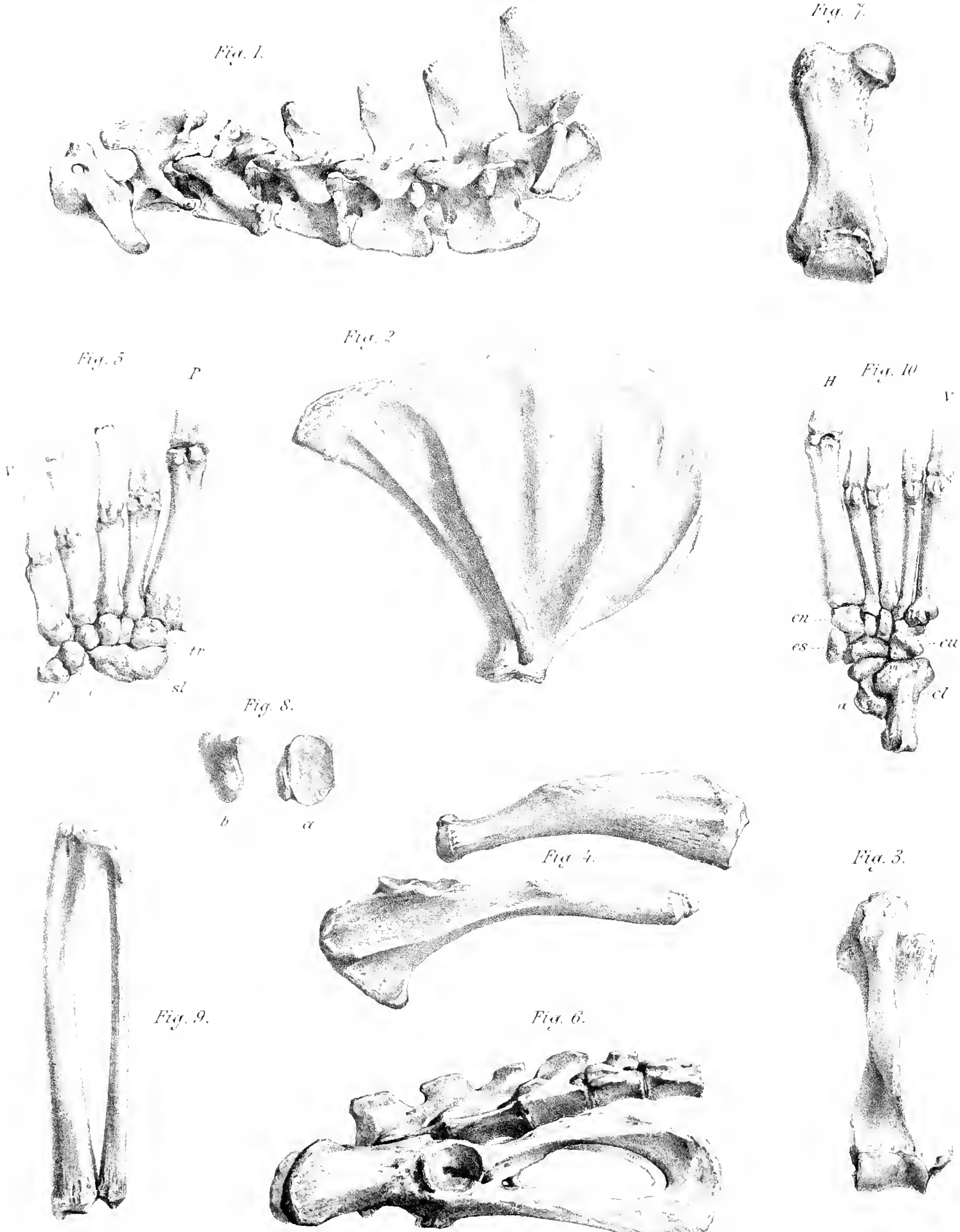
Fig. 6. Left side of pelvis with three of the caudal vertebræ.

Fig. 7. Anterior surface of right femur.

Fig. 8. *a*, Articular surface of left patella; *b*, profile view of same bone.

Fig. 9. Tibia and fibula of left leg.

Fig. 10. Plantar surface of left tarsus and metatarsus; H, hallux; V, minimus; *a*, astragalus; *cl*, os calcis; *cu*, cuboid; *cn*, entocuneiform; *es*, entoscaphoid.



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FUR SEAL, SOUTH AMERICA.

PLATE VIII.

PLATE VIII.

Brain of Elephant Seal.

The fissures, convolutions, and other divisions of the brain, both in this and the succeeding Plates, are lettered as below :—

Fissures.

s. Sylvian.
c. crucial.
pc. præcruciate.
ps. præsylvian.
co. coronal.
ml. medilateral.
l. lateral.
ss. suprasylvian.
ssp. posterior suprasylvian.
rh. rhinal.
r. postrhinal.
[illegible] intraorbital.
ol. olfactory.
h. hippocampal.
sp. splenial.
sps. suprasplenial.
ph. postero-horizontal.
psp. postsplenial.
v. verticose.

Convolutions, &c.

rc. gyrus rectus.
isc. internal supraorbital.
esc. external supraorbital.
ur. ursine lozenge.
sac. sagittal or 1st external.
mlc. medilateral or 2nd external.
ssc. suprasylvian or 3rd external.
syc. Sylvian or 4th external.
sgc. sigmoid gyrus.
cc. callosal gyrus.
hc. hippocampal gyrus.
lh. lobus hippocampi or uncinatus.
spc. splenial convolution.
sspc. suprasplenial convolution.
prc. prorean convolution.
to. tuber olfactorium.
ob. olfactory bulb.
P. pineal body.
H. hypophysis cerebri or pituitary body.
ccl. corpus callosum.
cs. corpus striatum.
oth. optic thalamus.
ch. choroid plexus.
hm. hippocampus major.
f. fornix.
th. tænia hippocampi.
C1. 1st cervical spinal nerve.

In this and the following plates the Roman Numerals I.–XII. inclusive indicate the cranial nerves, as follows :—

I. olfactory.
II. optic.
III. motor oculi.
IV. trochlearis.
V. trigeminal.
VI. abducens.
VII. portio dura or facial.
VIII. portio mollis or auditory.
IX. glosso-pharyngeal.
X. pneumogastric.
XI. spinal accessory.
XII. hypoglossal.

Fig. 1. Superior surface of the brain of *Macrorhinus leoninus*. The dotted outline represents the form of the brain as taken from a cast of the cranial cavity.

Fig. 2. Inferior surface of the same brain.

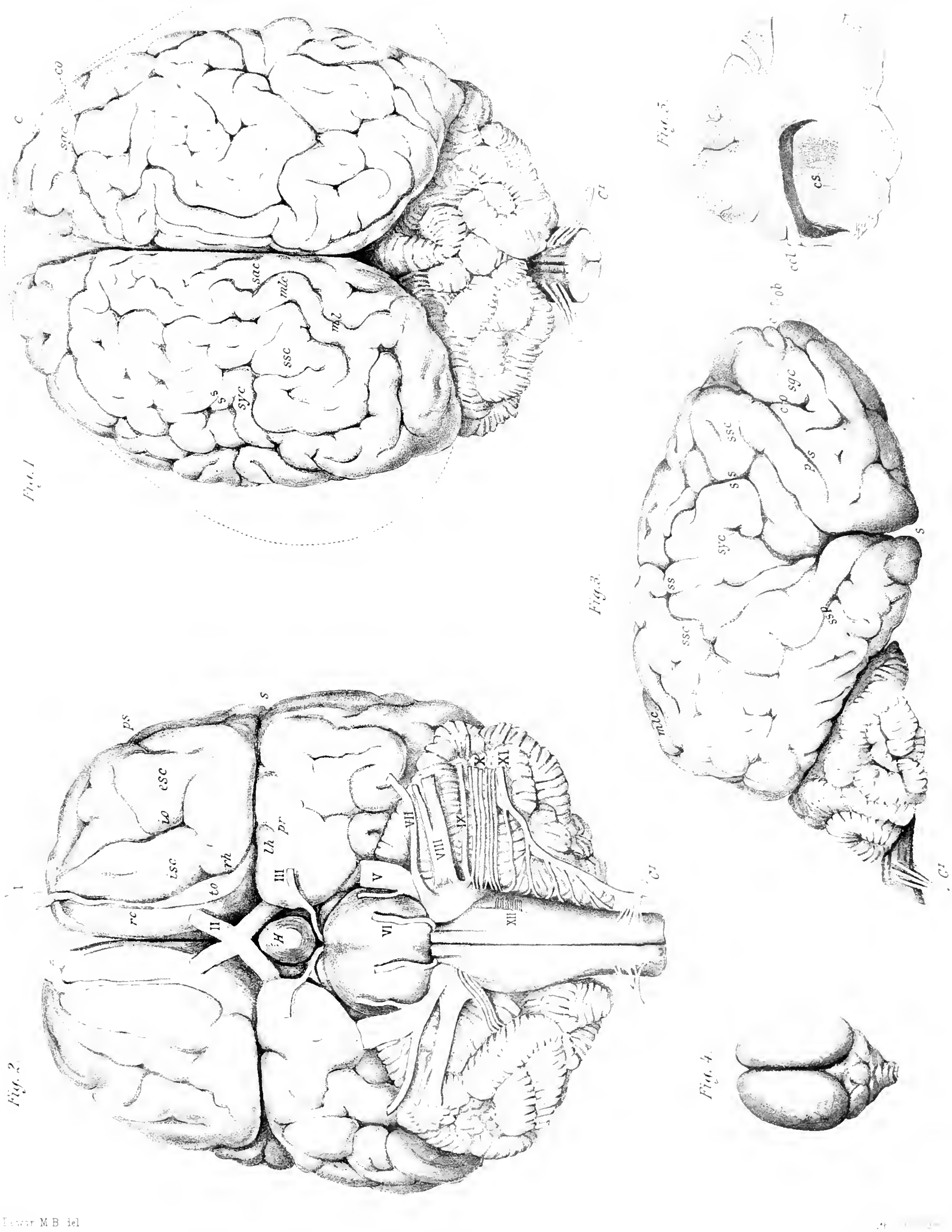
Fig. 3. Profile view of the right hemisphere of the same brain.

The above figures were drawn from nature by T. W. Dewar, M.B.

Fig. 4. Superior surface of the brain of a fœtal *Phoca grœnlandica*, with the pia mater not stripped off.

Fig. 5. Vertical transverse section through the right hemisphere and lateral ventricle of the cerebrum of brain *a* of the Walrus. *ccl*, corpus callosum forming the roof of the lateral ventricle; *cs*, corpus striatum.

Figs. 4 and 5 were drawn from nature from my dissection by Professor Richard Caton.



Lewis M.B. del

ELEPHANT SEAL

PLATE IX.

PLATE IX.

Elephant Seal and Walrus.

Fig. 1. Anterior end of the cerebrum of *Macrorhinus leoninus.* The olfactory bulb is turned down on one side to show the olfactory and præcruciate fissures and ursine lozenge. Drawn from nature by T. W. Dewar, M.B.

Fig. 2. Tentorial and inner surfaces of the left hemisphere of the same brain, obtained by making an antero-posterior mesial section through the corpus callosum. Drawn from nature from my dissection by K. M. Scott, M.B.

Fig. 3. Tentorial and inner surfaces of the left hemisphere of the Walrus (brain *a.*) This and fig. 4 were drawn from nature from my dissection by Professor Richard Caton.

Fig. 4. View of the floor of the lateral ventricle and the descending horn in the right hemisphere of the cerebrum of the Walrus, obtained by removing the corpus callosum.

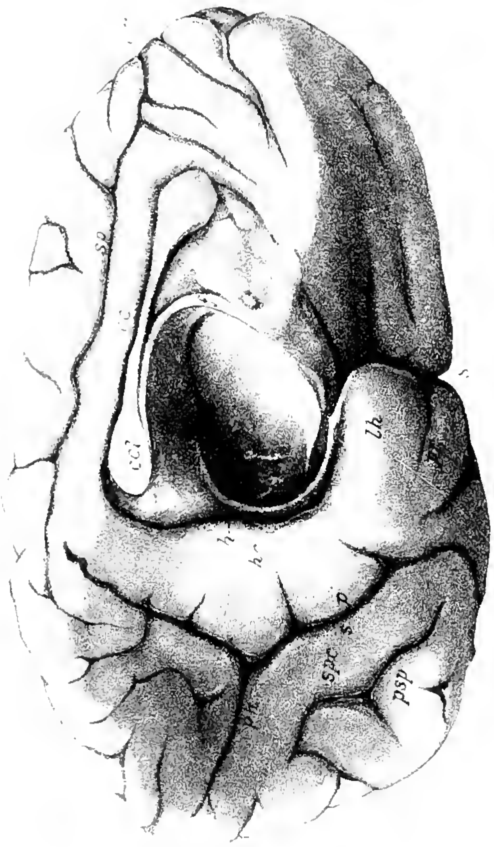


Fig. 3.

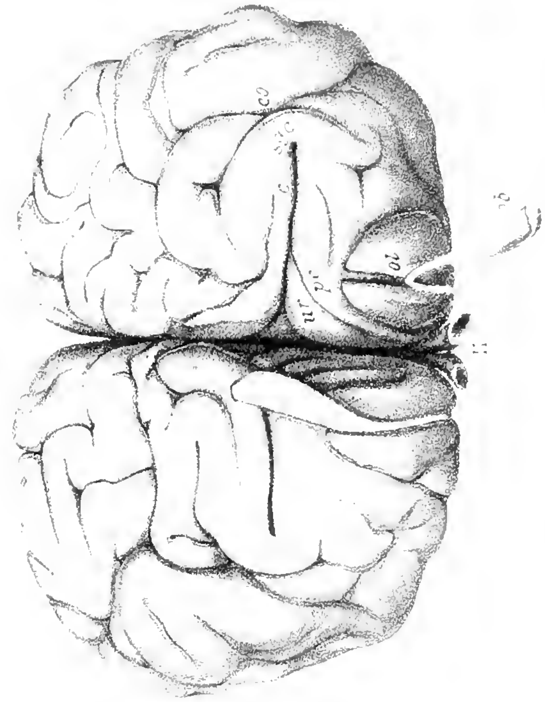


Fig. 1.

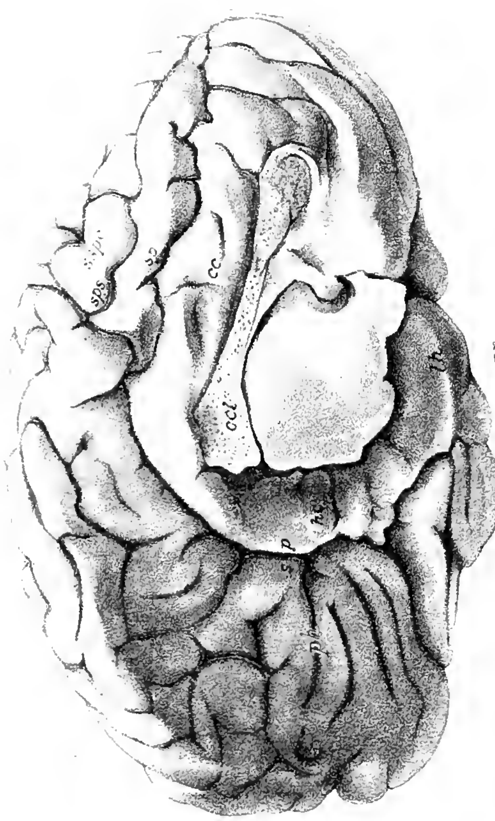


Fig. 2.

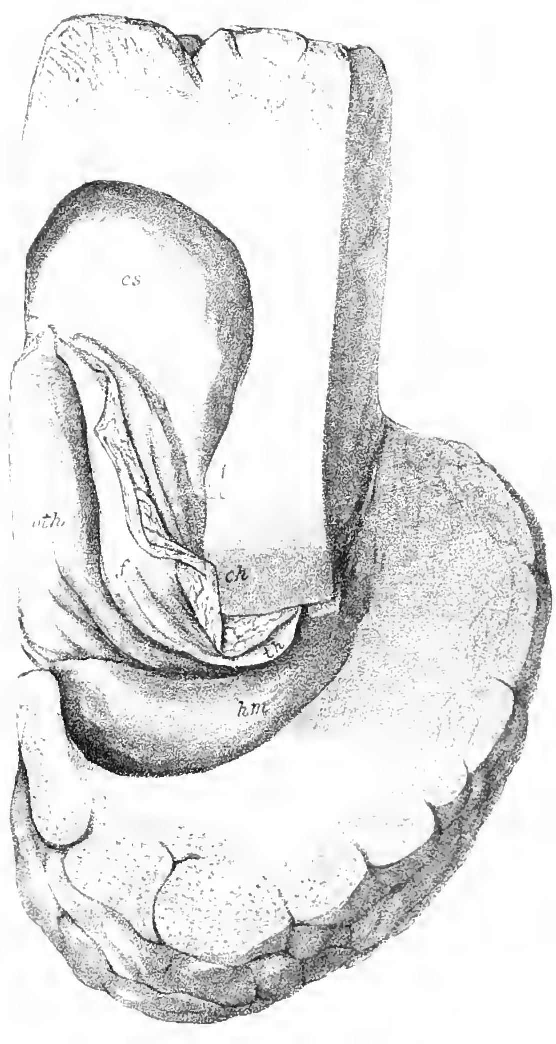


Fig. 4.

ELEPHANT SEAL & WALRUS.

PLATE X.

PLATE X.

Walrus.

Fig. 1. Superior surface of the brain (*a*) of *Trichechus rosmarus*; the ends of the olfactory bulbs are seen anteriorly, and the pineal body is visible posteriorly between the two diverging hemispheres. The pineal body has been filled in from brain *c*, by K. M. Scott, M.B.

Fig. 2. Inferior surface of the same brain from which the pituitary body drawn in fig. 6 had been removed. The sensory root of the right 5th nerve has the Gasserian ganglion connected with it. The verticose fissure in the hemisphere of the cerebellum is well seen. The cranial nerves behind the 8th had been torn off. The shape of the medulla oblongata was restored from brain *c*.

Fig. 3. Profile of the left hemisphere of the same brain.

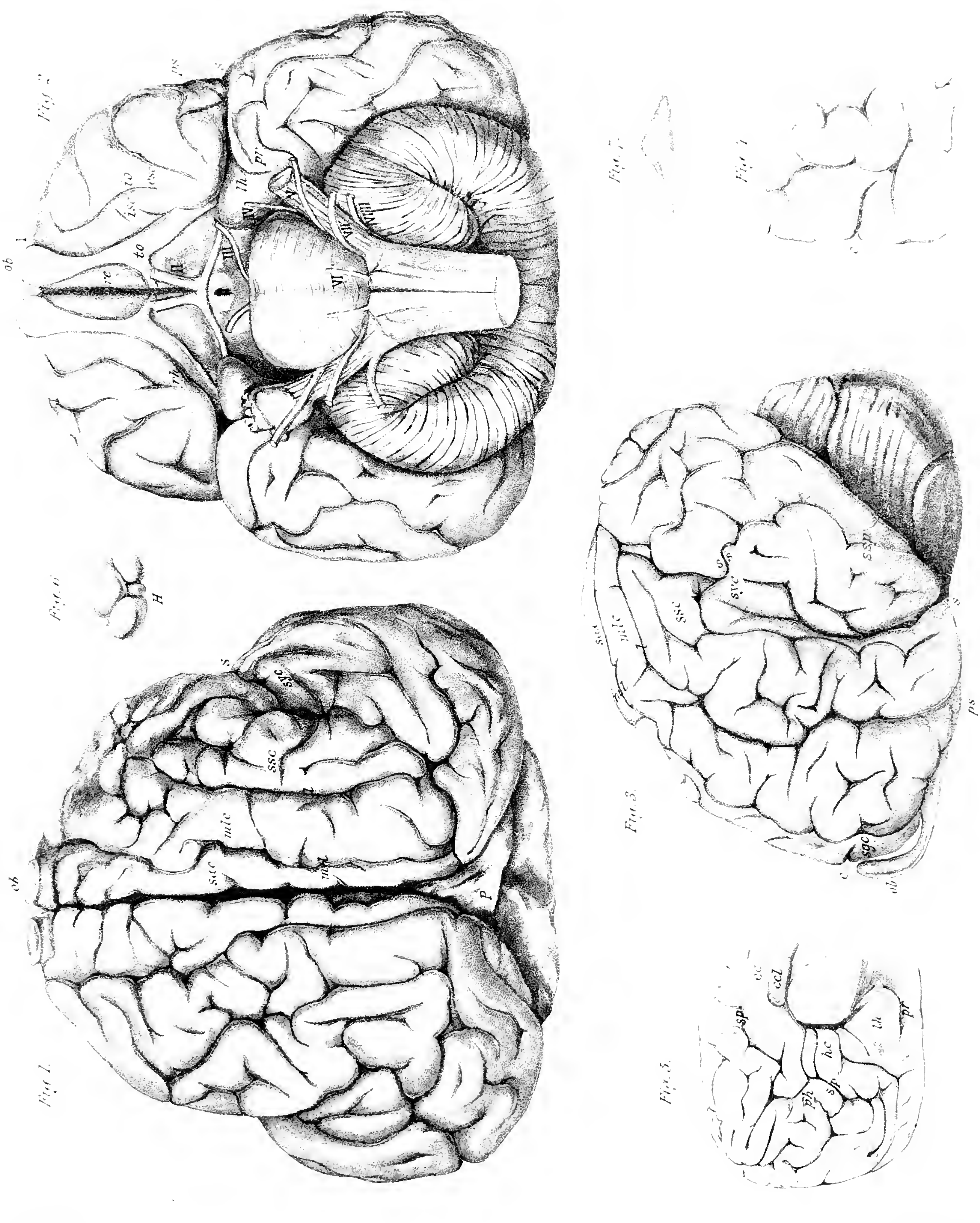
The above figures were drawn from nature by Professor Richard Caton.

Fig. 4. Anterior end of the left hemisphere of the cerebrum of brain *c*, to show the crucial fissure.

Fig. 5. Tentorial surface of the left hemisphere of the same brain, reduced. When compared with fig. 3, Pl. IX., several modifications in the splenial fissure and adjacent convolutions will be seen.

Fig. 6. Inferior surface of the pituitary body divided into four lobes.

Fig. 7. Profile view of the pineal body, epiphysis cerebri.



W A L R U S.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the ACTINIARIA dredged by H.M.S. Challenger during the years 1873–1876. By Prof. RICHARD HERTWIG.

SUPPLEMENT.

INTRODUCTION.

AFTER I had concluded my Report on the Actiniaria of the Challenger Expedition, a number of additional specimens were sent to me, on which I now present a short Supplementary Report. Unfortunately the work has been delayed longer than I could have wished, partly on account of a series of experimental investigations upon the fertilisation and segmentation of the ovum, which I had undertaken in concert with my brother, but mainly owing to the claims on my working-time caused by my transference from Königsberg to Bonn, and from Bonn to Munich.

Amongst the material occurred several specimens of species which have been previously described and can therefore be treated in few words; besides these, there are also several new forms, representing new and interesting genera, which require a detailed description, and which are, for the sake of clearness, designated by an asterisk. At the end (p. 54) will be found a list of those Actiniæ of which a systematic study was impossible, either because they were not sufficiently well preserved, or because their appearance was no longer characteristic owing to the absence of sculpturing and colour, the necessary result of the method of preservation.

Since the publication of the earlier part of this Report, the great monograph of Angelo Andres on the Actiniaria has appeared.[1] During the progress of his work this

[1] Fauna und Flora des Golfes von Neapel, Le Attinie, 1884.

author was acquainted only with the short preliminary notice of my researches published in the Jena Proceedings,[1] not with the Report itself; a fact easily understood when one considers how long before the date of publication a monograph constructed on such a plan must be completed. In his comprehensive revision of the Actiniæ, and re-definition of families and genera, he has been prevented from referring to my contemporaneous attempt at revision, since this first appeared in the detailed Report. As it is most desirable that two systems, appearing within a short time of one another, should be brought into such relation as to avoid future discordance and mistake, I accept with pleasure the opportunity of a critical utterance on their mutual relations.

As against the six chief divisions into which I divide the Actiniæ (Hexactiniæ, Paractiniæ, Monauleæ, Edwardsiæ, Ceriantheæ, Zoantheæ), Andres erects seven, viz. Edwardsinæ, Actininæ, Stichodactylinæ, Thalassianthinæ, Zoanthinæ, Cerianthinæ, Minyadinæ. With regard to three chief groups we are in complete accord (Edwardsiæ, Ceriantheæ, Zoantheæ), except for the fact that Andres, in my opinion, relies on too inconstant and unimportant external characters; while, as I have shown, these groups, at least, admit of anatomical characterisation by the arrangement of their mesenteries, and thus can be far more clearly and sharply circumscribed. If the reader compare in this connection the definitions of the Zoantheæ furnished by myself and by Andres, it will be readily admitted that none of the characteristics of the latter author, such as colony-formation or incrustation, are constant within the group; that, on the other hand, all the forms follow one and the same law of mesenterial arrangement, first recognised by G. von Koch.

If we carry the comparison further, we find that Andres places beside the Actininæ, as separate groups, the Thalassianthinæ, the Stichodactylinæ, and the Minyadinæ; though with a certain caution, as having himself studied no representative of them. I believe that he has here exceeded the systematic value which can be safely assigned to the form of the tentacles and their distribution on the mesenterial chambers. I have studied certain Stichodactylinæ (*Corallimorphus rigidus*, *Corallimorphus profundus*, and *Heterodactyla hemprichii*), and of the Thalassianthinæ, *Thalassianthus aster*, and can assert, as the result of a thorough examination of their structure, that in all important points they agree with the hexamerous Actiniæ; nor have I any doubt that these forms, even if united into separate families, must be ranged among the Hexactiniæ. Finally, the group of Minyadinæ has for many reasons, which I entirely recognise, undergone at the hands of Andres so sharp a criticism, that one can hardly see why he retains it, or why at least he does not allow it to rank merely as a subdivision of Hexactiniæ, until the necessity of its removal from that group is rendered apparent by anatomical investigation.

From the point of view explained, I am of opinion that all the forms referred to

[1] *Jenaische Zeitschr.*, Bd. xv. p. 10, 1881.

by Andres must be comprehended in the four divisions, Edwardsiæ, Hexactiniæ, Zoantheæ, and Ceriantheæ, and accordingly hold to the systematic classification which I have published. The groups of Paractiniæ and Monauleæ are in all respects natural, and would also certainly be retained by Andres had representatives of them been known to him.

Even greater discordance than that of which I have hitherto spoken, between the classifications of Actiniæ followed by Andres and myself, presents itself when the determination and nomenclature of families and genera are regarded. Independently of each other, and from different standpoints, we have taken in hand a systematic revision of Actiniæ: Andres starting with the advantage of a richer material, and studying species with which earlier publications are especially concerned, and which he could command in a living condition; while my qualification for a systematic classification was that afforded by close anatomical investigation, namely, that I relied for systematic characteristics upon such weighty differences as the structure of the sphincter, the arrangement of the mesenteries, the structure of the musculature and of the oral disc, etc., points which Andres has, hitherto at any rate, entirely left out of consideration. Thus it has resulted that in the determination of families and genera, and also in the value assigned to existing names, we have in many cases taken up a totally different attitude; and as, in consequence of this, no inconsiderable confusion has arisen in the method of diagnosis, I hold it advisable to inquire critically what must be retained of the system of the Italian observer.

Of least importance are our differences of opinion relating to those Actiniæ which possess acontia. Andres has here adopted the separation, instituted by Verrill, into Sagartidæ and Phellidæ. Having regard to his wider acquaintance with the species, I agree with him in accepting as a distinctive character the chitinous covering extending over two-thirds of the body-wall; and for clearer characterisation of both families, the following marks not mentioned by Andres should be included in the diagnosis,—a mesodermal sphincter, and a differentiation of the mesenteries into sterile complete primary mesenteries, and incomplete secondary mesenteries provided with generative organs. Of the Challenger Actiniæ, there would belong to the Phellidæ only *Phellia pectinata;* to the Sagartidæ, *Sagartia sp.*, *Cereus spinosus*, *Calliactis polypus*, *Bunodes minuta*. Of these, the two latter require an alteration of name; *Calliactis polypus* must be termed *Adamsia polypus*,[1] and *Bunodes minuta* be known as *Cylista minuta*, since it has been shown by Andres that the typical *Bunodes* possesses no acontia, and therefore cannot belong to the Sagartidæ.

Andres has incorrectly allowed the generic name *Cereus* (Oken) to drop, and has

[1] The specific name *Rondeletii* has been wantonly substituted by Andres for the older *polypus*, the former being used for the first time by delle Chiaje in 1825, while the latter was already instituted by Forskål in 1775. Milne-Edwards is therefore correct in calling the animal *Adamsia polypus*.

introduced in its place the more recent name *Heliactis*, for Sagartidæ with numerous large papillæ; although Oken adduces *Cereus bellis* as the type form, which stands in the same relation to the genus *Heliactis*. The papillate Sagartidæ are of two kinds, the one having a soft surface, while in the other the body-wall is covered as far as its upper edge with a bark-like cuticle which recalls the Phellidæ; it is therefore advantageous to confine to the former the name *Heliactis*, applied, though unjustifiably, by Andres, and for the latter to restore *Cereus*, the old designation of Oken, a representative of the newly characterised genus being *Cereus spinosus*.

In discussing the families instituted by Andres, we next come to the Paractidæ. As I understand the diagnosis given for this family,—"margine tentaculato, non rilevato e privo d' acroragi,"—the tentacles spring at the edge where body-wall and oral disc pass into one another, just as is the case both in the Corallimorphidæ and Antheomorphidæ, which I have described in more detail, and, generally speaking, in such Actiniæ as are devoid of a circular muscle. But this relation also holds good in Actiniæ with a weak sphincter, as, for example, in *Anemonia cereus* (to which Andres, strange to say, ascribes a "margine rilevato"); and, finally, in Actiniæ, in which the sphincter is developed at some distance outwards from the upper edge of the body-wall. The facts adduced are sufficient to prove that this characteristic is systematically useless; and in addition to this I insist that the few forms grouped in the family do not appear to agree with the diagnosis. The tentacles of an *Anemonia* are, according to Andres, formations placed more at the edge than are those of a *Paranthus* or a *Paractinia*. On the contrary, the *Paractis peruviana*, which Andres adduces as the type of the family, seems to me to have no tentacles which would be marginal. Indeed, it agrees so entirely with a Challenger form, *Paractis excavata*, that I long doubted whether it were not right to unite the two. In *Paractis excavata*, I am certain that a strong mesodermal sphincter is present, and. corresponding to this fact, body-wall and oral disc are sharply marked off from each other, whence I conclude that the same holds for *Paractis peruviana*. Since I have thus good ground for holding unsuitable the methods by which Andres has instituted his family Paractidæ, and can, in addition, claim the right of priority, I adhere to the definition which I previously published, leaving only to future investigators to decide upon the advisability of erecting Actiniæ with marginal spherules, sucking-papillæ, and papillæ into a family separate from the Paractidæ (*sensu stricto*) with smooth body-wall.

The next family in the system of the Italian naturalist is formed by the Actinidæ, and corresponds to the Antheadæ and Actinidæ of Gosse. I formerly followed Gosse in separating these two families, but had previously maintained that anatomically they are closely related, and should perhaps on that account be united. I have therefore nothing to adduce against this proceeding of Andres, though the detailed investigation of the Actinidæ, which I recommended, has not yet been carried out. It is also correct to replace the name *Anthea* by the older *Anemonia*, and to range the genus *Comactis* under it. On the other hand, my *Comactis flagellifera* is not identical with *Anemonia sulcata* (*Anthea cereus*), and should therefore be referred to as *Anemonia flagellifera*.

In the system of Andres the Bunodidæ bear the closest relation to my family Tealidæ. I was unacquainted with any typical *Bunodes*, and had supposed (*cf. supra*) that they possessed acontia. This supposition is, according to Andres, incorrect; and the close relationship to *Tealia* is thus anew proven. Accordingly I withdraw the name Tealidæ in favour of the older designation Bunodidæ; but, now as formerly, the endodermal sphincter must occupy the first place in the diagnosis. I relinquish, however, to future observers, as with the Paractidæ, the decision whether forms with smooth and with papillate body-wall should be separated from one another, or not.

A last point of dispute with Angelo Andres lies in the fact that I reckon the *Halcampæ* among the Ilyanthidæ, while he erects them into a separate family. I will not decide in this place either for the one opinion or the other, but will discuss merely the point of view, which, as it seems to me, must be of importance for a decision.

The more we have learnt in late years of the structure of these forms, the more has it become apparent that Actiniæ, which are rounded posteriorly and devoid of pedal disc, exhibit in most cases a sort of ancestral character; eminently primitive forms are, above all others, the Edwardsiæ. Among such forms is the genus *Halcampa*, from which again the genus *Halcampella* is a transition to the remaining Actiniæ, in virtue of its numerous tentacles, and of its commencing to exhibit accessory mesenteries. I opine that the genus *Ilyanthus* stands in close relation to the *Halcampellæ*; the regular increase of the mesenterial pairs by multiples of six, which is commencing in the one case, is in the other clearly expressed, as may be inferred from the presence of the numerous longitudinal furrows of the body-wall; while the siphonoglyphes (ciliated grooves), the hinder edge of the body, and the sphincter, are obviously of weak development, as among the *Halcampæ*. Possibly a study of the mesenteries may yield further points of agreement, but, unfortunately, nothing is accurately known of these important features in the structure of *Ilyanthus*; and so long as this is the case, no conclusion can be certain. If my expectations be confirmed, a union of the *Halcampæ* with the Ilyanthidæ would be desirable; the latter would form a transitional family placed at the top of the Hexactiniæ, and bridging the gap between them and the Edwardsiæ; while, as a peculiar and aberrant branch of the Actiniæ, would be ranged near them the Siphonactidæ, the forms possessing a conchula.

All the forms of which we have as yet spoken possess the typical digitate or tubular Actinian tentacles, so arranged that one tentacle corresponds to each radial chamber; there are, however, two variations of this arrangement. In the one, the tentacles are replaced by appendages of a different value, for instance, by stomidia in the Liponemidæ which I have described, or by bushy or arborescent growths in the families Sarcophianthidæ and Thalassianthidæ erected by Andres. On the other hand, there are forms in which more tentacles than one correspond to a mesenterial chamber; accessory tentacles, placed on the oral disc, being present in addition to the primary tentacles. This is conclusively proved only for species of *Corallimorphus*, but Andres has rendered it excessively probable also for species of *Corynactis* (compare the account of *Corynactis*? sp.? p. 10, *infra*). For such forms I have instituted the family Corallimorphidæ, Andres the family Corynactidæ. I believe that my designation deserves preference, because it is the older, and because my diagnosis of the family alone insists upon the important anatomical characteristic; on the other hand, I concede to the Italian naturalist that the family may be restricted to species with knobbed tentacles, and that all Actiniæ with modified tentacles, of which an accurate investigation is still required, may be brought under a series of further families.

For a comprehension of the above discussion, I give a view of that arrangement of Hexactinian families which I hold the most advantageous, in the form of a synoptic table.

A few changes have been made in the English terminology used in the former part of this Report: "œsophagus" has been replaced by "stomatodæum," "mesoderm" by "mesoglœa," and "œsophageal groove" by "siphonoglyphe."

SYNOPSIS OF THE FAMILIES OF THE HEXACTINIÆ.

A. Hexactiniæ with simple wreath of tentacles.

- Tentacles
  - digitate. Pedal disc
    - absent. Siphonoglyphes and sphincter obscure
      - without conchula...... *Ilyanthidæ.*
      - with conchula......... *Siphonactinidæ.*
    - present. Acontia
      - present. Sphincter mesodermal. Cuticular covering...
        - absent....... *Sagartidæ.*
        - present...... *Phellidæ.*
      - absent. Sphincter...............
        - absent....................................... *Antheomorphidæ.*
        - present
          - weak.......................... *Actinidæ.*
          - strong, endodermal......... *Bunodidæ.*
          - strong, mesodermal......... *Paractidæ.*
          - mesodermal. Transverse axis elongated... *Amphianthidæ.*
  - abnormal in shape...
    - clavate, knobbed .... *Heteractidæ.*
    - replaced by stomidia.............. *Liponemidæ.*
    - branching or bushy ....
      - *Sarcophianthidæ.*
      - *Thalassianthidæ.*

B. Hexactiniæ with double or multiple wreath of tentacles.... .... *Corallimorphidæ,* etc.[1]

[1] (*Cf.* Andres, *op. cit.*, p. 264.)

DESCRIPTION OF GENERA AND SPECIES.

Tribe I. Hexactiniæ.

Family 1, Corallimorphidæ, R. Hertwig.

Genus *Corallimorphus*, Moseley.

Corallimorphus rigidus, Moseley.

Amongst the supplementary material I have found the original specimen on which Moseley formerly founded the species *Corallimorphus rigidus*. I had already mentioned this on Moseley's authority in my earlier Report, though I had not myself seen it, and had described from my own observation four more specimens, of which one, from Station 157, agreed in all essential particulars with the three others from Station 146. I am now in a position to confirm the statement that the three latter agree with Moseley's specimen in form, in colour (of which traces only remain in spirit specimens), and in the condition of the body-wall,—they exhibit no thickenings, but merely forty-eight longitudinal furrows corresponding to the insertions of the mesenteries. Another specimen, from Station 299, also agreeing with Moseley's type, is of interest, since, of the twenty-four tentacles on the oral disc, one accessory tentacle of the first order is duplicated, two little tentacles being planted close together. I have already described a similar, though more strongly expressed, development of supernumerary tentacles in *Corallimorphus profundus*, so that it appears probable that the law of increase in the tentacles of Corallimorphidæ is not yet so definite as among other Actiniæ, and allows of more variation than in other cases.

Corallimorphus obtectus, n. sp.

While the five last-named specimens agree with one another, that from Station 157, on which I chiefly based my former description, demands a separate position, so that I now account it the representative of a new species to which I give the name *Corallimorphus obtectus*, having regard to the buckle-like thickenings which cover the insertions of the mesenteries. A further difference lies in its disc-like shape, due to the relations of size between pedal and oral disc. Both are in this case of the same size, but in *Corallimorphus rigidus* the former is considerably the smaller, producing a saucer-shaped profile. The two species may be differentiated by the following diagnosis :—

1. *Corallimorphus rigidus.*—Twenty-four tentacles are planted on the oral disc,

and forty-eight at its edge; the insertions of the mesenteries are recognisable by longitudinal furrows; the oral disc essentially larger than the pedal.

In addition to the examples referred to above, there belongs to this species one specimen from Station 299, December 14, 1875; lat. 33° 31′ S., long. 74° 43′ W.; depth, 2160 fathoms.—Dimensions, height, 1·3 cm.; breadth of the oral disc, 4 cm., of the pedal disc, 1·7 cm.

2. *Corallimorphus obtectus.*—Twenty-four tentacles are situated on the oral disc, and forty-eight at its edge; the mesenterial insertions are covered, in the lower third of the body-wall and the peripheral third of the pedal disc, by cylindrical thickenings; the pedal and oral discs of approximately the same size.

To this species belongs only the example from Station 157, with which my former description was concerned.

Genus *Corynactis*, Allman.

Corynactis (?) sp. (?)*

The tentacles, both on the disc and at its edge, are knobbed; those on the disc are arranged in several circles, so that more than one tentacle communicates with each intra-mesenterial chamber.

Habitat.—Station 219, March 10, 1875; depth, 150 fathoms.

Dimensions.—Diameter of the oral disc, 2·5 cm.; height of the column, 0·8 cm.; greatest length of the tentacles, 1·6 cm.

Angelo Andres gives in his monograph a description of the genus *Corynactis*, based partly on personal observation, partly on the account of Allman, from which I infer that, with one and the same radial chamber communicate one of the marginal tentacles and, in many radii, several of those placed on the disc; five cycles are present, of which the first contains four tentacles, the second sixteen, the third, fourth, and fifth twenty-four. Gosse records other numbers, namely, four rows with sixteen, twenty-four, thirty-two, and thirty-two tentacles respectively. In such remarkable contradiction, one may well doubt whether one has any right to deduce a law of position from either account; and the descriptions of the manner of distribution of the tentacles are so inadequate, that it is impossible to conjecture how many of the tentacles placed on the disc correspond to a radial chamber.

Amongst the Challenger material was an Actinian which I originally took for a *Corallimorphus*, till I recognised that on four radii of the body two tentacles on the disc and one at its edge proceed from one and the same radial chamber. This is in contradiction to the law of the position of tentacles in *Corallimorphus*, but on the other hand is related to that in *Corynactis*; to the latter genus I therefore provisionally refer it, even though many characters do not agree in the two forms. Especially is its shape divergent, being saucer-like as in *Corallimorphus*, and not elongated as in *Corynactis*. Further, the animal is very irregularly developed; the number of marginal tentacles amounts to fifty-six, larger and smaller generally alternating; two cycles, each of twenty-eight, might thus be recognised, did one not consider that the tentacles of each cycle differ markedly and somewhat irregularly in size. One is compelled to rank under the primary circlet, tentacles which in diameter are far short of tentacles of the second order. Even more irregular is the arrangement of those tentacles which are situated on the disc: their total number, twenty-three, falls into three cycles, six tentacles being placed near the mouth (oral tentacles), ten near the edge (peripheral tentacles), and seven intermediately. Despite these apparently irregular numbers, I have noticed the complete validity of a law in one-half of the animal, and it is of importance that this regular half commences with the one pair of directive mesenteries and reaches to the other, thus just completing one side of the animal. In the half in which a regular arrangement is followed, we have three oral, six intermediary, and six peripheral, accessory tentacles. The six intermediary alternate with the six peripheral, three of them standing on the same radius as the oral tentacles. If we compare with these the marginal tentacles, the larger twelve are on the radii already occupied by the tentacles on the disc, while the smaller twelve are placed on the intermediate radii. At each of two points two tentacles are present, a larger and a smaller; and, being out of accord with the law which governs Actiniæ, are either a token of the commencement of further growth, or constitute a case of those numerous abnormalities which occur in the group.

In the other half of the animal occur important gaps in the ground plan just quoted. The three oral tentacles are in the same place as in the other half, (one is over the chamber bounded by the directive mesenteries), but five of the intermediary tentacles and two of the peripheral are wanting. The single intermediary tentacle occurs in the region bordering on the directive mesenterial chamber just mentioned; this region is normally arranged, the peripheral tentacles being also present on it. As with the tentacles on the disc, so also the marginal ones exhibit great irregularities; their number amounts to twenty-eight; in size their relations are also variable, so that the rule, that larger and smaller tentacles alternate, is in places infringed.

The peculiar results of a macroscopic examination induced me to cut out a sextant of the animal for a closer study by means of sections, choosing that sextant of the normal side which contained the directive septa, and which only departed from the regular scheme of the Hexactiniæ in the presence of two supernumerary tentacles. The results were, that the mesenteries are grouped in pairs by the arrangement of their muscles thus,—one pair of directive mesenteries, and four other pairs, all of which reach to the stomatodæum. Of these four pairs I reckon one in the second cycle, two in the third, the remaining pair being developed asymmetrically and repeating the irregularity already noticed in the tentacles.

From the intra-mesenterial chamber of the directive septa are evaginated three tentacles; besides the marginal, one oral tentacle and one intermediary are placed on the disc. In the intra-mesenterial chamber of the second order the former (oral) was wanting; in those of the third order, the intermediary tentacle was also wanting, or rather was replaced by a peripheral tentacle. From all the inter-mesenterial chambers, and also from the supernumerary intra-mesenterial chamber, spring only marginal tentacles.

Histologically our *Corynactis* is closely related to the *Corallimorphi*. The mesoglœa is homogeneous, branched stellate cells are richly scattered in it, while the modified bladder cells, which occur in *Corallimorphus obtectus*, are wanting. Beneath the endoderm runs a fibrous layer, sometimes closely under it, sometimes separated from it by a homogeneous layer, giving off bundles which run to the endodermal surface. The musculature of the oral disc and tentacles is weak and ectodermal; there is no special sphincter, and the mesenteries are provided with only weak muscles on both sides. On the other hand, I was surprised at the *occurrence of longitudinal muscles on the outer side of the body-wall*. They are not very strong, and are mostly composed of short spindle-shaped fibres, the lamella being always slightly pleated here and there. This discovery made it necessary to study *Corallimorphus obtectus* anew, with reference to the body-wall. The epithelium having been preserved only at exceedingly few spots, constituted the reason why I had not previously observed the muscle, but a renewed study yielded figures by which I arrived at the following definite opinion, based on numerous preparations from different parts of the body.

At the basis of each epithelial cell lies a small body, staining in carmine, and resembling, in sections accurately transverse to it, a muscle fibril. If the section be taken at an angle of about 30°, these bodies appear elongated and somewhat spindle-shaped; but I have seen no such obvious longitudinal fibres as in *Corynactis*. I am therefore of opinion that *Corallimorphus* possesses longitudinal muscles, but that they are extremely rudimentary.

The observation of ectodermal longitudinal muscles on the body-wall of *Corynactis* is an exceptionally interesting discovery. Among all Anthozoa, we know of a similar condition in *Cerianthus* alone, and, as I may here mention, anticipating future investigation, in *Arachnactis*, a genus very closely allied to *Cerianthus:* while in the typical Anthozoa the ectodermal musculature is confined to the tentacles, the oral disc, and the stomatodæum. On the other hand, all Hydroids in the hydra-form (*i.e.* Hydroid-polypes and Scyphostomæ) possess ectodermal longitudinal muscles of the body-wall, which are prolonged directly into the tentacles and oral disc (peristome). We have here, throughout the whole body, circular muscles on the endodermal side, and longitudinal, *i.e.* radial, on the ectodermal.

On the ground of previous researches on the sexual organs, I have published the view, since defended by Götte, that the Scyphomedusæ are ancestral forms of the

Anthozoa, the development of radial (mesenterial) folds which commences in the former being further advanced in the latter. In this case the ectodermal longitudinal musculature of *Corynactis* and the *Ceranthi* would be, as it were, heirlooms from the Scyphostomæ. Both genera would thus retain an ancestral character no longer to be found elsewhere among Anthozoa, with which would agree that both genera must on other grounds be placed near to the original ancestor of the group. Of all Hexactiniæ, the Corallimorphidæ are, next to the *Halcampæ*, the most primitive; the Cerianthidæ, again, must be derived from the extremely primitive Edwardsiæ.

Family 2, Antheomorphidæ, Hertwig.

Genus *Ilyanthopsis*, n. gen.

Antheomorphidæ with the tentacles in several rows; body-wall smooth; body goblet-shaped, broadening upwards from the small pedal disc to the broad oral disc.

Ilyanthopsis longifilis,* n. sp. (Pl. II. fig. 2).

Tentacles very long, pointed, with an obvious terminal pore, ranged in four circlets, increasing in length from the centre outwards.

Habitat.—Reef of the Bermudas, June 1873. One specimen.

Dimensions.—Diameter of base, 4 cm., of oral disc, 7 cm.; height, 3·5 cm.

The single specimen, which was well preserved but strongly contracted, in its shape occupies a middle position between *Aiptasia* and *Anemonia*. The base is relatively small, the body not very high, but broadening out conically towards the mouth. The body-wall being raised in goblet shape over the edge of the oral disc, the animal possesses a "collar" in the sense of Angelo Andres, and consequently, owing to the absence of cinclides and acontia, must be reckoned near the Ilyanthidæ. From these it differs in the presence of a well-developed pedal disc, by which it undoubtedly attaches itself to rocks.

The thin body-wall is smooth, except for transverse wrinkles due to the strong contraction of the mesenteries. No sphincter is present. The circular muscle-lamella is, in all parts of the body-wall equally, pleated into muscular laminæ, which are low, and either not at all or only slightly arborescent.

The tentacles are very numerous, and are arranged in four rows, the oral disc being free from them in the immediate neighbourhood of the mouth. Since I counted but 160, not all the tentacles of the sixth order can as yet have been developed. The longest of them were some 4 cm. in length, and 0·5 cm. broad at the base; the slightly truncated tip possessed a small pore. In studying the ectodermal muscle-lamellæ, peculiarities presented themselves which suggested the longitudinal muscles on the outer surface of the body-wall in *Cerianthus*. The muscular pleats are generally slightly arborescent, as is shown in Pl. II. fig. 2, and arranged close to one another like the leaves of a book. At the free edge of the pleat the musculature is interrupted, since here the fibres of the mesoglœa, which serve as foundation for the muscle-pleat, radiate into the epithelium. For some distance they are united in a bundle; they then part, and each fibre individually tends in the direction of the epithelial surface. The nerve-fibre layer is consequently pierced by fine fibrils, arranged parallel to and at equal distances from one another. I would have gladly determined how far the connective tissue fibres reach, and whether they are connected with individual epithelial cells or not; but in thin sections I could only follow them into the dim granular striated layer of epithelial cells, in which they were no longer distinguishable from other fibres. Attempts to exhibit the isolated fibres by brushing and agitating thin sections, or by maceration in alkali, yielded no result; and staining with picrocarmine was also unsuccessful. The latter generally stains the mesoglœal structures of a deep red, and is therefore peculiarly adapted for exhibiting the mesoglœal lamina which carries the muscles, but it refuses to differentiate the fibrils. The red tint is therefore only seen to extend so far as is expressed in the figure by shading; the fibrils probably do not stain, but only the cement substance uniting them. The condition here described may be followed on to the oral disc, inasmuch as the supporting laminæ of the muscle pleats here also run out in fibres, and the individual fibres radiate to the epithelium. I have only further to remark that radial furrows, shallow and slightly expressed, run from the edge of the oral opening towards the tentacles.

The stomatodæum, in the only specimen which I could examine, was evaginated, and consequently so tightly stretched that even the siphonoglyphes were almost smoothed out, and hardly recognisable.

The mesenteries agree in number with the tentacles; all reach the stomatodæum, and bear generative organs. The younger mesenteries touch the stomatodæum somewhat further back, and are in other respects less developed than the older; but their generative organs are more voluminous than those of the first and second orders. Stomata in the mesenteries, and acontia, I have not been able to recognise.

Family 3, Actinidæ, A. Andres.

Antheadæ, Hertwig.

Genus *Hormathia*, Gosse.

Actiniæ with broad diffuse endodermal sphincter; smooth thin body-wall, and parietal spherules (*i.e.* marginal spherules placed on the body-wall).

Hormathia delicatula,* sp. n. (Pl. II. figs. 1, 3, IV. fig. 9).

More than 160 tentacles; parietal spherules tentacle-like, one of the latter to about every four tentacles.

Habitat.—(?) (Inscription on the label completely soaked away.) Two specimens.

Dimensions.—Diameter of the nearly spherical body, 2·5–3·0 cm.

Gosse has conferred the name of *Hormathia margarithæ* on an Actinian brought up by the line of a deep-sea fishing-boat. Having obtained but one specimen, and that not till some time after death, he could give but an incomplete description; the most important point of which is that on the delicate body-wall, at some distance from its upper edge, are placed prominences resembling marginal spherules, the number of which is about ten, and is essentially less than that of the tentacles. In his monograph treating of the Actiniæ, Angelo Andres has included the animal among the doubtful genera, as being of uncertain systematic position. It was therefore very agreeable to me to find in the Challenger material two Actiniæ obviously belonging to the genus *Hormathia*, by the study of which I am enabled both to justify the creation of a new genus, and also to define accurately its systematic position.

Both specimens were so strongly contracted as to resemble an apple in shape. The upper part of the body-wall, the pedal disc and the mouth being entirely drawn in, and the latter covered over, one saw at first only the lower part of the body-wall, the smooth surface of which was so little characteristic that I came near to ranking the animal among the undeterminable forms. Only after dividing a specimen longitudinally did the circlet of parietal spherules come into view, their position being characteristic of the genus *Hormathia*.

The pedal disc is strongly constricted and pleated by the violent contraction. The body-wall is exceptionally delicate, so that the septa are plainly visible through it, and is quite smooth. By a circular fold, which recalls to mind the boundary between body-wall and oral disc, and marks the limit of retraction in a withdrawn specimen, is bounded a separate invaginable region of the body-wall; close up to this fold, and on the side nearest to the oral disc, is placed a circlet of 42 knobs, which are hollow and beset with nematocysts, and which therefore recall the structure of the marginal vesicles or "bourses marginales" (Pl. IV. fig. 9). They are of different sizes, the largest generally longer than the marginal spherules; and are curved in a digitate manner at the end, so as to present some resemblance to tentacles. The number of tentacles and mesenteries being about 160, the parietal spherules, as I term these structures, are not placed, like the marginal spherules, one on each inter- and intra-mesenterial chamber; but there is one spherule to about every four chambers, with one of which it is always in communication, leaving the remaining two or three free.

The marked retractibility of the animal is effected by a sphincter muscle in a definite region of the body-wall, which, commencing at some little distance from the parietal spherules, and reaching to the origin of the tentacles, extends therefore over a airly wide belt. Correspondingly to this broad extension, it is nowhere strongly developed, and falls under the category of "diffuse" endodermal muscle, the lamella being most markedly pleated in the centre. Its arrangement is very characteristic, as a transverse section presents the appearance of numerous closely-packed acinose glands, excavated in the mesoglœa. In the more central parts—to continue the comparison—the gland-like crypts are longer and more closely packed than in the upper and lower parts (Pl. II. fig. 1).

The strongest development of muscles occurs on the ectodermal side of the disc, where the supporting lamina rises into high plates, covered by strong fibrils and richly arborescent. Here and there I have also noticed the plates fusing together, with a resultant mesodermal inclusion of the muscle fibrils (Pl. II. fig. 3). Towards the tentacles the muscles become weaker.

The tentacles are of a medium length, broad at the base, and drawn out to a fine point, which is probably not provided with an opening at the tip. The siphonoglyphes are hardly marked on the stomatodæum. To the latter, besides the mesenteries of the first cycle, those of the second and third cycles at least are attached. Their musculature is in no region strongly developed; in the specimen investigated nearly ripe testicular follicles occurred on them.

Family 4, Bunodidæ.

Genus *Aulactinia*, Verrill.

Aulactinia, sp. (?)*

Habitat.—Simon's Bay, Cape of Good Hope, December 1873; 10–20 fathoms. One specimen.

Dimensions.—Height in a strongly contracted condition, 2 cm.; breadth of pedal disc, 3 cm.

In this place I will devote only a few words to a Bunodidan, of which I reserve a detailed description till I shall have reviewed a rich supply of species of this family which has been forwarded to me. The body-wall of the sole specimen lying before me is thickly beset with thin-walled vesicular outgrowths, which are about 1 mm. in size, show a tendency towards arrangement into transverse and longitudinal rows, and are so thickly set that the intermediate stouter parts of the body-wall have a reticulate appearance. The three upper rows of these vesicles (about seventy in number) are closely packed with nematocysts, and so take on the character of marginal spherules; they may be distinguished into a stalk, and a branching head like a cauliflower. They recall somewhat those external appendages of species of *Oulactis*, which have been termed,—I do not know for what reason,—tentacles. The tentacles are arranged in three rows, and more than 200 are present. The endodermal sphincter is extraordinarily strongly developed, in the form of a ridge projecting into the cœlenteron.

Family 5, PARACTIDÆ.

Genus *Dysactis*, Milne-Edwards.

Dysactis crassicornis, R. Hertwig.

Two additional examples of this Actinian have reached me, dredged from a depth of 55 fathoms at Station 313. One had died in an expanded condition, so that the tentacles were in better preservation than in the specimens previously studied; from this I am enabled to determine some further characters of these organs.

In many cases terminal pores, which I was before unable to discover, were easily recognised on a surface view; I have therefore re-investigated the older material, and was able with some trouble to prove the existence of openings by injecting air into them under water.

Further, in the well-preserved tentacles, comes strongly into view a characteristic which I had previously figured (former Report, pl. vii. fig. 12), but had not introduced into the text; the tentacles are longitudinally striated, so covered with longitudinal ridges and furrows as to recall a fluted pillar; in section this is still more prominent. At tolerably regular intervals the mesoglœa rises in high ridges (Pl. II. figs. 6, 7), and at these points the mass of muscle lying in it is correspondingly increased. The muscles therefore form in transverse section a continuous ring, which in the region of the ridges of mesoglœa is drawn out into cusps. At the base of an especially strong tentacle I counted twenty-two longitudinal ridges, of which, however, some only reach to the tip.

Family 6, LIPONEMIDÆ, R. Hertwig.

Genus *Liponema*, R. Hertwig.

Liponemidæ with weak endodermal sphincter; the body-wall marked by longitudinal furrows, without marginal spherules; stomidia very numerous.

Liponema multiporum, R. Hertwig (Pl. I. fig. 13, Pl. II. fig. 4).

Stomidia, several hundreds in number, distributed in several cycles, and scattered over the whole oral disc; body apparently cup-shaped, broadening out from the small pedal disc upwards to the wide oral disc.

Habitat.—(*a*) Station 305A, January 1, 1876; 120 fathoms. One specimen.

(*b*) Station 147, December 30, 1873; 1600 fathoms. One specimen.

Among the Actiniæ with degenerate tentacles, I described in my former Challenger Report a new species, in which the extent of retrogression of the tentacles can be recognised in a degree attained by no other form. I was compelled to dispense with a detailed description of its structure, since the only specimen at my disposal was on the one hand much mangled, and on the other rendered so brittle by preservation in chromic acid that it could not be methodically investigated. I am glad to be in a position to fill up the deficiency by means of two specimens found in the supplementary material, both well preserved, although considerably altered in shape by violent contraction. In both cases, as in the example previously described, the stomatodæum is so much evaginated as to take the place usually occupied by the oral disc, the latter falling outwards from this point like a body-wall (Pl. I. fig. 13). On the other hand, pedal disc and body-wall are alike deeply retracted on the lower side. The body-wall forms a cup like the shell of a *Patella*, the pedal disc projecting into the cup somewhat like the body of the *Patella*. In so marked a de-formation, dimensions can with difficulty be given, and can serve only for approximate orientation. In the larger of the two specimens (from 120 fathoms at Station 305A), the pedal disc had a diameter of about 2 cm., the distance between the edge of the oral disc and the mouth reached 2·5 cm.; the length of the stomatodæum was at most places 1·5 cm., and at the siphonoglyphes more than 2 cm. The corresponding dimensions of the smaller example (Station 147; depth, 1600 fath.) are essentially less,—diameter of pedal disc, 0·07 cm.; radius of oral disc, 1·2 cm.; length of the stomatodæum, 1·0 cm. From the nature of the contraction may be inferred that in both cases the dimensions of oral disc and stomatodæum are excessive, as the result of evagination, while those of the pedal disc are too small.

On the pedal disc are about 160 radial furrows, of which, however, only a proportion reach the centre, the rest dying out sooner or later. The ridges between the furrows are somewhat toothed, in the manner formerly described by me as occurring in *Polystomidium* and *Polysiphonia*. In the centre of the pedal disc lies a pit about the size of a pin's head, which cannot be proved to be an opening.

On the exterior of the body-wall also, similar ridges, alternating with furrows, run longitudinally from pedal to oral disc; their number is greater, being close on 400; they differ in size, some few of less considerable development rising between every two of the stronger ridges. At the edge of the oral disc they all pass into a strong circular ridge, which forms the sharp boundary between body-wall and oral disc.

The pedal disc and body-wall possess on their inner surfaces the circular muscle-fibre layer occurring in all Actiniæ; on the body-wall this is strongly pleated, and the more so, the nearer we approach to the upper edge. In the immediate neighbourhood of the edge the pleating is so marked that one may term it a sphincter; it causes here the circular ridge mentioned above as occurring at the upper edge of the body-wall

(Pl. II. fig. 4). This circular ridge appears in transverse section as a pushing out of the body-wall, the circular muscle exhibiting a very different structure in the different regions. At the base of the organ the pleating of the muscle-lamella is insignificant, indeed weaker than at other points of the body-wall, but at both edges of the evagination it is exceptionally strong, and more especially so at the boundary of the oral disc. When the section comes to the actual spot on which one of the stomidia is set, the inner sphincter—as we call the nearest muscular pleating—is beautifully recognisable as a ridge projecting inwards, into the axis of which protrudes a mesoglœal ingrowth. From this axial ingrowth are given off on both sides richly branching mesoglœal lamellæ, clothed by powerful muscle-fibres in transverse section. At the remaining points, where the oral disc presents no stomidia, the sphincter is less clearly bounded, and resembles more the outer sphincter, which is essentially nothing but an approximation of muscular folds at two closely-adjacent points.

Relatively to the size of the animal, both sphincters are weak; a consequence of this is the fact that they have not drawn up the body-wall over the mouth disc, but that stomatodæum and oral disc have rather been pressed outwards.

The oral disc recalls in appearance a toadstool, having a faintly flesh-coloured surface, covered by whitish, slightly elevated spots. These spots are the stomidia or tentacles, which are distributed nearly up to the mouth, leaving but a narrow strip free. Between the stomidia the radial furrows run in undulating lines. Their number is difficult to determine, but may amount to about 400.

The stomidia are openings in the oral disc, surrounded by a slightly developed ridge, and projecting a little above the surface; roughly speaking, they are distributed uniformly over the oral disc, or allow only of a vague distinction into several zones. Of these zones one is peripheral, set close to the edge of the oral disc; one is central, not far from the oral opening; and two intermediate zones are placed between them. The openings increase in size from without towards the centre, and at the same time undergo an alteration of shape; in the peripheral zone they are like radially-set slits, with a long axis of 0·7–1·5 mm.; in the intermediate zones they are circular, with a diameter of 1–2 mm.; and in the central they again form slits of 2·0–2·5 mm. in the longer diameter, but are here placed at right angles to the radii.

The structure of the stomidia can best be exhibited by figures of transverse sections. Each stomidium completely occupies the intermediate space between two neighbouring mesenteries, and forms a tube, opening peripherally by a wide mouth. The walls of the tube appear in section to be direct continuations of the adjacent septa; morphologically their lower part is to be regarded as oral disc, their upper part as rudimentary tentacle; accordingly, they exhibit below the numerous muscular pleatings which at other points cause the radial ridges on the oral disc, while above these pleatings are absent. A remarkable structure is a small circular fold projecting below into the lumen of the tube, and constricting it like a diaphragm. This doubtless serves to close the tube, since it is covered by a marked layer of muscle fibres, running circularly round the opening.

Where no stomidium is placed, the oral disc exhibits on its ectodermal side a thick layer of radial muscle fibres, arranged in simple lamellæ, which, at most, branch but once. The lamellæ being higher midway between two mesenteries than elsewhere, the radial ridge-like thickenings of the oral disc are the result.

With reference to the relations between the stomidia and the inter- and intra-mesenterial chambers, in my former publication I expressed the opinion that an intra-mesenterial chamber might carry more than one stomidium, *Liponema* thus approximating to the Corallimorphidæ; an opinion which I can now designate as erroneous, on the ground of more accurate investigation. Each intra-mesenterial chamber possesses but one stomidium, which is the more closely approximated to the centre of the oral disc, in proportion as its adjacent septa are of older formation.

The stomatodæum is brownish-violet in tint, and 2 cm. long; on it are placed the marked siphonoglyphes, about 1·5 cm. in breadth, projecting considerably at the lower part of the tube, where they pass into the boat-shaped stomatodæal cone. They are bounded by two stout, transversely pleated, lips. Further, the stomatodæum is marked by about 200 longitudinal folds, of which some 80, by their stronger build, deserve the name of primary folds. Between every two primary folds lie, in many cases, two secondary folds; but at some places one only may occur, or they may be entirely wanting.

The number of mesenteries was determined by the method before mentioned, that of cutting out a sextant of the animal and studying it closely anatomically. I found six cycles, in all therefore 192 pairs of mesenteries. In the first four cycles all the mesenteries reach the stomatodæum, though those of the first two cycles only are attached to it for its whole length; they all possess wide openings near the edge of the lip (internal mesenterial stomata), and their muscular nature so far preponderates that only those of the fourth cycle carry generative organs. In this respect these mesenteries of the fourth cycle agree with those of the fifth and sixth, but the muscular development of the latter is considerably inferior to that of the others. The mesenteries of the sixth cycle are practically nothing else than small genital folds, projecting but slightly into the cœlenteron, and never provided with mesenterial filaments.

Of the generative organs I found exclusively the testicular follicles, containing spermatozoa in parts ripe, in parts only commencing to develop.

It is possible that in this animal a further growth takes place, with the formation of new mesenteries; this I infer from the great number of stomidia. In the sextant investigated they amounted to about 120, or to 700–800 for the whole animal. Since only about 196 intra- and inter-mesenterial chambers are present, and each of the former possesses but one stomidium, the latter apparently must be provided each with two or three,—an inference confirmed by dissection. Since it is the rule amongst Actiniæ that the development of tentacles precedes that of mesenteries, we can also infer in this instance from the plentiful development of stomidia, an imminent addition to the mesenteries.

Genus *Aulorchis*, n. gen.

Liponemidæ, whose generative organs are modified into a tube perforating the oral lip; gonidial grooves on both sides drawn out into a long ear-like cone.

Aulorchis paradoxa,* sp. n. (Pl. I. figs. 9, 10; Pl. III. figs. 2–6; Pl. IV. figs. 1–6).

Stomidia arranged in two alternating rows, approximately sixty in number.

Habitat.—Station 299, December 14, 1875; lat. 33° 31′ S., long. 74° 43′ W.; depth, 2160 fathoms. One specimen.

Dimensions.—Height, 4 cm.; greatest breadth (measured about half-way up the animal), 3 cm.

Among the accessory Challenger Actiniæ occurs this form, of great interest as enlarging by a new genus and new species the group of forms devoid of tentacles. Unluckily, I have had but the one solitary specimen for study, and even this was badly preserved, and had apparently suffered much from the dredge. It was exceedingly contracted; oral and pedal discs were externally unrecognisable, since both ends of the body-wall were closely drawn together. As a natural result of this condition, I have not been able to clear up many important points of the organisation so well as I could have wished. For investigation, I divided the specimen longitudinally, and dissected a sextant with scalpel and scissors, arriving at the following results.

The strongly contracted, and therefore small, pedal disc exhibits indistinct radial brownish wrinkles and furrows, and is sharply marked off from the body-wall, the surface of which is smooth. The latter is of a whitish tint, and of inconsiderable thickness, only here and there becoming more powerful, but never forming hooks or papillæ. Its consistence is less firm than that of cartilage, but considerably more so than that of Medusan mesoglœa. The tissue is of a fibrous nature, composed of very fine fibrils, which are generally interlacing and reticulate. At many points, however, they are thicker and bound together in more parallel series, so that cords and lamellæ are formed, which, though staining brilliantly with carmine, are not sharply differentiated from their surroundings. These lamellæ are ranged parallel to the two surfaces, and run constantly closer to one another till a firmly united mass of fibres is formed just below the epithelium. At other points, however, the fibres are more loosely plaited, so that spaces remain between them, which are filled up by homogeneous mesoglœa. In some places I detected hollow spaces in the tissue, which were devoid of an epithelial lining. They occur also in the mesenteries, the stomatodæum, and the oral disc, and may perhaps be caused by inadequate preservation.

In the upper part of the body-wall lies, close under the endoderm, a mesodermal sphincter muscle, its length amounting to about 1 cm., while its greatest breadth reaches 5 mm. at the upper end, from which point it gradually thins out. It is of interest from several points of view ; in the first place, the muscle-fibres are abnormally strong ; consequently the muscle-bundles are formed of but few elements, and consist in many cases only of two to four. Again, the individual tracts are so far from running parallel to one another, that in a longitudinal section many bundles are cut absolutely transversely, others obliquely, and others for long stretches superficially ; thus an appearance of extremely entangled fibres is presented (Pl. III. fig. 3*a*).

Finally, *Aulorchis* affords proof of the endodermal origin of the mesoglœal muscle-bundles, as we find on the endodermal side every transition from the mesoglœal bundles to the endodermal layer of circular fibres ; in one place the bundles lie close under the fibrous layer, at another are in communication with it by a broader or narrower band ; finally, we find slight infoldings of the endodermal muscle-layer (Pl. III. fig. 3*b*).

The stomidia lie in two alternating rows between the edges of the mouth and of the body-wall, somewhat nearer to the former ; they are about sixty-four in number (thirty-two between two pairs of directive mesenteries). The stomidia of the inner row are larger than those of the outer ; the smallness of the latter producing the impression, that they have just been formed, and that a further increase of their number is taking place. Radial ridges on the oral disc start at the edge of the body-wall and run up to the individual stomidia.

Transverse sections through the oral disc exhibit a strong mesodermal musculature ; this is interrupted along the lines of mesenterial insertion, and falls therefore into marked radial bands which cause the radial ridges of the oral disc. The individual muscle-bundles contain a few strong fibres, and are so separated from one another by mesoglœal sheaths, stout or slight, that the lines of mesoglœa form dendritic figures springing now from the ectodermal, now from the endodermal side (Pl. III. fig. 2).

The mesoglœa sends into the ectoderm arborescent supporting offsets, on which to my surprise I was unable to find muscle-fibres. It seems as if in *Aulorchis* the ectodermal musculature is completely wanting ; I would gladly have expressed something definite on this point, had the histological condition of the animal not been so indifferent ; but the ectoderm, where present, was unfortunately reduced to a detritus, in which no structure could be detected.

In order to demonstrate how the stomidia penetrate the thickness of the oral disc, I have drawn two figures, in the one of which (Pl. III. fig. 4) are seen the openings of the tube to the exterior and to the cœlenteron ; in the other (fig. 5) the section passes through a spot where the stomidial tube is closed at both ends, whence it may be inferred that its diameter is here considerably greater than that of the two openings. The radial mesodermal muscle-fibres pass into its walls with a longitudinal trend.

On the stomatodæum are placed the two siphonoglyphes, which are of a very characteristic appearance, as being more powerfully developed than in any Actinia which I have as yet seen; each projects over the mouth edge and upwards with two long ear-shaped cones. The groove itself is correspondingly deep and broad, pleated, and of a cartilaginous consistence. Between the two siphonoglyphes run on each side about ten strongly-marked longitudinal ridges, terminating in rounded knobs on the lip.

In investigating the mesenteries, I could at least prove their arrangement in pairs, but could not convince myself that the Hexactinian symmetry was carried out. Neither by microscopic preparations of a sector, nor by dissection of individual mesenteries, could I arrive at a definite law of arrangement; this point therefore requires investigation.

The mesenteries dissected bore no generative organs; these appeared to me to be confined entirely to one mesentery, and to possess a tubular structure unparalleled in the whole class of Anthozoa, a fact which decided me to choose for the genus the name *Aulorchis*. Even before dissection it had struck me that at a spot on the edge of the lip, and by a pore specially present for the purpose, was the opening of a cylindrical organ; this organ had obviously once been longer, as at its end a fracture was clearly recognisable. By splitting up the opening and the adjacent stomatodæum, the organ, which I will term in future, for reasons to be mentioned, the genital tube, could be clearly followed into an inter-mesenterial chamber (Pl. I. fig. 9). It meets one of the complete mesenteries, lies at this point embedded in the tangle of mesenterial coils, and, as appeared later from sections, ends at the mesentery in a horseshoe-shaped curve. The curved portion was firmly united with the mesentery. Transverse sections yielded further conclusions relative to its structure; but, unfortunately, owing to bad preservation, no exhaustive account of this is possible. For instance, I have not been so fortunate as to determine how far the structure of the genital tube can be referred to that of the ordinary Actinian ovary (Pl. IV. figs. 1–6).

The genital tube is superficially clothed by epithelium, which is limited externally by a border resembling a cuticle, but perhaps produced only by mucous secretion; then follows the mesoglœa with the ova embedded in it; internal to these lies a cavity, more or less spacious according to the mass of the ova. The mesoglœa is divided by a narrow granular layer into inner and outer zones, which here and there, by failure of the intermediate layer, join together. The outer zone is narrow, and exhibits what appear to me to be circular muscle-fibres referable to the epithelium, which in longitudinal sections through the organ (fig. 3) resemble narrow laminæ placed close together. The state of preservation was inadequate for the determination of the histological character of the granular median layer; in transverse section it gave the impression of a disintegrated epithelium, in longitudinal it resembled a loose connective-tissue. This layer is important as containing small, spherical, deeply-staining cells, which I regard as young ova. The masses of ova are in parts so considerable as to present the appearance of mosaic, if part of the wall of the genital tube be cut out, stained, and viewed from the surface (fig. 2). Next comes the second zone of mesoglœa, the layer of most importance, since ova of various sizes are embedded in it. Some of these are certainly connected with the superficial epithelium; this condition, I believe, occurs in all ova, and is effected by the fibre-arrangement characteristic of Actinian ovaries, of which remnants only could here be detected (fig. 1).

The lumen of the tube was mostly filled by a cell-detritus, but at some points was lined by a clearly ciliated epithelium (figs. 4, 6); I reckon therefore the lumen as a ciliated canal, serving for the transit of ripe ova and perhaps also of embryos, and opening to the exterior outside the oral disc. The ripe ova appear to lie on the floor of the tube, since here I found compact masses of a finely granular substance, appearing to me to resemble ova.

As to the distribution of the ova in the genital tube, I have the following facts to add: the smaller ovules are met with in sections through the upper part of the tube, forming a ring, on the one side of which the generative elements are more closely packed than on the other. This lop-sided development of sexual cells is expressed more obviously lower down, where on one side of the section they are entirely wanting, the ripening ova being only present in the other half.

With regard to the connection of the genital tube with the body of the Actinia, I have arrived at no positive results. At the pore, the organ merely perforates the oral lip without being attached to it, as I can assert both from macroscopic dissection and transverse sections; while at the lower end I have discovered no intimate connection with the mesentery; what I saw there was only an epithelial adhesion, not a transition from the mesoglœa of the mesentery into that of the genital tube. Such a connection, however, must certainly occur at this point.

From my description it may be recognised that *Aulorchis* is one of the most interesting Actiniæ, and that it would be very desirable that a richer material of it should be acquired by fresh Deep Sea investigations.

Family 7, Phellidæ.

Genus *Phellia*, Gosse.

Phellia spinifera, n. sp. (Pl. II. figs. 8, 9).

The bark-like part of the body-wall is bedecked with thorn-like pointed knobs, distributed more richly on the upper than on the lower parts.

Habitat.—(*a*) Station 311, January 11, 1876; depth, 245 fathoms. Three specimens. (*b*) Station 320, February 14, 1876; depth, 600 fathoms. One specimen.

Dimensions.—Length of the contracted animal, 2·5–3·2 cm.; breadth, 2·5–3·5.

At first I was inclined to refer the three specimens from Station 311, which were seated on Molluscan shells, and the single specimen from Station 320, to *Phellia pectinata*; for they possessed the characteristic appearance of the body-wall, resembling the tunic of *Cynthiæ*, while the upper indrawn part of the wall presented the ridged surface which has been already figured. I was, however, persuaded to a closer study by observing some points of divergence in the structure of the peripheral region of the body-wall. The transverse and longitudinal ridges are wanting, instead of which occur knobs, resembling those of *Cereus spinosus*; these start with a broad base, and terminate in a slightly truncated tip; they are distinguished from the body-wall, which is nearly white, by a brownish tint, and may amount to 200 in number, distributed more abundantly on the upper than on the lower regions of the body-wall. The upper knobs are as much as 0·25 cm. long, and are more strongly developed than the rest; they become gradually smaller below, and finally appear only as fine grains. Such an arrangement of the knobs in series, as exists in *Bunodes*, does not occur.

The mesoglœa of the body-wall is so extraordinarily stiff as to cause some trouble, before good sections of the sphincter can be effected. The latter is essentially constituted as in *Phellia pectinata*, so that reference to the description given under that species is sufficient. In position it is considerably nearer to the ectoderm than to the endoderm.

The oral disc and stomatodæum are of a brownish violet (partially altered in the alcohol), the former lighter in tint than the latter. On the stomatodæum the two siphonoglyphes, which are not pigmented, and are consequently of a whitish yellow, strike the eye on opening the animal as two broad, sharply-marked, stripes. They are only distinguished from their surroundings by this difference of colour, since they are flush with the rest of the stomatodæum. They are crossed by transverse folds regularly arranged, which are continuous over the rest of the stomatodæum. Further, the stomatodæal cone is hardly expressed at all, and the longitudinal furrows, which so commonly run parallel to the siphonoglyphes between the mesenterial insertions, are wanting.

For the characterisation of the species the condition of the musculature of the oral disc is also of importance; it exhibits two methods of formation. In the one case it is purely ectodermal and markedly pleated, the pleats running parallel to one another, and only slightly arborescent (Pl. II. fig. 9). At other points (fig. 8) the arborescence is very considerable, the individual branches anastomosing with one another; the musculature thus becomes partly mesoglœal, and a very obvious and stout muscle-layer arises. The muscle-fibres are here, as in the sphincter and the powerfully developed laminæ of the retractors, of exceptional thickness.

All the mesenteries are unusually muscular; the primary mesenteries are sterile, and reach to the stomatodæum, while the secondaries are incomplete but bear generative organs. I observed a few acontia; cinclides, on the other hand, are wanting.

In conclusion, I might refer to the possibility that *Phellia spinifera* may be only a variety of *Phellia pectinata*. In the sole example from Station 320, the spinose knobs were developed only on the upper part of the bark-like body-wall, and even here not abundantly; so that its appearance is intermediate between the characters of *Phellia pectinata* and *Phellia spinifera*. In spite of this, I have retained the separation of the two species, because the musculature of the oral disc of *Phellia pectinata* does not yield, on further study, the characteristic appearance drawn in Pl. II. fig. 8. In this respect, the transitional form agrees with the type of *Phellia spinifera*.

Family 8, Amphianthidæ, R. Hertwig.

Genus *Amphianthus*, R. Hertwig.

Amphianthus ornatum,* n. sp. (Pl. I. fig. 8).

Body-wall beset with numerous (about 26) longitudinal rows of papillæ; the latter are for the most part recognisable by the naked eye, and are not arranged in transverse series.

Habitat.—(*a*) Station 56, May 29, 1873; depth, 1075 fathoms. One specimen. (*b*) Station 241, June 23, 1875; depth, 2300 fathoms. Three specimens. (*c*) Station 244, June 28, 1875; depth, 2900 fathoms. One specimen.

Dimensions.—Height, 0·2–0·5 cm.; length of the pedal disc, 0·3–2 cm.

The five specimens which I describe under the name of *Amphianthus ornatum* have on the one hand many points of resemblance to *Amphianthus bathybium*, on the other to *Cylista* (*Bunodes*) *minuta*; with the latter they agree in the form of the papillæ, but differ from it in the divergent shape of the body and in characteristics of the family Amphianthidæ, as also in the absence of acontia; with the former, on the other hand, they tally in general habits, but exhibit a divergent condition of the body-wall. *Amphianthus bathybium* possesses small papillæ, recognisable only with the aid of a lens, and arranged in small groups, with a tendency to transverse series. In *Amphianthus ornatum*, however, they are large, and comparatively isolated in position; they form about 20–30 longitudinal rows, which die out sooner or later at some distance from the lower end of the body-wall. The papillæ are not all of one size; indeed, it even happens that rows of larger and smaller alternate.

In the very young specimen from Station 244, only twelve rows of papillæ were present, all most regularly distributed on the periphery of the body, and all of essentially similar structure, since both in the size and number of the papillæ the individual rows were closely identical. The number of the papillæ varies between six and seven. From this observation it may be inferred that with increasing growth an addition to the rows of papillæ occurs, proportional to the additions to the pairs of mesenteries. In connection with this is the fact that the rows of papillæ correspond to the intra-mesenterial chambers.

Two examples of the present species were taken from the same locality as the one example of *Amphianthus bathybium*, Station 241. This renders it necessary to weigh the possibility that the differences which have been made of importance, are perhaps only of secondary significance, and that all the specimens may be referred to one species. Owing to the limited material, the question could not well be decided.

From the minuteness of the organism, anatomical investigation could only be effected by means of longitudinal and transverse sections; to this purpose I devoted two complete examples, the one from Station 241. the other from Station 244, besides quadrants of specimens from Stations 241 and 56. It resulted that the papillæ were proved to be solid outgrowths of the body-wall, and, like it, consist of an extremely fibrous mesoglœa. The fibres are generally interlacing, as is for the most part normal among Actiniæ, so that the tissue appears finely granular; they also here and there show a tendency to arrangement into bundles. In transverse sections, therefore, a reticulate figuring appears round the endodermal lining; this can be rendered clearer by staining, when it appears that small branches of the fibrils cross the course of the rest of the fibrils in a longitudinal direction. Similarly, one sees numerous radial fibres also in the peripheral parts of the body-wall, and a corresponding radial striation is thus produced.

The sphincter is completely embedded in the connective-tissue of the body-wall, and consists of small mesoglœal muscle-bundles composed of few, but powerful, fibres. In some places only two or three fibres are united in a bundle, or a single fibre even may run in the connective-tissue. The individual bundles are enclosed in such numbers in the mesoglœa as to be separated from the two epithelial surfaces by only a narrow layer. In transverse section, the muscle in most cases forms a club-shaped figure, being of weak development below and broadening out strongly upwards; this increase in breadth is so considerable that the whole upper end of the body-wall is strongly thickened. Even in the youngest specimens the sphincter was completely formed, and inclosed in the mesoglœa. As it is separated from the endodermal circular musculature by the insertion of a layer of connective-tissue, it seems that in the course of further growth the bundles can only increase by division of the bundles of fibrils.

The musculature of the oral disc and tentacles is purely ectodermal, but very markedly pleated. The number of tentacles corresponds to the number of mesenteries, and this is different in the different individuals investigated. In the youngest specimen from Station 244, the two first cycles were already formed, and of the third traces seemed to me to be recognisable in that inter-mesenterial chamber which is equidistant from the ends of the transverse and sagittal axes. With this agreed the distribution of the tentacles; they were about equal in number to the mesenteries, and amounted to more than twenty-four, *i.e.* the first three cycles and some tentacles of the fourth were present, and those of the fourth cycle lay at points corresponding to the inter-mesenterial chambers above mentioned. In the other specimens, between forty and forty-eight mesenteries were present in the whole circuit of the body-wall, so that here the fourth cycle was nearly complete. The number of mesenteries was still greater in the angle between pedal disc and body-wall, the point where mesenterial growth is first recognisable in Actiniæ. This part being very transparent, the number could be determined with approximate accuracy, and reached to nearly a hundred.

From the fact that in places the mesenteries were discontinuous in transverse section, I infer the existence of mesenterial stomata. On the other hand, I could not demonstrate acontia; generative organs (testicular follicles) I saw only in one specimen, and, as they were at all points adherent to the mesenteries, I could not determine whether they were present on all mesenteries, or were wanting on the primaries.

Directive septa and siphonoglyphes were distinguishable on all four specimens, but only in two examples, namely the smallest and largest, could I accurately determine the position which agrees with the typical attitude of Amphianthidæ. The sagittal axis of this Actinian is at right angles to the long axis of the body on which it has fixed itself, or, in other words, the lengthening of the animal takes place in the direction of the transverse axis.

With tolerable certainty I can at length assert that only the mesenteries of the first order are complete.

With the sole example of *Amphianthus ornatum* from Station 56 was associated another Amphianthidan, externally so little characterised, that I decided not to describe it. It possessed a smooth body-wall, which was pleated only as the result of contraction; the pedal disc was 1·5 cm. long, and the total height 0·4 cm.

Family 9, Ilyanthidæ, Gosse.

Genus *Halcampa*, Gosse.

Halcampa kerguelensis,* n. sp. (Pl. II. fig. 5).

Tentacles devoid of longitudinal furrows, pointed; circular muscles of the body-wall weak; retractor muscles of the mesenteries powerfully formed.

Habitat.—(*a*) Station 149 A, Betsy Cove, Kerguelen, January 10, 1874; depth, 25 fathoms. Ten specimens. (*b*) The same locality; 25–30 fathoms. One specimen. (*c*) Station 149 G, off London River, Kerguelen, January 29, 1874; 110 fathoms.

Three specimens. (*d*) Station 149 J, off Cumberland Bay, January 29, 1874; 105 fathoms. Three specimens. (*e*) Station 149 H, off Cumberland Bay; January 29, 1874; 127 fathoms. One specimen.

Dimensions.—Length, 1·5–2·5 cm.; greatest breadth, 0·7–1·0 cm.

On an external inspection I was inclined to identify this species with *Halcampa clavus*, which it strongly resembles. The preparation of transverse sections, however, caused me to abandon this view, and a more accurate study produced a number of points of divergence, which I will briefly enumerate.

1. The tentacles, though twelve are also present in this species, are essentially longer than in the other, and end in a fine point. The two longitudinal furrows which occur on them in *Halcampa clavus*, can be recognised neither superficially nor in transverse section.

2. The circular muscles of the body-wall are weakly developed; the laminæ which they form are not so striking as in *Halcampa clavus;* and they project into the cœlenteron at greater distances from each other. The sphincter-like enlargement of the circular muscle-layer is wanting.

3. On the stomatodæum the marked projections, which designate the insertions of the mesenteries, are absent.

4. In the mesenteries the muscle-lamina is pleated in a most complicated manner, so that in transverse section it exhibits an abundant arborescence. The centre of the muscle forms a sort of tree (Pl. II. fig. 5), a thin lamina starting outwards from the mesentery, and branching like the top of a tree. This whole region is usually marked off by an indentation from the adjacent parts, the mass of muscle being thus divided into three sections.

Genus *Halcampella*, Angelo Andres.

Ilyanthidæ with six powerfully developed pairs of mesenteries, but with numerous rudimentary mesenteries, and numerous tentacles.

*Halcampella maxima,** n. sp.

Tentacles small, approximately 46; body devoid of longitudinal furrows; its surface partly bark-like, partly somewhat incrusted; the polyp of considerable size.

Habitat.—Station 209, Zebu, Philippine Islands, January 22, 1875; 95 fathoms. Six specimens.

Dimensions.—Length, 8–15 cm.; greatest breadth, 2–3 cm.; breadth at narrowest point (near the pedal disc), 0·4–1·2 cm.

In all the specimens the body is a lax thin-walled sack; its diameter is least at the posterior end, which is stalk-like and rounded off, but anteriorly it bellies out, contracting again in the region of the oral disc. With the exception of the largest, all the specimens are so contracted that tentacles, oral disc, and upper part of body-wall were all drawn inwards together; in the largest, however, part of the tentacular crown protruded.

The surface of the body-wall is incrusted with sand-grains, so that at first sight I was inclined to take the animal for a *Sphenopus*. The sand-grains are not, however, embedded in the mesoglœa, but adhere to the cuticle of the ectodermal epithelium, so that they can easily be removed by scraping. At the anterior end they are more sparse, and are practically absent on the upper third. This part of the body-wall assumes a different appearance to the rest, being more leathery or bark-like, and traversed by rough longitudinal furrows. The bark-like appearance is produced by the cuticle, which is strongly developed, and of a brownish tint, resembling that of *Phellia pectinata* and *Tealia bunodiformis*. A fairly sharp boundary marks off from the rougher part of the body-wall a strip about 1 cm. wide, which adjoins the oral disc and wreath of tentacles, and which has a completely smooth surface. One can thus, as in *Halcampa clavus*, recognise three regions of the body,—capitulum, scapus, and physa; but only the capitulum is marked off from the rest with any degree of sharpness.

Histologically the body-wall is composed of a strong fibrous connective-tissue. The individual fibres are extremely fine, and are united in great numbers into tracts; they are not so sharply bounded, as, for example, in the connective-tissue of Vertebrata, but, like them, have a curving course. Generally they cross one another and interlace in every direction, and only under the endodermal surface does a longitudinal arrangement preponderate, parallel to the endoderm. Here the fibres stain exceedingly deeply in picrocarmine, while at all other points fine cords alone retain the stain after washing.

The endodermal circular muscle-layer is formed into lamellar pleats, arranged closely like the leaves of a book, and seldom showing arborescence in section. A muscular region specially developed for a sphincter is not present.

The tentacles are small conical stumps, measuring in the contracted condition about 0·5 cm., and devoid of the two longitudinal ridges occurring in *Halcampa clavus*. On the other hand, the terminal pores are obvious, and in many cases are recognisable with the naked eye. The tentacles are arranged in several rows; their number in one case amounted to forty-six, and was perhaps increasing, as I found several small tentacles among the larger. The longitudinal muscle lamella is ectodermal, and but little pleated.

The oral disc is very small, and presents twelve radial ridges, produced at the edge of the mouth into the longitudinal ribs of the stomatodæum; the latter are sharply-angled, with deep furrows between them. A specially differentiated siphonoglyphe is not present. The length of the stomatodæum in the largest example amounts to nearly 2 cm. Correlated with the absence of a siphonoglyphe is that of a stomatodæal cone. The boundary between oral disc and stomatodæum is sharply marked by the lip being elevated into a circular fold.

The radial muscles of the oral disc are ectodermal, and form a slightly pleated layer; a notable point is the presence of small bundles irregularly embedded in the mesoglœa.

The number of mesenteries appears on macroscopic examination to be confined to twelve, set at equal distances on the periphery of the stomatodæum; they are so grouped in pairs according to the muscular distribution, that one can distinguish two pairs of directive and four pairs of intermediate mesenteries. They resemble thin veils stretching between body-wall, oral disc, and stomatodæum, unusually delicate, and tearing at the slightest strain; below, they reach nearly to the posterior pole of the body, but are here so weakly developed as to hardly project at all into the cœlenteron.

In these veil-like mesenteries are recognisable, as special thickenings, the following organs:—1, the muscle pennons or retractors; 2, the muscles of the edge; 3, the generative organs; 4, the digestive filaments.

The retractors are powerful swellings about 1–2 mm. wide, which are tolerably sharply bounded, and appear as if glued to one side of the mesentery; they commence at the angle where oral disc and stomatodæum are continuous, and run from this point in a slight curve outwards and downwards to the boundary between the first and second thirds of the body-wall, where they terminate, thus dying out disproportionately soon, far sooner than even in *Halcampa clavus.* Transverse sections exhibit their structure in greater detail; in the region of the muscle the supporting lamina is strongly thickened, and is elevated, together with the muscle-layer resting on it, into lamellæ which are long, thick, and parallel to one another, but which either do not branch at all, or only slightly. An arborescent or bushy appearance is occasionally produced by a ridge of the mesoglœal mesenterial lamina bearing on both sides a complete series of muscular lamellæ. The sharp boundary of the muscular masses is referable to the circumstance that on both sides the pleating of the muscular layer ceases abruptly.

The edge-muscles form a band of tendinous appearance running close along the body-wall, and are most clearly expressed in the posterior parts of the body. Here they constitute nearly the whole of the mesentery, and the mesenterial filament is affixed almost directly to them.

The mesenterial filament is fairly obvious for the first two centimetres below the stomatodæum, and is arranged in a few coils. Afterwards it becomes finer, but is wound into a mass of twisted loops, continuing thus for about the next four centimetres. The contortions then become gradually less marked, till, sooner or later, the whole filament dies out; in one mesentery it could be followed to within two centimetres of the posterior pole. The first section of the filament is trilobate, possessing one glandular and two ciliated lobes; lower down it undergoes, as in other cases, a simplification of structure by the dying out of the ciliated lobes.

Both the glandular and the ciliated lobes are of exceptionally strong development; the continuations of the mesoglœal lamina entering them broaden out in the shape of a wing, so that an accurately transverse section of the trilobate filament exhibits the mesoglœa in form of a cross, the arms of which are broad and wing-shaped.

The generative organs lie in the thin septum which is intercalated between the retractor and the mesenterial filament, and were male in one specimen investigated, in the other female. The testes are 1·5 cm. long, 0·2 cm. broad, composed of separate follicles which are arranged in about thirteen transverse swellings. At the edge of the organ occur small bodies, recognisable only in transverse sections, which I take to be the first commencements of the follicles; the supporting lamina widens out, enclosing a space in which are included roundish cells (spermatoblasts?), fewer (five) or more numerous according to the size of the cavity. The latter always opens towards the epithelium by a small but obvious pore. The latter would argue, if there were any question here of stages of development of the testis, for its derivation from endoderm; unfortunately, however, the mesenteries were not sufficiently well preserved for a close histological investigation.

In the female organ the conditions were similar; the ova are irregularly scattered in the mesentery as larger or smaller grains; those of fair size project above the surface, while the largest of all stand out markedly beyond its plane, and are connected with the mesentery only by means of a fine pedicle. The pedicle passes into a chorion which surrounds the ovum on all sides, the latter being about 1 mm. in diameter. In this condition the ovum appears to be already in segmentation.

In the mesenteries occur, finally, external stomata; they are oval, about 0·5 cm. long, and occur rather to the outer side of the great mesenterial muscles, on a level with the wreath of tentacles. Whether also internal mesenterial stomata exist just below the oral lip, remains doubtful.

From the type of the true *Halcampæ*, this Actinian diverges in exhibiting a commencement of additional mesenterial cycles, although these are extremely weakly developed. The accessory mesenteries are small projections, which, in the upper part of the body alone, emerge from the angle between body-wall and oral disc; here there occur pairs of mesenteries both of the second and third orders, readily distinguishable by difference of size. Since, as we have seen above, the number of the tentacles also is larger than in the true *Halcampæ*, the genus *Halcampella* leads up to the remaining Ilyanthidæ, and through them to the true Actiniæ.

Halcampella, sp. (?)*

Habitat.—Shallow water; St. Vincent, Cape Verde Islands, July 1873.

To the genus *Halcampella* doubtless belongs another Ilyanthidan with numerous tentacles, although too much mutilated for close investigation or systematic determination. It is to be distinguished from *Halcampella maxima* at once, by the absence of incrustation on the body-wall.

II. PARACTINIÆ.

Family 10, SICYONIDÆ.

Genus *Sicyonis*, R. Hertwig.

Sicyonis elongata,* n. sp.

The animal is elongated, with about 54 tentacular papillæ; the genital mesenteries project into the cœlenteron from between the oral disc and the body-wall.

Habitat.—Station 244, June 28, 1875; 2900 fathoms. One specimen.

Dimensions.—Height, 7 cm.; breadth about 3·5 cm.; diameter of the pedal disc, 2 cm.

The sole specimen at my disposal was so strongly contracted that one could hardly find the entrance to the oral disc. The pedal disc was also exceedingly small, due partially, no doubt, to contraction. Had the specimen, which in other respects also was but poorly preserved, not been so compressed in the packing, it would have had the shape of a long sack sewn up at both ends.

The external appearance of the animal is therefore essentially different from that of *Sicyonis crassa*, the body of which is flattened like a cake; but in the internal structure there is considerable agreement between the two. The sphincter, the muscles of the tentacles and oral disc, the cuticular consistence of the mesoglœa, the differentiation of muscular and genital mesenteries, the enormous folding of the siphonoglyphes, the radial striation of the oral disc, the shape and arrangement of the tentacles, are in both cases identical. I was therefore inclined to regard it as a new specimen of *Sicyonis crassa*, had I not lighted on one distinguishing characteristic of great importance.

The genital mesenteries in *Sicyonis crassa* are thin lamellæ, which bear only the generative organs, and spring in the angle between pedal disc and body-wall; but in this new specimen the muscles are obvious, and are arranged in "muscle-pennons;" the most noteworthy point, however, is, that the genital mesenteries belong to the upper section of the body, lying in the angle between oral disc and body-wall; on the former they reach as far as the oral opening, and on the latter, in the form of slight folds, up to the pedal disc. Mesenterial filaments do not occur on them. Since the specimens of both *Sicyonis crassa* and *Sicyonis elongata* were males, the different position of the mesenteries cannot be due to the difference of sex.

Part of the animal was anatomically investigated with reference to the arrangement of the mesenteries, and part of the body-wall, with the mesenteries in the neighbourhood of the stomatodæum, was utilised for transverse sections. I was able to prove the normal arrangement of the mesenteries in pairs at some points; but at certain spots irregularities occur, owing to the alternation of isolated genital mesenteries with isolated complete ones. It is probable that, here and there, the one mesentery of a pair is formed, the other arrested. I was compelled to relinquish the determination of the number of the mesenteries, in order to spare the specimen. I counted, however, the number of tentacular papillæ, amounting to fifty-three; some of these, in the neighbourhood of the single siphonoglyphe, were very small. I infer from this that increase of the number of the tentacles was not yet concluded.

III. Edwardsiæ.

Family 11, Edwardsidæ.

Genus *Edwardsia*.

Edwardsia, sp. (?).*

Habitat.—Station 168, July 8, 1874; 1100 fathoms. One specimen.

The sole example of the genus *Edwardsia* which I met with in the Challenger material, and which came from a depth of 1100 fathoms, was so strongly contracted that the capitulum was concealed within the scapus, and in the posterior section was so completely crushed that it was difficult to detect the rounded hinder pole.

The surface is extraordinarily rough and bark-like, probably in consequence of an incrustation of mud on the cuticular layer; at the anterior end the entrance to the mouth is visible, and round it are eight radial furrows, which, owing to the indifferent preservation, could be followed only for a short distance upon the body-wall. The opening is slit-like; the wedge-shaped regions bounded by the furrows at the anterior pole are dissimilar in size, and are so arranged that the broadest is at one end of the slit, the smallest at the other, while the remaining six are symmetrically arranged right and left. At the posterior end of the animal, only seven of these furrows, which correspond to the mesenterial insertions, can be recognised.

I attempted to investigate the structure further by means of transverse sections, but was reluctantly forced to the conviction that nothing remained of the mesenteries and stomatodæum.

IV. Zoantheæ.

As the result of researches instituted by G. von Koch and myself, I have in my former Report separated from the hexamerous Actiniæ, the sharply marked group of the Zoantheæ, and have described as their representatives the genera *Sphenopus*, *Zoanthus*, and *Epizoanthus*.

I conceived it to be eminently inappropriate that such discordance should exist in the nomenclature of the individual species and genera of Zoantheæ, a discordance referable chiefly to the fact that the forms described had been quite insufficiently studied, and that consequently the systematic characters had been referred to points of secondary moment only. In this condition of affairs no alteration has been effected by the monograph of Angelo Andres; the great abundance of forms cannot be compressed, as he has attempted to compress them, into the three genera, *Zoanthus*, *Palythoa*, and *Sphenopus* (the genera *Verrillia*, *Bergia*, and *Antinedia* having but a doubtful position, so long as we possess such scanty information about them as at present).

I have therefore requested Dr. Erdmann, one of my students in Bonn, to undertake a revision of the Zoantheæ with reference to the following important anatomical characters :—(1) condition of the cœnenchyme ; (2) arrangement of the mesenteries ; (3) structure of the sphincter ; (4) condition of the integument ; (5) colony-formation. His conclusions are as follows :—The Zoantheæ may live solitary (Sphenopidæ), or may form colonies (Zoanthidæ) ; in the latter case the cœnenchyme may either consist of basal stolons more or less branching, sometimes even anastomosing, or of a connecting lamella, or of a mass which unites the polyps almost for their whole height. The integument either consists merely of an epithelium and cuticle, or else there occur on it foreign bodies, which penetrate the mesoglœa of the body-wall, and more or less fill it. In the arrangement of the mesenteries two points are of importance : (1) that the pairs of mesenteries, with the exception of the directives, consist of a macro- and a micro-mesentery ; (2) that a dorsal and a ventral zone of mesenteries must be distinguished. The two zones may approximate either with small (Microtype) or with large mesenteries (Macrotype). Finally, the sphincter exhibits three modes of formation ; it may be (1) endodermal ; (2) mesoglœal ; (3) it may be mesoglœal, but distinguished by a muscle-free region into upper and lower portions.

With reference to the points above mentioned, Erdmann has distinguished five genera in the colonial Zoanthidæ, the characteristics of which may be followed without further comment in the accompanying table :—

Genus.	Mesenterial arrangement.	Sphincter.	Cœnenchyme.	Integument.	Generative organs.
Zoanthus.	Microtypal.	Mesodermal, duplex.	Stolonar.	Soft.	Hermaphrodite.
Mammilifera.	Microtypal.	Mesodermal, simple.	Stolon-like, with a tendency to form lamellæ.	Soft.	(?)
Epizoanthus.	Macrotypal.	Mesodermal, simple.	Connective, lamellar.	Incrusted.	Diœcious.
Palythoa.	Macrotypal.	Endodermal.	Resembling a ribbon or tongue.	Incrusted.	Diœcious.
Corticifera.	Microtypal.	Mesodermal, simple.	Polyps sunk in the cœnenchyme to their upper ends.	Incrusted.	(?)

The material which I was able to place at Dr. Erdmann's disposal was derived partly from the Bonn Museum, partly from the Triton expedition, but chiefly from the Challenger collection. For the descriptions of the Challenger Zoantheæ I give here short extracts from his Memoir,[1] for the accuracy of which I can vouch, as the whole investigation was carried out under my direction. I have achieved, what he omitted, in identifying as far as possible the forms obtained with species previously described, and, where that was impossible, have introduced new names, and have reduced the diagnoses of species to shorter and more precise terms.

Family 12, ZOANTHIDÆ.

Genus *Zoanthus*, Cuvier (*pro parte*).

Integument not incrusted; cœnenchyme stolonar, with an occasional tendency to lamellar extension; sphincter differentiated into upper and lower sections; mesenteries arranged on the microtype.

Zoanthus danæ (?), Le Conte (Pl. I. fig. 1).

Polyps with fleshy body-wall, the larger borne on a stalk-like extension, and arranged closely together on reticulately branching stolons; approximately fifty tentacles arranged in two cycles.

Habitat.—Bermuda Islands; shallow water.

Dimensions.—Of the individual polyps—height, 0·5–2·5 cm.; breadth, 0·3–0·5 cm.

This animal, which I refer with considerable reserve to *Zoanthus danæ*, is identical with the *Zoanthus* which I have already described. To that description I can add the following points, based on Erdmann's researches:—

1. The colony grows on a foundation of rock in such a manner that the upper ends of all the polyps lie in the same plane. As the foundation is irregular, the individual polyps must be of unequal lengths, a result of which is that those animals which correspond to hollows in the foundation are produced posteriorly into a kind of stalk, distinguished from the body proper by a constriction, and by the thinner consistence of the body-wall.

2. A peculiar attachment of the cuticle to the body-wall, and one perhaps more widely distributed among the Zoantheæ, is effected by mesoglœal processes which perforate the epithelium and are inserted on the cuticle.

3. The colony investigated by Erdmann was sexually mature; ova and testicular follicles occurred in the same mesentery.

[1] Erdmann, Ueber einige neue Zoantheen. Ein Beitrag zur anatomischen und systematischen Kenntniss der Actinien, *Jenaische Zeitschr.*, Bd. xix. pp. 430–488, pls. iv. v.

*Zoanthus confertus,** Verrill (Pl. I. fig. 12).

Polyps with thin transparent body-wall, so closely packed as to be polygonally flattened.

Habitat.—Simon's Bay, Cape of Good Hope; 10–20 fathoms.

Dimensions.—Of the individual polyps—height, 0·6–0·8 cm.; breadth, 0·3–0·4 cm.

The species is in general structure very close to the preceding, but differs in the thin consistence of the body-wall, through which may be seen the mesenteries, and in the compact arrangement of the polyps. The latter being consequently compressed polyhedrally, a character of importance is afforded for the species, which is further marked off by the transparence and delicacy of the body-wall.

Genus *Epizoanthus*, Verrill.

Integument incrusted, cœnenchyme (mostly?) lamellar; sphincter simple, mesoglœal; mesenteries arranged on the macrotype; colonies (mainly?) parasitic.

*Epizoanthus thalamophilus,** n. sp. (Pl. I. fig. 3; Pl. IV. figs. 7, 8).

Incrustation scanty, exclusively composed of Foraminiferal shells, which are arranged on the individual polyps into 15–20 longitudinal rows, bifurcating downwards; body-wall transparent; tentacles 30–40, very long, and arranged in two rows.

Habitat.—Station 299, December 14, 1875; 2160 fathoms; on Gastropod shells.

Dimensions.—Height of the contracted individuals, 0·2–1·3 cm.; diameter at the base, 0·9–1·5 cm.

"The colony of seventeen individuals has settled on a deserted *Fusus* shell about 8 cm. long. The polyps are principally situated on the back of the shell, and only the five young individuals at its apex are arranged in a whorl round it. The region round the aperture of the shell is free from polyps; they rise with elliptical bases from a common cœnenchyme, and arch upwards like a dome. The largest specimens have a base of 10–15 mm. in diameter, and are 13 mm. high; but we find every transition to the smallest specimens, which appear as flat elongated projections with a base of 5–9 mm., and a height of 1·5–3 mm. The cœnenchyme is a continuous sheet, 0·3–0·5 mm. in thickness, which covers the shell as far as the colony reaches. Towards its termination it becomes constantly thinner and more transparent, till it ends as a very delicate pellicle, which may be easily rubbed off. All the polyps were in a highly contracted condition; and at the dome-shaped summit lies, on a prominence which is bounded by a circular furrow, the entrance to the interior; it is hardly recognisable as an opening, and is formed by the indrawn parts of the body-wall. The latter is of slight thickness, so that the mesenteries may be seen through it as clear stripes. In the external zone of its mesoglœa lie the deposits above mentioned, consisting exclusively of Foraminiferal skeletons. They are evenly distributed over the cœnenchyme; but on the body-wall are ranged in a most regular and elegant manner, the following facts being recognisable with the aid of a lens. From the apex outwards run, in a well-grown individual, fifteen to twenty looping rows of Foraminifera in clear elevated lines. Where the body-wall bends downwards at right angles, each row bifurcates, and each branch so produced runs downwards on the body-wall in a straight line; a single row of Foraminifera is thus situated over each mesentery, the insertion of the latter being externally clearly recognisable, owing to the thinness of the wall. While therefore, from the apex of the polyp outwards, the ridges agree in number with the pairs of mesenteries, in the lower part of the body-wall there are present as many rows of shells as there are individual mesenteries. Towards the base these become less plain, so that at the lowest part of the polyps, as on the cœnenchyme, the Foraminiferal coating is evenly distributed all over" (Erdmann). The rows of shells are continued on to that region of the body-wall which has been drawn inwards; and their arrangement can here be only understood by referring to the point of transition from body-wall into oral disc. This occurs along an undulating curve, since at one point the oral disc with its outer circlet of tentacles, at another the body-wall with its rows of shells, projects the farthest. A horizontal section therefore, through the region under discussion, meets alternately with rows of Foraminifera and the origins of tentacles (Pl. IV. fig. 8). Further, at the point of junction, the body-wall forms a strongly projecting fold in which lies the greater part of the sphincter (Pl. IV. fig. 7). The horizontal section represented in fig. 8 exhibits this fold on the inner side, while on the outer lie the body-wall and oral disc, united by mesenteries.

The fold of the body-wall bears, on both sides, rows of Foraminiferal shells, supported on ridge-like processes of the body-wall, and appearing therefore in transverse section as coronets; they are, as we learn from longitudinal sections, discontinuous at the free edge of the fold, so that the outer and inner rows of shells do not pass into each other.

The sphincter embedded in the fold of the body-wall is mesoglœal and simple, and forms here an evenly distributed complex mass of muscle-bundles, the latter being variously shaped. It also overlaps a small strip of that region of the body-wall which is not drawn inwards.

The tentacles are, as in other cases, in two alternating circlets, and are in part produced into long pointed filaments, in part contracted into short stumps. Their muscles are ectodermal and slightly pleated; the mesoglœal supporting lamina lying at the base of the pleats sends processes into the epithelium.

The stomatodæum is oval, and the siphonoglyphe only slightly expressed.

The number of mesenteries varied in the three specimens investigated between twenty-eight and thirty-six, according to their size. The dorsal and ventral zones of mesenteries approximate always with macromesenteries.

No channel filled with cells is present at the bases of the mesenteries; the muscle-pennons indistinct; the generative organs so abundantly developed as to fill the greater part of the cœlenteron. These latter occur only on the macromesenteries, and consisted of testicular follicles in the three specimens studied.

The cœnenchyme is extremely thin, and possesses internally smooth connecting-tubes lined by endoderm; on the upper surface Foraminiferal shells are sparsely embedded; while on the other side, which covers the Gastropod shell, these are entirely absent.

The name *thalamophilus* was chosen with reference to Thalamophora and Polythalamia, names which have been applied to the Foraminifera.

Epizoanthus stellaris,* n. sp. (Pl. I. fig. 4).

"Polyps of inconsiderable height, nearly saucer-shaped; body-wall vertical at the sides, but strongly flattened above; on its horizontal upper surface are numerous radial ridges, separated by furrows, 15–20 in the adult animal; colour of the colony dark greyish-brown; deposits very various."

Habitat.—Station 201, off Samboangan, Philippine Islands; 82 fathoms.

Dimensions.—Of the individual polyps—height, 0·05–0·4 cm.; diameter, 0·15–0·7 cm.

"Of this species I possess a colony, covering the rooting spicules of a *Hyalonema* for a distance of about 14 cm., and consisting of about 100 individuals. The cœnenchyme forms a tube open at both ends, and surrounds like a sheath the bundle of spicules, the latter being about 5 mm. thick. The individuals spring from it at longer or shorter intervals by an elliptical base, measuring in the largest polyps (3–4 mm. high) about 5–7 mm. in diameter. From these to the smallest, which hardly project above the cœnenchyme, and are 1·5–3 mm. broad, by 0·5–1 mm. high, every transition is found. All the animals are strongly contracted; on the strongly flattened, discoidal, horizontal surface of the body-wall may be dimly seen the entrance to the interior by a circular pit. From this point outwards radiate over the surface of an adult specimen, about 15–20 ridges separated by furrows.

"The colour of the colony is a dirty dark-grey. The body-wall is of considerable thickness, caused by the strongly developed mesoglœa. The exterior surface of the latter is charged with various deposits, consisting of irregular grains of sand and lime, sponge spicules of very varied origin, and finally of the small dark crystalline bodies which cause the dark tint of the colony. These deposits occur in additional quantity on the radial ridges before mentioned. They are continued inwards as elevated ridges over the edge of the covering fold without a break, and run even further, on the inner face of the indrawn part of the body-wall. Sections through the upper region of the polyp yield appearances similar to those described under the preceding species, though, owing to the abundant and various deposits enclosed, they are not so regular and elegant.

"In those inner parts of the mesoglœa which are free from adventitious accretions there lie embedded in the homogeneous matrix—1. fine radial fibres, penetrating the whole thickness of the soft mesoglœa, provided here and there with nuclei; 2. round mesoglœa-cells containing a large nucleus; 3. round or oval spaces packed with cells. Hertwig, who has observed similar structures in the *Epizoanthus parasiticus* described by him, conjectures that these oval cell-islets are produced only by indifferent preservation, and result from the breaking down of a system of anastomosing cords, such as the mesoglœa of *Zoanthus* exhibits. I [Erdmann] am inclined to regard these roundish heaps of cells as primary structures, like the canals of *Zoanthus*, since I have been able to recognise them in almost all my species of *Epizoanthus*, which were without exception in a very good state of preservation. As to their origin I have no data; but there is no reason why they should not be referred to an ectodermal origin as well as the cell-canals of *Zoanthus*, the derivation of which from ectoderm is indisputable; besides, many of these cell-islets clearly exhibit an elongate outline, with here and there even a slight tendency to branch, by which an external approximation to *Zoanthus* is effected.

"The mesoglœa of the mesentery is well developed, and on its inner edge is thickened like a club. The micromesenteries project only slightly into the interior, but, like the macromesenteries, clearly present marked muscle-pennons. On these mesenteries there springs on the side opposite to the muscle-pennons a mesoglœal lamella, which is considerably elongated in order to carry the generative organs and to form, centrally to these, the mesenterial filaments. The former are present in considerable numbers; and, being cut more or less superficially owing to the contorted course of the mesentery, may be recognised in transverse section as roundish balls enveloped in a thin mesoglœal lamella, pressed against the body-wall and generally filling the adjacent chamber. All the specimens which I investigated were female, the generative balls consisting of a large number of ova closely appressed together, but separated by a fine mesoglœa lamina.

"The body-wall is deeply drawn inwards, and conceals in this region a strongly built sphincter, which has the shape described for the preceding species, but which is distinguished by a greater complication in the branching of the bundles of fibrillæ.

"The stomatodæum is oval, with a clearly defined siphonoglyphe. The ensheathing cœnenchyme measures 1–1·3 mm. in thickness; in its interior run longitudinally numerous connecting tubes. The mesoglœa carries on its surface foreign deposits of the same character and quantity as those on the body-wall, but the inner face, which lies on the foundation, is completely free from incrustation. The soft mesoglœa of the cœnenchyme is, with reference to histological differentiation, in the same relation to the body-wall as it is in *Zoanthus*, since here also, in addition to the other points of marked agreement, the nucleated fibres are supplanted by mesoglœal cells.

"With a view to observing the mesenterial arrangement, I studied two examples, one of medium size, and one fully grown; both exhibit the regular macrotype. In the younger specimen occurred a symmetrical arrangement of the pairs of mesenteries; of these there were sixteen, seven being regularly distributed on each side of the directives. The other polyp possessed nineteen pairs, of which nine were situated on the one side, and eight on the other."

Epizoanthus elongatus,* n. sp. (Pl. I. fig. 2).

"The individual polyps form elongated cylindrical tubes, the body-wall is flattened above, with a marked indentation, but terminates without radial furrows; colour of the colony a yellowish-grey."

Habitat.—Station 322, off Monte Video; February 26, 1876; 21 fathoms.

Dimensions.—Height of the polyps, 0·05–1·0 cm.; breadth, 0·15–0·4 cm.

"This species can only be externally distinguished from the preceding. The colony is 10 cm. high, consisting of about 100 individuals, and lives on a bundle of the siliceous threads of a *Hyalonema*, about 3 mm. only in thickness. The largest polyps are long cylindrical tubes, about 8–10 mm. high and 3–4 mm. broad; in their neighbourhood occur gradations to the youngest buds, which are small warts projecting from the cœnenchyme, of 0·5–2 mm. in height, 1·5–2·5 mm. in breadth. All the animals are in a state of the most marked contraction; the horizontal upper surface of the body-wall is more or less flattened, and exhibits a circular indentation. This part of the body-wall is entirely free from radial ridges and furrows. The colour of the colony is a greyish-yellow.

"The body-wall is thinner than in the preceding species, and possesses in its outer zone the same deposits, though in smaller quantity. The remaining anatomical and histological relations agree closely with those of the former species, but it is important to observe that the sphincter is less strongly developed. The body-wall is drawn inwards less deeply; its sphincter is in transverse section correspondingly short, but curved, and pointed at both ends. The generative organs consisted of ova in the five specimens investigated."

Epizoanthus cancrisocius,* Studer (Pl. I. fig. 15).

Colony much incrusted, and consequently so brittle as to break readily in pieces; individual polyps slim, body-wall at the upper end bent outwards in the contracted condition into a plate-like expansion, from the indented centre of which run 15–20 furrows towards the thickened edge.

Habitat.—Station 49, May 20, 1873; 85 fathoms, upon a Gastropod shell tenanted by a *Pagurus*, the shell entirely dissolved away by the cœnenchyme.

Dimensions.—Length of the polyp, 0·6–1·0 cm.; breadth, 0·3–0·5 cm.; colour, greyish-yellow.

"This species forms a colony of eleven individuals, on a shell some 2·0 cm. high. The calcareous substance of the latter is completely absorbed, and at all points replaced by the cœnenchyme, the latter having obviously taken its place, while preserving its external form. Only the anterior side of this cœnenchymatous structure, *i.e.* the part directed forwards in movement of the Crustacean, possesses polyps; the free posterior side allows the coils of the former Gastropod shell to be clearly recognised. Of the eleven individuals, eight large mature polyps occupy the edge of that side which is directed anteriorly in the movement of the crab. They form long cylindrical tubes, 6–10 mm. high and 3–5 mm. broad. In the median space which they bound, stand three very young polyps, projecting as vertical cylindrical warts from the cœnenchyme, with height and breadth alike of 1·5–2 mm. One may remark that the large polyps bend forwards, *i.e.* their oral discs face upwards, in the direction corresponding to the locomotion of the *Pagurus*, so that they are most favourably placed for the reception of the food matters which stream against them. Owing to the curving just mentioned, the large polyps are above strongly compressed laterally.

"The whole colony has a rough shagreen-like exterior, of a grey colour. The otherwise smooth body-wall forms above a horizontal plate, which not only projects like the capital of a column over the vertical part, but has also a characteristic sculpture, and the appearance of a plate with raised edges and indented centre; in the middle of the latter lies the entrance to the interior, which is slit-like, corresponds to the lateral compression, and is always recognisable as an obvious opening. From this median point outwards radiate over the plate-like surface 15–20 radial furrows, which are continued outwards for a short distance over the marginal thickening, appearing on it as deep notches.

"When a polyp is opened with scissors, one remarks that the mesenteries run down the whole length of the body-wall, but do not pass over on to the horizontal floor of the cœlenteron. In the lowest parts of the polyp, the mesenteries are visible as slightly projecting ridges, striking the eye by their clear colouring; at about one-fourth of the total height, the macromesenteries form filaments; these are yellowish-white contorted coils, which completely obscure the micromesenteries. One can without damage remove the mesenteries from the body-wall, and study them independently. The supporting lamina of the mesenteries is very thin, and runs simply to the base without any excavation; the mesenterial filaments are of the customary structure. I have been unable to detect generative organs in any specimen investigated.

"Owing to the abundant incrustation, the body-wall becomes as hard and brittle as stone, and does not permit therefore of investigation by means of sections. In this case therefore, and in the remaining forms with similarly strong incrustation, I made use of the method of grinding tested and recommended by G. v. Koch in his researches on *Tubipora*.

"The body-wall is of considerable thickness; its mesoglœa exhibits a structure very different from the remaining species of *Epizoanthus*, as being penetrated by deposits throughout its whole depth. These deposits consist of particles of sand with irregular angles, and are set in a strong circular fence, reducing the mesoglœa to thin lamellæ; but there persists a very narrow internal lamella bounding the endoderm all round. In the homogeneous mesoglœa-lamellæ are situated roundish cells which give off fine radiating processes, and fine fibres provided with nuclei; the presence of the cell-heaps, which are to be met with in the remaining species of *Epizoanthus*, I was unable to demonstrate in this case. A transverse section through the wall of the shell exhibits a similar condition in the cœnenchyme. This latter is also of considerable thickness, and is internally traversed by the large endodermal tubes which connect the various cœlentera together.

"The body-wall is, as has been already mentioned, bent above at a sharp angle, thus forming a plate-like surface. In contrast to the remaining members of the genus, where it turns deeply inwards vertically, it is here only slightly invaginated, a difference resulting from the slighter development of the sphincter. The latter commences to a certain extent on the horizontal part of the body-wall, and then thickens gradually into a truncated muscular mass, which appears fusiform in section, and is only slightly curved inwards. It lies enclosed in the innermost lamella of mesoglœa; the latter is thus much thickened, and is free from adventitious deposits. The sphincter is on both sides bounded by a layer of mesoglœa, which extends inwards to the commencement of the oral disc, is charged with the usual accretions, and is a direct continuation of the outer sandy layer."

So much for the anatomical description given by Erdmann, which sufficiently proves that *Epizoanthus cancrisocius* must be separated systematically from *Epizoanthus parasiticus*, the latter possessing larger and coarser polyps and far less incrustation. I have identified the animal with the *Epizoanthus cancrisocius* of Studer, as he records for his specimens similar dimensions, and a marked incrustation, at least for the basal membrane.[1] In other points his description is not sufficiently exhaustive, and this is still more true of Gray's account.[2] Only the statement of the latter that the large

[1] *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1878, p. 547.
[2] *Proc. Zool. Soc. Lond.* 1867, p. 237.

polyps break up easily, and the reference to a figure of Gosse's which recalls our *Epizoanthus cancrisocius*, make it probable that his *Epizoanthus papillosus* and the *Epizoanthus cancrisocius* are identical.

Erdmann refers it in his Memoir to the expedition of H.M.S. "Triton." I find, however, his specimen in a bottle from the Challenger collection, with the label given above; some mistake must therefore have occurred in his manuscript.

Genus *Corticifera*, Lesueur.

Cœnenchyme extending from the base upwards between the individual polyps, and uniting them together almost as far as the upper edge of the body-wall; integument incrusted; sphincter mesoglœal; mesenteries arranged on the microtype.

On the above diagnosis I may remark that, on the body-wall of each polyp may be distinguished two regions, the one surrounded by cœnenchyme, the other projecting freely above it. When the animal contracts, the latter is drawn inwards to the level of the cœnenchyme as in Madreporaria; it partly serves to close over the anterior end, and partly is invaginated inwards. A colony in contraction consequently forms a crust-like covering, in which the individuals are only indistinctly marked off from each other.

Corticifera lutea,* Quoy and Gaimard (Pl. I. fig. 6).

Individual polyps marked off by fairly obvious stripes on the cœnenchyme, and recognisable as annular ridges on the common surface of the colony; they differ but little from each other in size.

Habitat.—Bermuda, June 1873; shallow water.

Dimensions.—Height, 1 cm.; breadth, 0·4–0·5 cm.; colour, yellowish-white.

"The colony at my disposal consists of a flat, quadrangular, crust-like structure, about 16 cm. long and 7 cm. broad. It does not present a complete whole, but is merely a piece torn off from a larger mass, carrying about 400 individuals; the latter reach a height of 10–15 mm., and are in diameter 4–5 mm. It must be insisted that this external height of the polyps in no way corresponds to the internal, since the cœnenchyme forms on the under side so thick an investment that of the total height only about two-thirds belong to the cœlenteron, the other third to the cœnenchymatous layer beneath. All the individuals are strongly contracted, and the body-wall is drawn deeply inwards. The edge of the body-wall projects above the general surface as an annular depressed ridge, in the centre of which lies, always clearly open, the aperture to the interior. At the unmutilated edge the individuals stand out as slight swellings.

"In that part of the cœnenchyme which borders on the ectoderm, are present numerous accretions, producing a firm pellicle. The main bulk of the incrustation consists of irregularly-shaped calcareous bodies; besides these, occur more sparingly

Foraminiferal and Radiolarian skeletons, and finally, numerous Sponge-spicules of various kinds. In the cœnenchyme between the polyps, the accretions are present only in small quantity, and fill here simple scattered cavities, which may be recognised after decalcification as wide lacunæ. The rest of the cœnenchyme is soft; and in its homogeneous matrix we meet with large canals, lined by pigmented epithelium and traversing the cœnenchyme in every direction; they are especially numerous in the lower cœnenchymatous investment, which consequently presents a reticulate spongy texture. As appears from longitudinal sections, these canals are direct continuations of the cœlenteron from the base of the polyp outwards, and extend from this point upwards through the whole of the cœnenchyme; they may consequently be homologised with the endodermal connecting tubes to be found in all Zoanthidæ. The mesoglœa of the cœnenchyme exhibits also numerous roundish cell-islets lined by epithelium, in which we may perceive the origin of such ectodermal cell-heaps as have been described for *Epizoanthus*. The whole of the endodermal epithelium is pigmented by dark granules, as are also the large endodermal connecting-tubes. On the other hand, the roundish cell-aggregations just mentioned are free from pigment granules; this difference of condition affords an indirect proof that the latter are by no means of endodermal origin, but are purely ectodermal structures. Finally, the soft cœnenchyme exhibits fine nucleated fibres starting from the endoderm, and, as is usual, numerous mesoglœal cells provided with fine processes.

"The main bulk of the whole colony is to be regarded as cœnenchyme; the individual polyps consist merely of a mesoglœal cylinder lined internally by endoderm, of moderate thickness and homogeneous consistence. The supporting lamina of the mesenteries is of similarly weak development. Below, the latter enclose a canal filled with cells, which in the case of the macromesenteries is frequently divided up by cross anastomoses. The muscle-pennons are well developed, and appear, especially in the larger mesenteries, as branching processes, which extend over a wide stretch of the mesentery. Nothing of interest can be said about the mesenterial filaments. In none of the specimens investigated could I find generative organs. The stomatodæum is pear-shaped in section, with a well-marked siphonoglyphe."

The sphincter is mesodermal, simple, and only slightly developed. It begins early, as a narrow strip, in that part of the body-wall which is drawn horizontally inwards, and extends without any thickening to the edge of the invaginated part. The number of the mesenteries, which are arranged on the microtype, varied in five individuals between thirty-four and forty.

Corticifera tuberculosa,* Klunzinger (Pl. I. fig. 5).

Individuals closely appressed together and flattened polygonally, generally separated by a deep furrow, and of very dissimilar sizes, so that the surface of the contracted colony appears to be irregularly covered with knobs. These knobs exhibit radial furrows which run outwards from the indistinct opening.

Habitat.—Simon's Bay, Cape of Good Hope; 10–20 fathoms.

Dimensions.—0·6–0·8 cm. in height; diameter, 0·2–0·5 cm.

Colour.—Brownish.

The small colony of about forty individuals differs essentially from the above described *Corticifera lutea* in its external appearance. From the small development of cœnenchyme, it results that the individual polyps press closely on one another, and frequently become polyhedrally, generally hexagonally, flattened. They are separated by deep grooves on the surface, which, at few points only, become shallower or disappear altogether. The absence of the groove between two polyps possibly signifies a genetic dependence, the one having arisen by gemmation from the other; and smaller individuals are frequently adjunct to the larger polyps in this fashion.

The individuals of the colony are of most varying size; from the large dome-shaped convex animals with a diameter of 0·6 mm. those of intermediate size lead to the smaller, which measure only 0·1 mm. in the one direction and 0·2 mm. in the other. Since the surface therefore exhibits smaller and larger knobs, I refer the species to the *Palythoa tuberculosa* of Klunzinger, and have therefore retained the well-chosen specific name.

In length there is but little difference between the larger and smaller animals, the former measuring 0·6 cm., the latter 0·4 cm. As they all diminish downwards in a wedge-shape, the lower side of the colony is so much narrower that the polyps on the edge are nearly horizontal.

All the polyps are so strongly contracted that the entrance to the interior is recognisable only as an indistinct indentation, from which radiate outwards numerous shallow furrows.

With reference to the finer anatomy, what has been said for *Corticifera lutea* holds good in this species. In the two specimens investigated there were respectively thirty-four and thirty-six mesenteries, which followed the microtype.

Genus *Palythoa*, Lamouroux.

Integument strongly incrusted; cœnenchyme little developed, ribbon- or tongue-like; mesenterial arrangement on the macrotype; sphincter endodermal.

Palythoa anguicoma,* Norman (Pl. I. fig. 7).

Incrustation superficial, so that a thick layer of mesoglœa remains free of deposit; cœnenchyme tongue-shaped; individuals, when in a contracted condition, long, with a terminal capitular enlargement, on which run 15–20 radial furrows.

Habitat.—Station 135A, off Inaccessible Island; October 16, 1873; 60–90 fathoms; hard ground, shells, and gravel.

Dimensions.—Height of the polyps, 0·4–0·8 cm.; breadth, 0·2–0·4 cm.

Colour.—Brownish-yellow.

"From the material at my disposal, which appears to have been carelessly detached, the general form of the present species cannot with certainty be inferred. The greater part of it consists of single individuals, in which one can recognise the forcible detachment from the colony. One group, which to all appearance represents a complete and intact colony, is composed of four individuals; they are situated, in a row and at short intervals, on a thin cœnenchyme which is extended like a ribbon; their dimensions are 4–8 mm. high by 2·5–4 mm. broad. All the polyps are strongly contracted; the body-wall forms above, in this condition, an obliquely-angled ridge projecting outwards; its upper surface presents an elevation, rendered obvious by a circular furrow, in the centre of which the aperture to the interior is recognisable. From the middle of this upper surface radiate outwards 15–20 furrows, which are continued over the projecting ridge on to the vertical body-wall, where they then flatten out. The colour of the polyps is a dirty yellow.

"The integument is furnished with accretions, and exhibits a rough shagreen-like exterior. On rubbing away the thin sandy layer, there remains the thinner soft part of the mesoglœa, which is excellently fitted for the preparation of longitudinal and transverse sections with a razor.

"The soft mesoglœa is of considerable thickness, and consists of a homogeneous matrix, in which come into view the large number of cavities charged with cells. These may be simple, *i.e.* preserve their roundish or elliptical outline, or, as in most cases, may branch to form a system of anastomosing canals which entirely recall *Zoanthus.* Below the endoderm such a canal runs in an almost unbroken ring through the whole of the body-wall; it lies so close under the epithelium as to be separated from it only by a narrow lamella of homogeneous matrix. Its diameter is not constant throughout its whole circuit, but is frequently constricted, and occasionally such constriction produces an actual discontinuity. It is further of importance that the canal invariably presents a considerable hollow expansion under each mesenterial insertion. At many points can be demonstrated a communication between the smaller branching cell-canals and this large ring-canal, the latter being at such places apparently expanded into a kind of funnel. Further, there are found in the mesoglœa numerous mesoglœal cells, giving off fine processes; and, finally, delicate nucleated fibres, the course of which, however, is here not radial, but in the main circular.

"The structure of the cœnenchyme agrees in all respects with that of the body-wall, except for the fact that it possesses endodermal connecting tubes.

"The mesoglœa of the mesenteries is strongly constructed, and on it can be recognised well-developed muscle-pennons. The generative organs, borne in the supporting lamina, consisted of ova in the individual which I investigated. The mesenterial filaments are of the customary structure.

"The mesenterial arrangement is to be referred to the macrotype. The specimen investigated possessed thirty-six mesenteries, of which five pairs pertained to the dorsal zone, and thirteen pairs to the ventral; in the latter zone were ranged regularly, on each side of the directives, six pairs, consisting of a macro- and a micro-mesentery.

"The body-wall is drawn inwards at a right angle; on the inner side of this region a definite endodermal sphincter may be recognised. The pleatings of the endodermal muscle-lamina are more clearly marked than in *Palythoa axinellæ;* and produce on the mesoglœa prominent antler-like prongs. The accretions are continued on to the indrawn region of the body-wall, but die out at its lower edge, where the oral disc commences."

The identity of this animal with *Palythoa anguicoma* is doubtful, as Norman, who created the species, gave no figure of it. I was influenced by the circumstance that eighteen rough radial furrows are ascribed to this form; besides which the incrustation on it should be only superficial.

Palythoa, sp. (?)*

Habitat.—(*a*) Station 135 A, off Inaccessible Island, October 16, 1873; 60–90 fathoms. (*b*) Station 135 C, off Nightingale Island, October 17, 1873; 100–150 fathoms.

In the same bottle with *Palythoa anguicoma* was another species of *Palythoa*, which recurred in a second tube, the contents of which were dredged a day later than the first, and at a greater depth. The specimens in question could easily be distinguished from individuals of *Palythoa anguicoma* by containing black particles of hornblende. Erdmann attempts to separate the two species, and gives the following description:—

"In this species also the larger part of the material consists of individuals torn away from the colony; one colony, which was undoubtedly not mutilated, was represented by three individuals, ranged behind one another on a ribbon-like cœnenchyme. Externally this species differs from the preceding in colour only, which is in this case a dull grey-brown; besides this, from the greater firmness and unevenness of the body-wall, it may be recognised that the mass of accretions is greater. The body-wall presents, in contrast to the former species in which the relations are reversed, a considerable zone charged with accretions, opposed to a slightly-developed soft zone of mesoglœa. In the latter there passes close under the endoderm a cell-canal, frequently constricted, but rarely interrupted; external to this follow immediately the accessory deposits, so that of the numerous canals and spaces observed in the preceding species only a few roundish cell-islets are preserved."

Palythoa (?) sp. (?)*

Habitat.—Station 299, west of Valparaiso, December 14, 1875; 2160 fathoms.

I found a small Actinia, labelled "Actinia on nodule," which had settled on a piece of pumice near an Ascidian. The animal, being incrusted with sand particles, probably belongs to the *Palythoæ*, but its minuteness and the sandy incrustation forbade a detailed study. The body, not so much as 1 mm. high, was flattened into a disc 5 mm. broad. The number of mesenteries which, as in the Zoantheæ, were very regularly arranged, amounted to thirty-two.

Family 13, SPHENOPIDÆ.

Genus *Sphenopus*, Steenstrup.

Sphenopus pedunculatus,* n. sp. (Pl. I. fig. 11).

Body marked off into an upper swollen trunk, an elongate narrow foot, and a broad sole-like (?) "clasping-disc;" from the apex run, over the upper part of the trunk, about 10–12 indistinct rough furrows.

Habitat.—Station 203, off Panay, Philippine Islands, October 31, 1874; 12–20 fathoms. Three specimens.

Dimensions.—Length, 2·4–3·2 cm.; breadth, 2–2·4 cm.

Colour.—Grey.

"This species differs in many respects from the already known *Sphenopus marsupialis* (Steenstr.) and *Sphenopus arenaceus* (Hertw.). The fully-grown animal permits of an external differentiation into three regions. The most obvious part of such a polyp is formed by the upper bladder-like 'body' (Pl. I. fig. 11), which conceals within itself the organs of nutrition and reproduction. On it is marked off, by a more or less obvious cross-furrow, a hood-shaped anterior region, sculptured by coarse radial furrows. The body passes into a long narrow 'foot,' from which it is sharply defined by a marked furrow, and finally the foot broadens out at its base into a kind of 'clasping-disc.' The three animals of this species which were at my disposal represented stages of different age. In the oldest individual the bladder-like body has been irregularly contracted by preservation in spirit, its exterior is folded, and exhibits besides a lateral compression. The head region, defined by an obvious constriction, is strongly tuberculate, and marked by twelve coarse radial elevations, separated by discontinuous and incomplete furrows. The height of the body amounts to 2·5 cm., its greatest width to 2·4 cm. Sharply marked off from it by a circular furrow is the cylindrical foot, the diameter of which reaches 1·2 cm. Unfortunately this latter has been broken away, so that I can give no accurate information either about the total length, or about the clasping-disc of this animal. The second polyp was of medium age; its total length amounted to 3·2 cm., of which 2·0 cm. belong to the body, and 1·2 cm. to the foot. The former is on one side crushed inwards about the middle, where it is of the greatest diameter (2 cm.), while on the other it is as strongly swollen out. Above, it diminishes gradually into the head region, which is indistinctly furrowed radially; and below, equally gradually, into the foot. The latter is cylindrical, and has a diameter of 0·5 cm., while the sole-like clasping-disc has at its base a breadth of 0·9 cm. The third and still younger polyp consists mainly of the 'body,' which above is flat and discoidal, without differentiation of a head-region, but is at the periphery pressed into folds; its height is 2·4 cm., its breadth 2·0 cm. Below it passes gradually into the foot, which is rudimentary, round, only a few millimetres high, and ends without a clasping-disc.

"For investigation I made use of the middle specimen, which was completely preserved. A longitudinal section dividing the polyp into two halves yielded the following results. The mesenteries run in the foot as clear narrow ridges on the body-wall, scarcely projecting into the interior; they extend also on to the horizontal pedal disc, and appear in this region as radiating lamellæ, which meet at the centre of the flat base. The filaments first appear on the mesenteries at the point of transition into the broader 'body;' they form a thick investment, which nearly fills the whole cœlenteron and covers the mesenteries completely. The body-wall is fairly thick, and even with the naked eye can be distinguished into two layers; an outer, which appears granular owing to the accretions, and an inner, which is soft, shining, and free from deposits. It is further noticeable, that the quantitative relations between the incrusted and the softer layers vary with the height of the part in question, and in such a manner that, at the upper part of the body, both parts are about equally strongly developed, while with increasing depth the harder constituents become more numerous, till at last, in the foot, a complete obliteration of the softer zone is produced. Above, the body-wall is drawn rather deeply inwards at a sharp angle. On to this infolded region the accretions are uninterruptedly continued as far as the point of origin of the oral disc, the latter being inserted just at the inner edge of the fold. The stomatodæum reaches far downwards, and is characterised by a siphonoglyphe of considerable depth.

"A transverse section in the region of the stomatodæum allows the mesenterial arrangement to be recognised even by the naked eye. The longitudinal section having been carried midway between two mesenteries on both sides, they were completely intact, and the combination of the two sectional halves yielded a complete picture of the mesenterial arrangement, which falls under the microtype. Sixty mesenteries in all are present; of these, after deduction of the regularly formed dorsal pairs, there fall into the ventral zone on each side of the directive macromesenteries, twelve pairs, consisting each of a macro- and a micro-mesentery.

"For a study of the anatomical relations in more detail, I made use of von Koch's method of grinding. The integument is composed, as was stated above, of an internal softer zone, and an external zone penetrated by accessory deposits. The latter consist mainly of clear angular fragments of sand; but there occur also various indeterminable mineral splinters of different colours, and finally, more sparingly, Sponge-spicules and Foraminiferal shells. All these particles lie confusedly mingled, and so closely together as to form a stout external rind; between them they allow of only thin mesoglœa-lamellæ, in which are embedded fine nucleated fibres, as well as a few stellate mesoglœal cells. The zone of mesoglœa, which is soft and free from deposits, consists of a homogeneous matrix, in which sharply circumscribed lenticular cell-islets are embedded in large numbers and of various sizes. They are especially plentiful in the neighbourhood of the endoderm; but, in passing outwards, every gradation of size, up to fine fusiform structures, is met with. The plane of the long axis of these cell-islets is always circumferential. The nucleated fibres are extremely abundant in the mesoglœa; they extend from the endoderm outwards, their course being sometimes straight, but more generally undulating, with close coils almost like a cork-screw. Besides the contents already mentioned, one observes also the existence of stellate mesoglœal cells, which are sparsely scattered and emit fine processes into the homogeneous matrix.

"The supporting lamina of the mesentery is well developed, and presents an antler-like muscle-pennon. At its base passes a canal, filled with cells, and penetrating the mesenteries for their whole length; in transverse sections through the micromesenteries this appears simple and cylindrical, but forms on the macromesenteries a longer cavity divided up by cross anastomoses. This quite subordinate character accompanies the microtype through all the genera, however different both externally and anatomically; no macrotypal form showing even a trace of this mesenterial canal.

"The sphincter of *Sphenopus* is mesodermal and simple, and is so far characteristic that it commences incomparably deeper than in any other known Zoanthean; it extends so deeply downwards in the outer part of the body-wall, that, even in the contracted animal, its lowest point lies in the same horizontal plane as the lower end of the stomatodæum. In longitudinal section one can see how, at its deepest point, the bundles of fibrillæ, like small circles, are laid so closely together that they appear almost to form a continuous line. Above they are more extended, and place themselves with the long axis perpendicular to the endoderm, from which they are only separated by a narrow lamina of homogeneous mesoglœa. In this condition the sphincter forms a system of bacillate fibrillæ-bundles, which are arranged extremely regularly in the form of a palisade. At the edge of the infolding of the body-wall the bundles begin to bay out irregularly, and finally set themselves, on the indrawn part of the body-wall, to form the sphincter proper, a plait of delicately branching and anastomosing bundles. This circular muscle increases in bulk downwards, and terminates below with a rounded end. It does not completely traverse the mesoglœa, but leaves free on either side a homogeneous layer, which in its turn is bounded by a stripe reaching to the commencement of the oral disc, and carrying the usual hard deposits."

Sphenopus arenaceus, R. Hertwig.

Habitat.—Station 187, Torres Strait, Australia, September 9, 1874; 6 fathoms. Two specimens.

Sphenopus marsupialis, Steenstrup.

Habitat.—(*a*) Station 188, in the Arafura Sea, September 10, 1874; 28 fathoms. One specimen. (*b*) Station 208, Philippine Islands, January 17, 1875; 18 fathoms. One specimen.

In the Challenger material I have found four further examples of the genus *Sphenopus;* two of these I have determined as *Sphenopus arenaceus* on account of their rusty red tint, and other two as *Sphenopus marsupialis*, in consequence of the earthy-grey colour and the absence of a stalk. It seems to me, however, desirable that, with an opportunity of more abundant and fresh material, a renewed study should be undertaken to decide whether the received specific characters are variable, and whether all three species should not be united in the single *Sphenopus marsupialis*.

APPENDIX TO THE ZOANTHEÆ.

Genus *Stephanidium*, n. gen.

Among the Zoantheæ I include with some reserve a genus which is represented by a single species, and has thus been insufficiently investigated. It differs from the characteristic forms of Zoantheæ in the absence of incrustations, and the non-formation of a colony. Both characteristics, however, may be absent in true Zoantheæ, *e.g.* the soft-skinned *Zoanthus* and the solitary Sphenopidæ. Of more importance is the fact that, in spite of careful study, I have not yet been so fortunate as to demonstrate beyond all doubt the decisive characteristic of Zoantheæ, namely, the regular distribution of micro- and macro-mesenteries. I consequently omit to give separate diagnoses of the species and genus.

Stephanidium schulzii, n. sp. (Pl. I. fig. 14; Pl. III. figs. 1, 7).

Habitat.—Station 209, off Zebu, Philippine Islands, January 22, 1875; 95 fathoms.

Dimensions.—Breadth, 1·5–2·2 mm.; height, about 1·0 mm.

Some Actiniæ were forwarded to me by Prof. F. E. Schulze, found among the Hexactinellidæ entrusted to him for description; they were mainly small, insufficiently characterised forms, which I did not care to investigate; but among them occurred five specimens of one species, which I will here describe on account of the striking appearance of the body.

The body of Stephanidium is in diameter 1·5–2·2 mm., and about 1 mm. high in the contracted condition. The epithelium had been stripped off at most points, and remained only on the lowest parts of the body-wall, the mesoglœa thus being exposed over a wide extent, and allowing the mesenteries to be seen through it. The resulting appearance is drawn in Pl. I. fig. 14, and was originally interpreted as follows:—I believed that the surface was indented by deep furrows corresponding to the mesenteries; the ridges lying between these furrows become narrower, from a definite part of the body-wall outwards; they are extremely unequal in breadth, a broader and a narrower ridge alternating regularly with one another, and to every broader ridge corresponds, at the upper edge of the body-wall, a special structure of the following nature: the edge of the body-wall is elevated into a kind of battlement (Pl. III. fig. 7), on the outer side of which are situated roundish or oval bodies, which call to mind the marginal spherules of *Actinia mesembryanthemum*. The longitudinal ridge of the body-wall meets the spherule, splits into two forks, and surrounds the structure from below.

Sections through the animal, however, showed that the body-wall is smooth, and that the appearance of furrows was caused by the insertions of the mesenteries. On the other hand, the spherules are really present, and form evaginations of the body-wall, above a spot which is marked by the position of the circular muscle (Pl. III. fig. 1). The latter, in spite of the contracted condition of the Actinian, is of weak development, and is merely a part of that endodermal circular muscle-layer which is at other points hardly recognisable, but is here elevated into small folds. It is most obvious at those places where it traverses the thickness of a mesenterial insertion; here the endodermal muscle-layer is not recognisable, but mesoglœal muscle-rings are embedded in the region of the sphincter, largest at the upper end, and becoming gradually less obvious in a downward direction, till one meets with small groups of only two or three fibres, or even with completely isolated fibres.

Of the tentacles and oral disc it can only be said that the ectodermal muscle-layer is strongly pleated.

The mesenteries, the number of which may be learnt even by superficial observation, amount to twenty-six, and are differentiated, as in the Zoantheæ, into macro- and micro-mesenteries. Of their arrangement, despite much trouble, I have not yet arrived at a completely clear comprehension, but I could demonstrate the probability that the directives of the one side are macro-mesenteries, those of the other micro-mesenteries, that dorsal and ventral mesenterial zones meet with micro-mesenteries, and that one pair is more developed on the one side than on the other.

The mesenteries (probably only macro-mesenteries) bore ripe male generative organs. I was unable to recognise a siphonoglyphe.

V. Ceriantheæ.

Family 14, Cerianthidæ.

Genus *Cerianthus*, Delle Chiaje.

Cerianthus membranaceus, Spall.

Habitat.—Zebu, Philippine Islands, on the reefs.

Dimensions.—Length, in a contracted condition, 4·5–10·0 cm.; breadth, 1·5–1·8 cm. Two specimens.

UNDETERMINED SPECIES.

1. Station 153, in the Antarctic Ocean, February 14, 1876; 1675 fathoms.
   An Actinian, nearly as thin as paper, strongly contracted and folded together, 1·5 cm. in size.
2. Station 173, off Matuku, Fiji Islands, July 24, 1874; 310–315 fathoms.
   An Actinian, firmly fixed on a Gastropod shell (probably an *Adamsia*).
3. Station 195, off Banda, October 3, 1874; 1425 fathoms.
   An Actinian, about 5 cm. long, very rotten.
4. Station 209, off Zebu, Philippine Islands; 95 fathoms.
   An Actinian, 4 mm. broad, 2 mm. high, sessile, strongly contracted.
5. Zebu, 100 fathoms.
   An Actinian, 6·0 mm. broad, 2 mm. high, of the usual structure; 12 complete pairs of mesenteries, two directives, 36 (= 12 + 24) small pairs.
6. Station 219, North of Papua, March 10, 1875; 150 fathoms.
   One small Actinian, 1·5 cm. high, 1·5 cm. broad, slightly contracted (probably no sphincter), about 30 short, plump, sack-like tentacles. Preservation inadequate for study.
7. Station 244, North Pacific, East of Japan, June 28, 1875; 2900 fathoms.
   One Actinian, 12 mm. broad, 3 mm. high, very strongly contracted.
8. Station 286, South Pacific, between Tahiti and Valparaiso, October 16, 1875; 2335 fathoms.
   An Actinian, 1·4 cm. broad, 0·4 cm. high, probably a *Phellia*.
9. Station 299, off Valparaiso; 2160 fathoms.
   Actinian adhering to a *Dentalium;* one elongated specimen (3·5 cm.), flattened by contraction, in shape recalling the Amphianthidæ.

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PLATE I.

PLATE I.

The lettering is the same in all the figures.

cu Cuticula.
ec Ectoderm.
en Endoderm.
g Generative organs.
h Mesenteries.
im Intermediary layer.
m Muscle-fibres.
me Mesoglœa.
ms[1] Upper circular muscle.
ms[2] Lower circular muscle.
o Ova.
r Marginal spherules.
sr Siphonoglyphe (œsophageal groove).
t Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Fig. 1. *Zoanthus danæ.*
Fig. 2. *Epizoanthus elongatus.*
Fig. 3. *Epizoanthus thalamophilus.*
Fig. 4. *Epizoanthus stellaris.*
Fig. 5. *Corticifera tuberculosa.*
Fig. 6. *Corticifera lutea.*
Fig. 7. *Palythoa anguicoma.*
Fig. 8. *Amphianthus ornatum;* × 4.
Fig. 9. *Aulorchis paradoxa:* genital tube exposed by splitting the lip and the stomatodæum.
Fig. 10. *Aulorchis paradoxa;* siphonoglyphe, stomatodæum, oral disc, and mesenteries exposed on removal of about one-third of the animal.
Fig. 11. *Sphenopus pedunculatus.*
Fig. 12. *Zoanthus confertus.*
Fig. 13. *Liponema multiporum;* oral disc and stomatodæum evaginated.
Fig. 14. *Stephanidium schulzii;* × 30.
Fig. 15. *Epizoanthus cancrisocius.*

(Figs. 1–7, 11, 12, 15 are after Erdmann.)

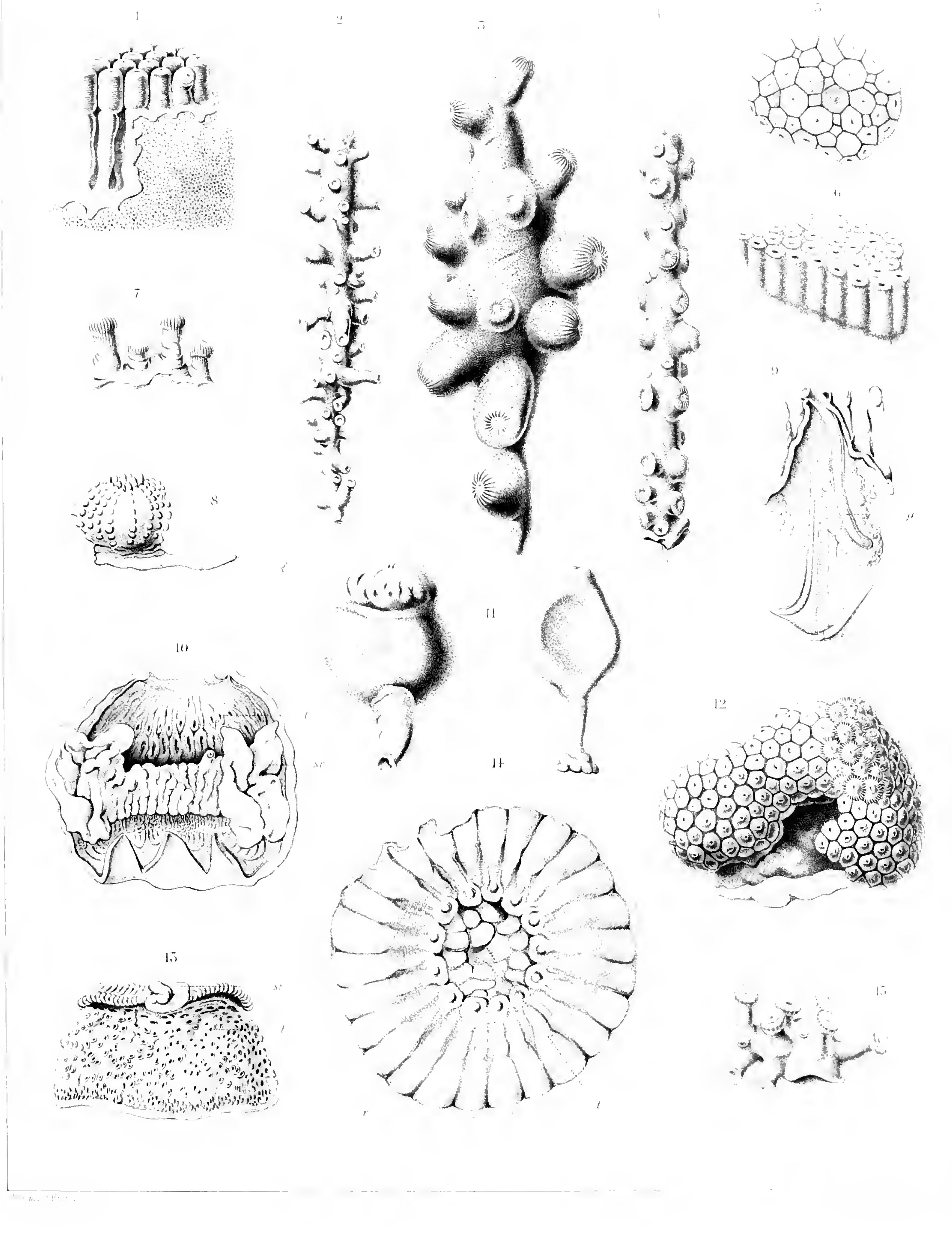

PLATE II.

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The lettering is the same in all the figures.

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Fig. 1. Portion of the circular muscle of *Hormathia delicatula.* D, Oc. 2, somewhat diminished.

Fig. 2. *Ilyanthopsis longifilis;* musculature of the oral disc. $^{1}/_{18}$, Oc. 1.

Fig. 3. *Hormathia delicatula;* musculature of the oral disc. D, Oc. 2.

Fig. 4. Circular muscle and marginal spherules of *Liponema multiporum.* A, Oc. 1.

Fig. 5. Muscle-pennon of *Halcampa kerguelensis.* A, Oc. 2.

Fig. 6. *Dysactis crassicornis;* transverse section through a tentacle. a^3, Oc. 2.

Fig. 7. Portion of the tentacle represented in fig. 6, more strongly magnified. A, Oc. 1.

Fig. 8. *Phellia spinifera;* transverse section through the musculature of the oral disc. E, Oc. 2.

Fig. 9. The same.

PLATE III.

PLATE III.

The lettering is the same in all the figures.

cu Cuticula.
ec Ectoderm.
en Endoderm.
g Generative organs.
h Mesenteries.
im Intermediary layer.
m Muscle-fibres.
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ms^1 Upper circular muscle.
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r Marginal spherules.
sr Siphonoglyphe (œsophageal groove).
t Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Fig. 1. Circular muscle of *Stephanidium schulzii*;—1*a*, in the region of an inter-mesenterial chamber and of a marginal spherule; 1*b*, in the region of the origin of a mesentery.

Aulorchis paradoxa (figs. 2–6).

Fig. 2. Transverse section through the oral disc. A, Oc. 1, somewhat diminished.

Fig. 3. Parts of a transverse section through the circular muscle, showing the connection of the endodermal and mesoglœal muscle-layers: 3*a*, with D, Oc. 1; 3*b*, with E, Oc. 1.

Figs. 4, 5. Sections through the stomidia. a^3, Oc. 1.

Fig. 6. Transverse section through the mesoglœal musculature of the oral disc. D, Oc. 1.

Fig. 7. *Stephanidium schulzii*; upper edge of the body-wall, × 60.

2

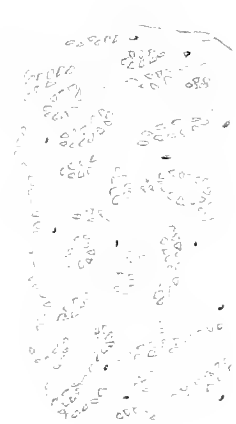
1a

5a

4

5

5b



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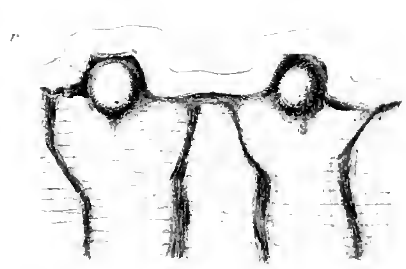

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PLATE IV.

PLATE IV.

The lettering is the same in all the figures.

cu Cuticula.
ec Ectoderm.
en Endoderm.
g Generative organs.
h Mesenteries.
im Intermediary layer.
m Muscle-fibres.
me Mesoglœa.
ms^1 Upper circular muscle.
ms^2 Lower circular muscle.
o Ova.
r Marginal spherules.
sr Siphonoglyphe (œsophageal groove).
t Tentacles.

All statements given as to magnifying powers have reference to Zeiss's system.

Aulorchis paradoxa (sections through the genital tube, figs. 1-6).

Fig. 1. Connection of an ovum with the endodermal epithelium, probably by means of a thread apparatus ("Faden-Apparat"). E, Oc. 2.

Fig. 2. Surface view of the germinal layer. I, Oc. 2.

Fig. 3. Longitudinal section through the germinal layer. E, Oc. 2.

Fig. 4. Transverse section through the lower part of the genital tube. A, Oc. 2.

Fig. 5. Transverse section through the upper part of the genital tube, in the region of the oral disc; the central detritus, which is probably produced by degradation of epithelium, is omitted in the drawing. A, Oc. 2.

Fig. 6. Epithelial layer from the interior of the genital tube (cf. fig. 4). E, Oc. 1.

Fig. 7. *Epizoanthus thalamophilus;* section through the circular muscle (after Erdmann).

Fig. 8. Horizontal section through the external and the invaginated portions of the body-wall of *Epizoanthus thalamophilus* (after Erdmann).

Fig. 9. *Hormathia delicatula.* Portion of the partly invaginated body-wall cut out and magnified slightly. The invaginated part bears the parietal spherules.


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