having a conchoidal fracture, hard, and not soiling the fingers. Its colour is black, velvet-black or brownish black. One portion has a beautiful lustre and high polish. It is described by Mr. Logan as burning with a clear flame, occasionally greenish, and with a slight decrepitation. It was found by a Penang Siamese, on the southern coast of the island of Junk-Ceylon (well-known for its tin). He said he had found a layer of it three feet thick close under the surface, and offered to import it into Penang at the rate of 12*s.* 6*d.* per ton.

On submitting a portion of a specimen of this coal to a rough investigation, it appears to be of very admirable quality. It yields an ash amounting only to 1·32 per cent. The quantity of sulphur, if any, is too small to be appreciated. It is very bituminous, and appears as if it would *coke* well. There can therefore be little doubt that if the specimen is fairly selected, and the quantity be sufficient, this mineral fuel may be applied to many highly important economic purposes.

June 9, 1847.

George Richardson, Esq., and John W. Kershaw, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *Microscopical Observations on the Structure of the Bones of* Pterodactylus giganteus *and other Fossil Animals.* By J. S. Bowerbank, F.R.S., G.S. &c.

On the 14th of May 1845 I had the honour of exhibiting to the Geological Society a portion of the head and other bones of a gigantic Pterodactylus from the lower chalk* near Maidstone, Kent, and subsequently these specimens were engraved and published, accompanied by a short description, in vol. ii. p. 7. Pl. I. of the Quarterly Journal of the Geological Society. In that memoir I expressed an opinion, that the bone represented by fig. 6 in the Plate illustrating my paper was of the same description of animal, and corresponding in position with that figured and described by Prof. Owen in the Transactions of the Geological Society, 2nd Series, vol. vi. Pl. 39, as a portion of the shaft of the humerus of a longipennate bird, and consequently that it was probable that the latter bone would ultimately prove to belong to a Pterodactylus. Since the expression of this opinion, I have had the pleasure of seeing several fine specimens of similar bones to those described by Prof. Owen, in the possession of Mr. Charles of Maidstone, Mrs. Smith of Tunbridge Wells, and Mr. Toulmin Smith, and I have been favoured by the latter two eminent and liberal collectors with the free use for examination and comparison of many beautiful specimens of such remains. Several of these bones, especially those from the rich collection of Mrs. Smith and Mr. Toulmin Smith, agreed so perfectly in all respects

* By an error on my part, the bones are described in the first memoir as being from the Upper Chalk, while in truth the pits from which they came are, I am informed, considered as Lower Chalk.

with the published specimens, as to impress more firmly than before upon my mind, the conviction that the whole would ultimately prove to be the remains of Pterodactyls. With a view of deciding this question if possible, I determined upon a close microscopical examination of the structural peculiarities of the bones, in the hope of eliciting some characters which would, in conjunction with their external forms, point out with some degree of certainty the class of animals to which these interesting remains in reality belonged.

In the first place I removed some small fragments from the jaw of the Pterodactyl from the chalk, in my own possession, and immersing them in water between slips of glass, I submitted them to examination by transmitted light with a power of 500 linear, and I was at once struck by the great difference in the proportions that existed between the bone-cells of the specimen under examination, and those of the human bone with which I was familiar. A measurement of five cells of the latter gave an average of length $\frac{1}{805}$ inch, greatest diameter $\frac{1}{3261}$ inch, while an average of five cells from the lower jaw of the *Pterodactylus giganteus*, represented by fig. 1. Pl. I., gave—length $\frac{1}{552}$ inch, greatest diameter $\frac{1}{6024}$ inch. In the latter also the bone-cells were considerably fewer in number, within the same amount of space, than they were in the human bone, and the canaliculi radiating from them less in number and larger in diameter.

With these striking differences in structure before my eyes, I felt a strong hope that the comparative number and proportions of the cells would afford a sufficient means of discriminating between the remains of the Pterodactyls and those of mammals, and probably birds; and I determined therefore, in the first place, to examine microscopically the whole of the bones from the chalk, and then to compare the results with those which might arise from a similar investigation of the bones of recent reptiles and birds.

Upon submitting to examination minute fragments of all the Pterodactyl bones represented in Pl. I. vol. ii. of the Geological Journal, I found the bone-cells in every case to agree precisely in their proportions and mode of distribution with those from the lower jaw of the *Pterodactylus giganteus* which are represented by fig. 1. Pl. I.

I then called upon Prof. Owen and informed him of my wish to examine the structure of the bones described by him in the Transactions of the Geological Society as those of birds, and he kindly furnished me with some minute fragments from near the centre of the shaft of the bone, represented by fig. 1. Pl. 39. vol. vi. of the New Series of Transactions of the Geological Society. Upon immersing these in Canada balsam, and submitting them to a similar course of microscopical examination to that which I had before adopted, I found the bone-cells to possess the same small diameter and great elongation that characterized those from the jaw of the Pterodactyl and the other remains of the same animal; the average length of five of the cells represented in fig. 2. Pl. I. being $\frac{1}{515}$ inch, and the greatest diameter $\frac{1}{6173}$ inch, so that in reality they are more elongated than those from the jaw of the Pterodactyl; but this it is quite natural should be the case, as I have subsequently found that

the bone-cells vary slightly in their proportions in different parts even in the same bone; those of the cancellated portions toward the ends of the bone being somewhat shorter and more irregular in their proportions than those of the shaft, surrounding the Haversian canals, which have proved in all the specimens I have examined to be very nearly uniform in their size and proportions. I have therefore in all cases described in this paper, selected the specimens for examination and figuring as nearly as possible from the central portion of the shaft of the bone.

The result of these examinations strongly impressed upon my mind the conviction, that the bones described as those of birds in truth belonged to Pterodactyls, and it remained only to examine and compare with them the structure of the bone of an Albatros; with the view of procuring which, I called on my friend Mr. John Quekett of the Royal College of Surgeons, and upon mentioning to him the course of investigation which I was pursuing, he at once told me that he had been for some time engaged in an examination of the structural peculiarities of the bones of the four great classes of the animal kingdom, and that he believed that distinctive characters existed which would readily enable an anatomist to decide from a fragment, to which of these classes a bone submitted to his examination might belong. Upon this declaration I immediately submitted to him Camera lucida drawings of the bone-cells from the jaw of the *Pterodactylus giganteus* from the chalk, and those from the bone belonging to the Earl of Enniskillen and described by Prof. Owen (fig. 1. Pl. 39. vol. vi. Geol. Trans. 2nd Series), and he at once declared that they were characteristic of the reptilian tribe.

This confirmation of the opinion I entertained of the reptilian character of the bones under examination was the more valuable, as neither Mr. Quekett nor myself were previously aware of the course of investigation which each had been pursuing.

Having obtained a portion of the shaft of a humerus of an Albatros, I submitted it to examination in the manner pursued with the Pterodactyl bones. I found that the bone-cells were nearly analogous in their proportions to those of the generality of mammals, but somewhat more numerous within the same amount of space, and like the mammalian cells, the canaliculi radiating from them were very much finer and more numerous than those radiating from the reptilian bone-cells, either of the Pterodactylus, or of the common frog or boa-constrictor. The average measurement of five of the bone-cells of the Albatros, represented by fig. 3. Pl. I., was—length $\frac{1}{688}$ inch, greatest diameter $\frac{1}{4274}$ inch; while those from Lord Enniskillen's specimen were—length $\frac{1}{515}$ inch, greatest diameter $\frac{1}{6173}$ inch; thus exhibiting an essential difference in their size and proportions as well as in the number contained within the same amount of space and in the number and proportions of the canaliculi radiating from the cells.

These differences in structure and proportion I found to prevail equally between the bone-cells of the common frog, the boa-constrictor, *Palæophis Toliapicus*, and other recent and fossil reptiles, and those of the bones of the domestic goose, duck, fowls, and several

other birds which I examined for the purposes of comparison; and that the latter were in every respect in accordance with those of the Albatros, while the bone-cells of the former exhibited the same small diameter and great elongation as well as the other peculiarities which characterized the bone-cells from the jaw of the Pterodactyl and from the large bone from the collection of the Earl of Enniskillen.

In the same paper by Prof. Owen on the supposed Ornitholites from the chalk, there is a second bone which is described as the "distal extremity of the tibia of probably the same bird," and is represented in the Plate by fig. 2. I did not receive any fragments of this bone for examination; but another specimen of the like description of bone, from I believe the same chalk-pit near Maidstone, has been obtained by Mr. Toulmin Smith, who has kindly allowed me to examine and figure it in illustration of this paper. It has been seen and compared with the figured specimen by Prof. Owen, and I am informed that he considers it as the same description of bone as the one represented by fig. 2 in his paper in the Transactions of the Geological Society.

On examining some small fragments of this bone taken from the broken end of the shaft at the point the farthest removed from the head of the bone, with a power of 500 linear, I found the bone-cells, which are represented at fig. 5. Pl. II., to correspond precisely in all their characters with those from the jaw of the Pterodactyl. The average measurement of five of them, represented at fig. 5. Pl. II., was —length $\frac{1}{519}$ inch, greatest diameter $\frac{1}{6822}$ inch. I have therefore no hesitation in considering this specimen, as well as the long bone from the collection of the Earl of Enniskillen, as truly reptilian, and not as the remains of a bird.

In my former paper on the *Pterodactylus giganteus*, I stated that from a comparison with the figures of Pterodactylus by Goldfuss, I believed that the bone represented by fig. 6 in the illustrations to that paper was an ulna, but unfortunately both that bone and the one in the possession of the Earl of Enniskillen were so imperfect towards their extremities that it was exceedingly difficult to decide that point with any degree of certainty. Fortunately the two fine specimens from the rich collection of Mrs. Smith of Tunbridge Wells, represented by fig. 1. Pl. II., in a great measure justify this conclusion, and in the bone *a*, which is apparently the corresponding bone to the one represented by fig. 1 in Prof. Owen's paper, the head is very nearly in a perfect state of preservation. It presents a simple cupped extremity, as represented by fig. 2, while the extremity of the second bone *b* has suffered so much as to render its form quite indistinct. The animal to which they belonged must have been of enormous dimensions, for there is a further portion of the shaft of the bone *b* imbedded on the mass of chalk, which makes the whole length of the specimen $9\frac{1}{2}$ inches, and the extremity of this part of the shaft does not exhibit any indication of its being near to the opposite end of the bone. There are also two other similar bones imbedded side by side in the collection of Mr. Charles of Maidstone, of still greater dimensions than those from the cabinet of Mrs. Smith. The head of

one of these bones, corresponding with fig. 1 *a*, Pl. II. of Mrs. Smith's pair, measures $2\frac{1}{2}$ inches at its greatest diameter, while that of Mrs. Smith's specimen is $1\frac{1}{2}$ inch only. The animal to which such bones belonged could therefore have scarcely measured less than fifteen or sixteen feet from tip to tip of its expanded wings.

In the bone belonging to Mr. Toulmin Smith, represented by fig. 4. Pl. II., there is an orifice at *a* which has every appearance of being a pneumatic foramen. I am not aware that such orifices have hitherto been observed in the bones of Pterodactyls, but I can see no good reason why they should not have been furnished with them. The whole structure of the skeleton, and the extreme thinness of the bones, proclaim them as eminently volant; and as we find among birds that those which are destined to be most continuously upon the wing are furnished to the greatest extent with pneumatic cavities in their bony skeleton, so we may reasonably expect that in a reptile so especially constructed for flight, nature would not fail in contributing organs so essential to the end of their peculiar construction.

The bone described and figured No. 2 by Prof. Owen was in a somewhat mutilated condition, but the head of Mr. Toulmin Smith's specimen is in a remarkably fine state of preservation. From a comparison of this specimen with the plate of *Pterodactylus Macronyx*, described by Dr. Buckland in the Geological Transactions, Feb. 6, 1829, there is every appearance that it is the corresponding bone to that indicated by N′, or the left femur of the animal. I have also compared it with the original in the British Museum, but unfortunately that valuable specimen has suffered so much dilapidation since the plate was engraved that the representation affords a much better reference than the original.

The satisfactory nature of the results of the examinations which I have detailed, led me to believe that I should be rendering an acceptable service to science if I were to extend my researches to other disputed bones beside those from the chalk. I therefore applied to Dr. Buckland for permission to examine in like manner the jaws from the Stonesfield slate, in the hope that their structural peculiarities would assist in deciding the long-mooted question of their mammalian or reptilian nature. To this request Dr. Buckland responded in the readiest and most liberal manner, by removing in my presence small portions of each of these rare and valuable specimens represented by figs. 1 and 3. Pl. 5. vol. vi. Transactions of the Geological Society, 2nd Series. Upon immersing these minute fragments in Canada balsam and examining them by transmitted light with a power of 500 linear, I found the bone-cells were to be seen in the most beautiful manner, and especially those from the jaw represented by fig. 3 in the Plate of the Transactions of the Geological Society. The small fragment removed had fortunately splintered off in the direction of the course of the fibres of the bone, so that the length and proportions of the cells were rendered in the most satisfactory manner, as represented by fig. 6. Pl. I. Upon accurately measuring five of these, their average gave the following dimensions: length $\frac{1}{980}$, greatest diameter $\frac{1}{4032}$. The minute canaliculi were apparent in great abundance,

radiating from the cells and presenting all the characters of those of well-known and characteristic mammals. The fragments from the second specimen of *Thylacotherium Prevostii*, represented by fig. 1. Pl. 5. vol. vi. 2nd Series of Transactions of the Geological Society, were not so fortunate in their direction, having splintered off rather obliquely to the axis of the bone, but in other respects they presented precisely the same characters as those from the first specimen. They are represented at fig. 5. Pl. I. Their average measurement was—length $\frac{1}{1214}$ inch, greatest diameter $\frac{1}{4673}$ inch. The canaliculi were equally abundant and quite as much attenuated as in the first specimen, and the abundance of the cells within a given space was in perfect accordance with the other mammalian characters; the difference in their length from the first specimen being accounted for by the oblique position in which they were presented to the eye.

Mr. Morris also kindly furnished me with a third specimen of a small jaw from the Stonesfield slate, which appears to me to be *Thylacotherium Broderipii*, and a similar examination of fragments from this produced precisely the same results as those recorded of the jaws in the possession of Dr. Buckland.

The structural peculiarities therefore appear to place the mammalian character of these long-disputed remains beyond a reasonable doubt, and to confirm the opinion so laboriously and ably worked out by Prof. Owen, of their having belonged to true mammals, and in no respect being allied to the Reptilia.

With the jaw from the Stonesfield slate my friend Mr. Morris sent me a small vertebra from the same formation, which is represented by fig. 6. Pl. II. Small fragments from this bone afforded similar results to those from the jaws. The bone-cells represented at fig. 4. Pl. I. present all the proportions and appearance of those of mammalian remains, and none of the characteristics of the reptilian tribe. The average dimensions of five of these cells were—length $\frac{1}{1087}$ inch, greatest diameter $\frac{1}{4500}$ inch.

The Chalk and the Stonesfield slate are not the only strata that have produced bones which have been the subject of dispute in the geological world. Dr. Mantell, on the 10th of June 1835, read a paper before the Geological Society "On the Bones of Birds discovered in the Strata of Tilgate Forest in Sussex." Doubts had existed previously to the publication of this memoir whether the bones which are the subject of it were not those of Pterodactyls; but on the high authorities, in the first place of Cuvier, and secondly of Professor Owen, they were decided to belong to extinct species of wading birds. Subsequently the latter great comparative anatomist, it appears, mistrusted this decision, and having re-examined the bones which are now deposited in the British Museum, and numbered 453 and 2353, he published the result of this fresh examination in a paper read before the Geological Society on the 17th of December 1845, entitled "On the supposed Fossil Bones of Birds from the Wealden." In this communication Professor Owen enters at length into his reasons for changing his opinion respecting these specimens, and ultimately decides upon designating them as remains of Pterodactyls; that is to,

say, those represented by figures 1*a*, 1*b* and 3 of Plate 13, illustrating Dr. Mantell's paper, and now numbered 453 in the British Museum. Of the bone represented by figure 6 in Dr. Mantell's paper, there is nothing said in this communication further than a general reference to the nature of the bones treated of in the concluding sentence of the paper, which is thus expressed:—"We have no satisfactory evidence, however, of the existence of birds in the Wealden."

On the 7th of January 1846 Dr. Mantell read a paper to the Geological Society, entitled "On the Fossil Remains of Birds in the Wealden Strata of the South of England," in which he questions the propriety of the conclusions arrived at by Professor Owen; but as neither of the authors of these papers appeared to have examined microscopically the structure of the bones in question, I resolved to endeavour to remedy this omission.

Upon submitting some minute fragments from the fractured end of the shaft of the bone represented by figures 1*a* and 1*b* of Dr. Mantell's paper, and figures 1 and 2 of Professor Owen's communication, published in No. 6 of the Quarterly Journal of the Geological Society, I found the bone-cells, as represented at fig. 8. Pl. I., to coincide in every respect with those of the Pterodactyl remains before described in this communication. An average of five of them gave the following dimensions:—length $\frac{1}{787}$ inch; greatest diameter $\frac{1}{7812}$ inch; and the number, proportion and mode of disposition of the cells, and of the canaliculi radiating from them, were precisely in accordance with those of the recent as well as of the fossil reptilia. We may therefore justly infer that the latter conclusion of Professor Owen regarding this bone is the correct one, and that the specimen is truly Pterodactylian. But not so with regard to the larger bone represented by figure 6 in Dr. Mantell's paper in the Transactions of the Geological Society of June 10, 1835. Fragments from about the middle of the shaft of this bone exhibited the characteristic cells in a very distinct and satisfactory manner, but, unlike the former, they agreed in every respect with those of birds as represented at fig. 9. Pl. I. An average of five afforded the following measurements:—length $\frac{1}{855}$ inch; greatest diameter $\frac{1}{4505}$ inch. The proportional characters of the bone-cells, and the bird-like build of the bone itself, leaves therefore little reasonable doubt of its being truly the remains of a member of the class Aves.

I have examined many other specimens of bones from the Wealden and the Stonesfield slate, as well as from the Chalk, and in every instance the class to which they belonged might, I am of opinion, be readily and correctly determined; but as the specimens I allude to have not been made especial subjects of doubt or discussion, I shall abstain from increasing the length of this communication by describing them. There is one case only to which I shall allude on the present occasion, and that is a specimen described and partly figured in page 22 of the first part of the London Geological Journal as "a reptile or fish" from the chalk of Kent. The possessor of this valuable fossil, Mr. Toulmin Smith, has kindly furnished me with a small fragment of the jaw, which exhibits very distinctly one of the pecu-

liar modifications of the bone-cells which characterize fishes, and is represented by fig. 7. Pl. I. This modification of the bone-cells is perhaps the nearest form among fishes to those of the reptilia. The normal form in fishes is an angular or nearly square cell, with large canals radiating from it in various directions. From these there is a transition of form until they assume the appearance represented by fig. 7, and in some cases the large canals radiating from this form of cell unite, and the whole then forms a plexus of canals of nearly equal diameter.

I cannot conclude this paper without expressing my thanks to my friend Mr. John Quekett for the very liberal manner in which he communicated to me the results of his own laborious and valuable researches on the structure of bone, which were subsequently communicated to the Microscopical Society in a paper read the 18th of March 1846, and which will, I feel convinced, prove a most valuable means of deciding disputed relations of obscure and difficult tribes of recent animals, as well as of pointing out at once to us the true relation of such geological remains of the animal kingdom as it might be otherwise exceedingly difficult, or perhaps impossible, from their dilapidated condition, to refer to their true position among animals.

Average length and greatest diameter of five Bone-cells, from each of the specimens treated of in the above Paper.

Name of Animal.	Length.	Diameter.	Proportion.
	inch.	inch.	
Human	1–805	1–3261	1 to 4
Albatros (Pl. I. fig. 3)	1–688	1–4274	1 to 6¼
Pterodactyle Jaw (Pl. I. fig. 1)	1–552	1–6024	1 to 11
Lord Enniskillen's specimen (Pl. I. fig. 2)	1–515	1–6173	1 to 12
Mr. T. Smith's (Pl. II. fig. 5)	1–519	1–5882	1 to 11⅓
Mrs. Smith's (Pl. II. fig. 3)	1–493	1–5814	1 to 11¾
Common Frog	1–392	1–4629	1 to 11¾
Boa Constrictor	1–561	1–6097	1 to 11
Thylacotherium Prevostii (Pl. I. fig. 6)	1–980	1–4032	1 to 4⅛
Vertebra from Stonesfield (Pl. I. fig. 4)	1–1087	1–4500	1 to 4⅛
Bone from Wealden, No. 453 B.M. (Pl. I. fig. 8)	1–787	1–7812	1 to 10
Do. Do. No. 2353 B.M. (Pl. I. fig. 9)	1–855	1–4505	1 to 5¼

DESCRIPTION OF PLATE I.

Fig. 1. A group of bone-cells from the jaw of *Pterodactylus giganteus*.
2. Bone-cells from the specimen represented by fig. 1. Pl. 39. vol. vi. 2nd Series Trans. Geol. Soc., in the possession of the Earl of Enniskillen.
3. Bone-cells from a femur of recent Albatros.
4. Bone-cells of vertebra from Stonesfield slate.
5. Bone-cells of jaw of *Thylacotherium Prevostii*, fig. 1. Pl. 5. vol. vi. Trans. Geol. Soc. 2nd Series.
6. Bone-cells from *Thylacotherium Prevostii*, fig. 3. Pl. 5. vol. vi. Trans. Geol. Soc. 2nd Series.
7. Bone-cells from Mr. Toulmin Smith's fossil fish from the Chalk, figured in the London Geological Journal, vol. i. page 22.

Fig. 8. Bone-cells from a Reptile from the Wealden, described as Bird, fig. 1. Pl. 13. vol. v. Geol. Trans. 2nd Series.
9. Bone-cells from a Bird from the Wealden, fig. 6. Pl. 13. vol. v. Trans. Geol. Soc. 2nd Series.

DESCRIPTION OF PLATE II.

Fig. 1. Radius and ulna of *Pterodactylus giganteus*, in the cabinet of Mrs. Smith of Tunbridge Wells.
2. Head of one of the same bones (*a*), fig. 1.
3. Bone-cells from the bone (*b*), fig. 1.
4. Part of a bone, in the possession of Mr. Toulmin Smith, similar to that described by Professor Owen as from a Bird, and figured in Pl. 39. vol. vi. fig. 2. Trans. Geol. Soc. 2nd Series.
5. Bone-cells from the specimen represented by No. 4.
6. Vertebra of a Mammal from Stonesfield slate, in possession of Mr. Morris.

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2. *On the Geology of some parts of the Alpine and Mediterranean regions of* South-Eastern Europe. By Ami Boué, M.D., F.G.S. &c.

Dr. Boué in this communication states his views in reference to the classification of the nummulitic rocks and the connected strata in various places round the shores of the Mediterranean. He points out especially the great extent of these deposits in European Turkey, as shown in a corrected copy of his Geological Map of that country which he has forwarded to the Society. In this map he also indicates the occurrence of Silurian formations in Carinthia, Styria, and some of the neighbouring regions.

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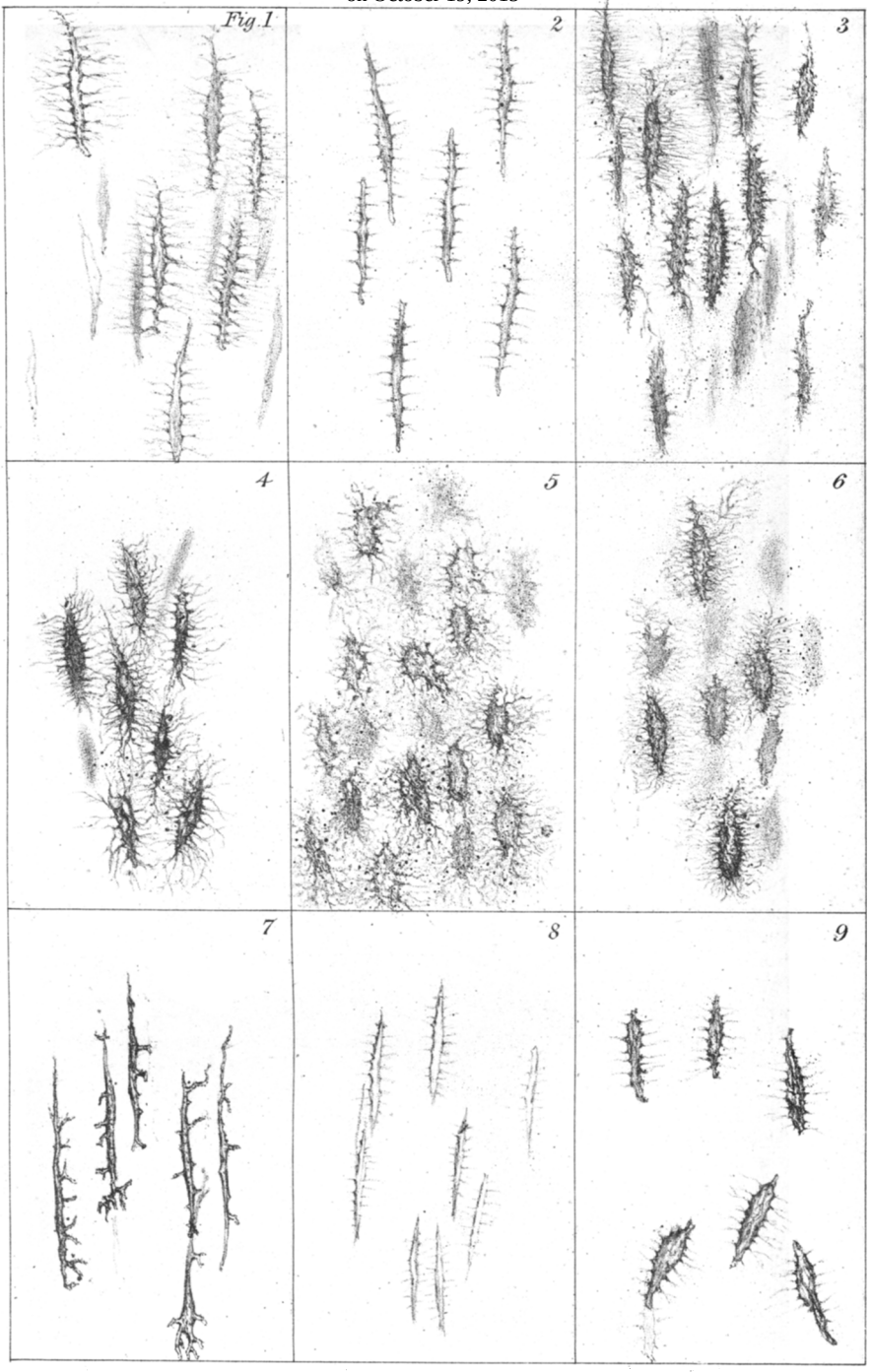
3. *On the relative Age and Position of the so-called Nummulite Limestone of* Alabama. By C. Lyell, F.R.S. and V.P.G.S.

In a former paper published in the Quarterly Journal of the Geological Society of London (vol. ii. p. 405, May 1846), I stated that the limestone containing abundantly the *Nummulites Mantelli*, Morton, which occurs near Suggesville, Clarksville, and other places between the rivers Alabama and Tombecbee, in the State of Alabama, was a member of the Eocene tertiary group, and that so far from constituting any part of the cretaceous formation, as had formerly been imagined, it holds in reality a place high up in the Eocene series of the South. In the same memoir I gave a section extending from Claiborne through Suggesville and Macon to the west of Clarksville, Alabama, in which the position of the so-called nummulitic limestone was explained. It was stated to be newer than all the beds of the well-known Claiborne Bluff, and I mentioned that "the bones of the gigantic cetacean called Zeuglodon by Owen were everywhere found in Clarke County, in a limestone below the level of the nummulitic rock and above the beds which contain the greater number of perfectly preserved eocene shells, such as *Cardita planicosta* and others."



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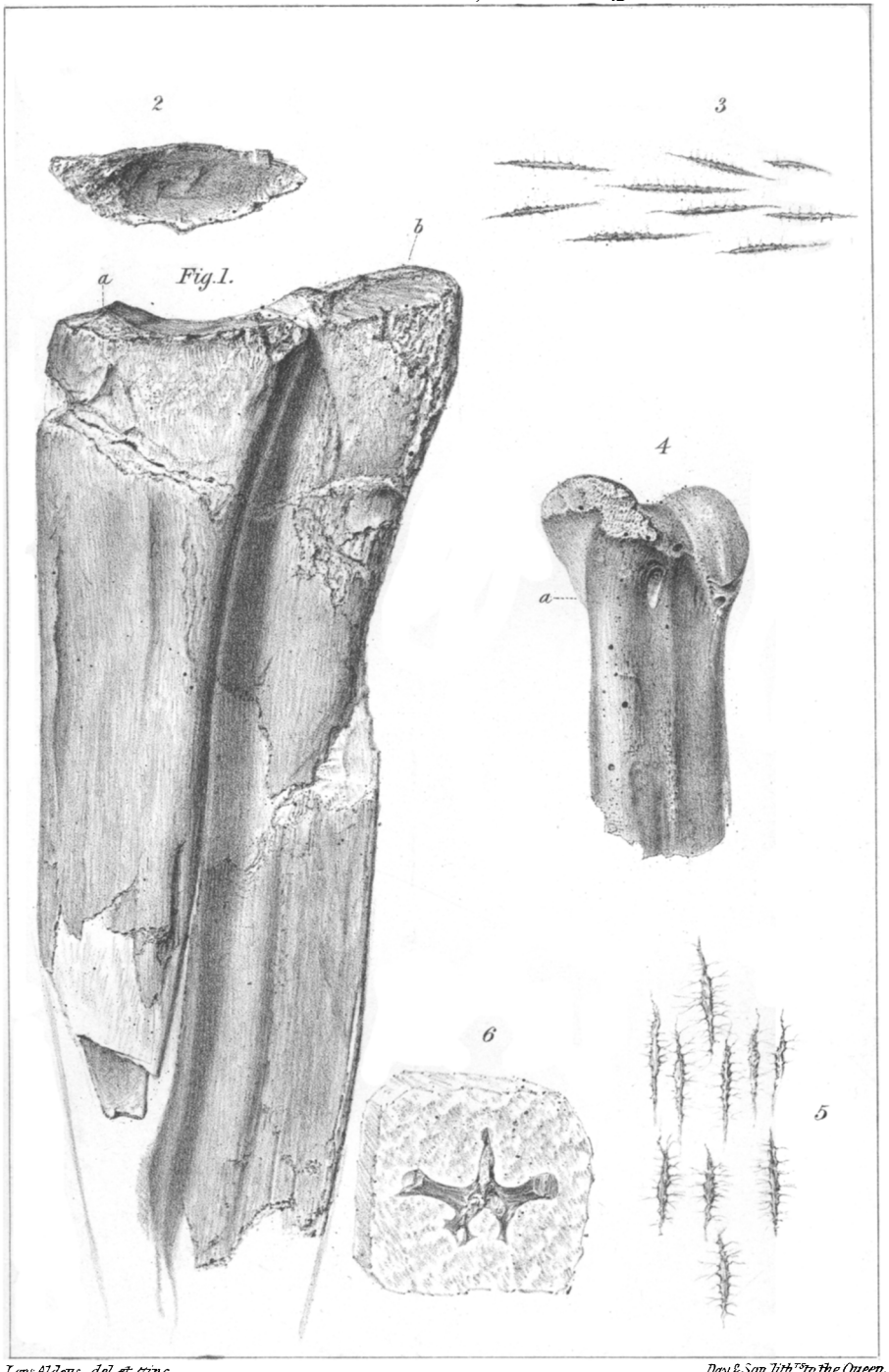
Mr. BOWERBANK ON BONE CELLS, P. 2. &c.



Lens Aldous del. et zinc.

Day & Son, lith.rs to the Queen.

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