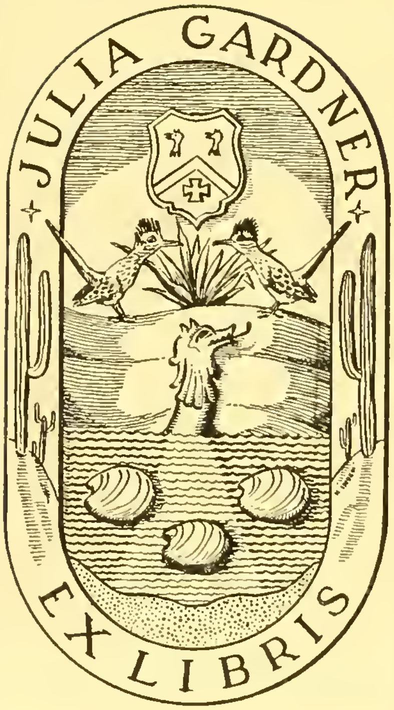
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THE EOCENE AND LOWER OLIGOCENE CORAL FAUNAS OF THE UNITED STATES

WITH

DESCRIPTIONS OF A FEW DOUBTFULLY CRETACEOUS SPECIES

BY

T. WAYLAND VAUGHAN

WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Washington, D. C., May 26, 1899.

Sir: I have the honor to transmit herewith a manuscript entitled The Eocene and Lower Oligocene Coral Faunas of the United States, with Descriptions of a Few Doubtfully Cretaceous Species, and to request that it be published as a monograph of the Survey. My study of these faunas was begun before my association with the Survey, but has been completed since my assignment as assistant to Dr. Wm. H. Dall, in the Division of Cenozoic Invertebrate Paleontology. My special thanks are due to Dr. Dall for his encouragement of this work.

Very respectfully,

T. Wayland Vaughan,
Assistant Geologist.

Hon. Charles D. Walcott,
Director United States Geological Survey.

PREFACE.

In the winter of 1892, while a student at Harvard University, I began a study of the Eocene corals of the United States, and have continued it, with considerable interruption, during six years.

The study of corals presents peculiar difficulties. The classification depends to a large extent upon minute and obscure structures that are frequently destroyed in fossil specimens; and the system of classification, as so many of the later students of these organisms have pointed out, is thoroughly unsatisfactory, but as yet no good system which can replace the old one has been proposed, although recent investigators have accumulated much valuable data that will probably serve as the foundation for a better and more natural system in the near future.

Another difficulty with which I have had to contend is one that confronts all students of systematic zoology, and especially those of paleozoology, viz, What shall constitute a species? In many instances I have had enormous amounts of material from successive horizons. It may be set down as a law, that the difficulty of defining species in such collections varies with the size of the collection. I have tried to be conservative, and when a form in one horizon grades into a form in the horizon next above, I have called them varieties of the same species, even when the variety possesses an individuality that makes it easily recognizable. In several instances diagrams showing the phylogeny of the varieties are given. These large suites of specimens have shown certain biologic facts that are indisputable, yet how these facts should be presented may be open to discussion. My aim has been to present them as clearly as possible, and in the simplest manner, and I hope that my method will prove satisfactory.

The objects of this paper should be here set forth: First, an attempt has been made to define every species, to present good figures of it, by which it can be easily identified, and to give its stratigraphic and geographic distribution with all precision possible. Many species of fossil corals are excellent time markers and horizon indicators, as they possess a very small stratigraphic range and a rather wide geographic distribution. Second, from the character of the coral fauna, assisted by the lithology, an attempt has been made to determine the bathymetric conditions under which the strata were deposited. Third, all obtainable data concerning the structure and development of the species and genera are given, and the relationships to other genera and species are often discussed, so that, when possible, additional light might be thrown on questions of coral morphology and general classification.

The scope of this paper is wide, and necessarily very many questions are broached that can not now be answered. An attempt has been made to avoid much generalization, because generalizing upon insufficient data within the last fifteen years has put the classification of corals (and in some instances their morphology) in a state of great confusion.

In my studies I have received numerous courtesies from both institutions and individuals in the loan of specimens and otherwise. I have had opportunity to examine collections belonging to the following institutions or individuals:

1. United States National Museum; Dr. William H. Dall, Curator of Tertiary Invertebrates.

2. Mr. T. H. Aldrich, of Birmingham, Alabama.

3. Wagner Free Institute of Science, Philadelphia, Pennsylvania; C. W. Johnson, curator.

4. Philadelphia Academy of Natural Sciences, which contains all of Lea's types and many of Conrad's. Many of these specimens were loaned to me upon the request of Messrs. Heilprin, Pilsbry, and Stone.

5. Museum of Comparative Zoology of Cambridge, Massachusetts, through the courtesy of Dr. R. T. Jackson.

6. Boston Society of Natural History; Prof. Alpheus Hyatt, curator.

7. Louisiana geological survey, through Dr. Otto Lerch, former State geologist.

8. Johns Hopkins University; Prof. W. B. Clark, curator.

9. American Museum of Natural History of New York; Prof. R. P. Whitfield, curator.

10. The private collection of Mr. J. A. Singley, Giddings, Lee County, Texas.

Dr. J. C. Merriam, of the University of California, sent me all of the Cretaceous and Tertiary material that he possessed from that State; and Dr. T. W. Stanton, of the United States Geological Survey, submitted to me the Eocene corals collected by himself in California, and loaned me all of the specimens in the United States National Museum from the Shark River group of New Jersey.

My own private collection, and that made by me for the United States Geological Survey, both of which are now the property of the United States National Museum, were also available for study.

Prof. Alphonse Milne-Edwards, Director of the Muséum d'Histoire Naturelle of Paris, sent me, at the request of Mr. C. D. Walcott, Director of the United States Geological Survey, photographs of Milne-Edwards and Jules Haime's types of *Astrohelia lesueuri*, *Oculina americana*, and *Eupsammia haleana*, and Dr. H. S. Gane loaned me a specimen of *Turbinolia acuticostata*, which has the costæ perfectly preserved.

Besides the acknowledgments already made, I am indebted to Dr. W. H. Dall, Mr. C. W. Johnson, Dr. R. T. Jackson, and Prof. Alpheus Hyatt for other personal kindnesses.

During the summer of 1897 I went to Europe, for the purpose of visiting various museums and studying collections of corals in order to make comparisons with American material. While there I received courtesies from Dr. W. Weltner, Custos in the Museum für Naturkunde, Berlin; Dr. N. Sokolow, of the Comité Géologique, in St. Petersburg; Prof. Th. Fuchs, and his assistants, Drs. Wähner and Kittl, K. K. Hofmuseum, Vienna; Professor Suess, of the University of Vienna; Geheimrath Professor von Zittel, in Munich; Professor Camerano, of the University of Turin; Messrs. Bernard and Boule, of Muséum d'Histoire Naturelle, Paris; Dr. Henry Woodward, Mr. A. Smith Woodward, Dr. J. W. Gregory, and Mr. R. B. Newton, British Museum (Natural History); Messrs. L. L. Belinfante, William Rupert Jones, and C. Davies Sherborn, of the Geological Society of London, and Sir Archibald Geikie and Mr. E. T. Newton, of the Museum of Practical Geology, London. To these gentlemen I express my heartiest thanks for the aid that was rendered.

Mr. Robert T. Hill submitted to me for study all of the material collected by him during many years of exploration for Mr. Alexander Agassiz in the West Indies. This material has been of great interest for comparison.

Lastly, Dr. Richard Rathbun has given me unrestricted use of the collection of recent corals in the United States National Museum, and Miss Mary J. Rathbun has shown every kindness possible in enabling me to get at any material that I desired to examine.

A few words of explanation of certain quotations in the synonymy should be given here. As the preparation of this paper has extended over several years, quite often a request has come to me for a list of a local fauna, or for descriptions of its species. These requests have been complied with, and in some of my own papers I have referred to certain of the corals as sp. nov. or simply cited a nomen nudum. I have given nomina nuda and species novæ in the synonymy of the proper species, so that what was meant in my earlier papers can be discovered. However, such species date from the publication of this paper.

The illustrations are from drawings by Dr. J. C. McConnell and Messrs. J. Henry Blake, Hunter Harris, E. Sheppard, and H. Chadwick Hunter. Dr. McConnell has made by far the greater number of drawings. The figures were drawn at three different periods, with rather wide intervals between. Some were drawn in 1894, some in the spring of 1897, and some in the winter of 1898–99. They have not all been made to the same scale, but in the plate explanations the scale of the figure or the size of the specimen is given.

THE EOCENE AND LOWER OLIGOCENE CORAL FAUNAS OF THE UNITED STATES.

By T. Wayland Vaughan.

NOMENCLATURE OF THE EOCENE AND LOWER OLIGOCENE FORMATIONS OF THE UNITED STATES.

Attention is called especially to Bulletin 83 of the United States Geological Survey, Correlation papers—Eocene, by W. B. Clark, and to "A table of the North American Tertiary horizons, correlated with one another and with those of western Europe, with annotations," by William H. Dall.[1] These two papers give a rather thorough treatment of the subject. The following table is extracted from Dall's paper. Two points in this table deserve special mention: First, the old name "Lignitic" or "Eolignitic" is abandoned, and the various beds of these are placed in two stages—a lower, "Midwayan," following Harris,[2] and an upper, to which the name "Chickasawan" is given; second, the old lithologic name "Buhrstone" is suppressed and the locality designation "Tallahatta" is given.

Often one can not differentiate the various horizons of the Claibornian in other States as they are recognized in Alabama and Mississippi; therefore the name "Lower Claiborne" is convenient to designate collectively that part of the Claibornian below the Claiborne sand horizon.[3]

[1] Eighteenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1898.

[2] Am. Jour. Sci., 3d ser., Vol. XLVII, 1894, p. 301.

[3] Harris was the first to use "Lower Claiborne" in this manner. Cf. Am. Jour. Sci., 3d ser., Vol. XLVII, p. 301.

Correlation table of lower Tertiary formations: data to 1895; by W. H. Dall.[1]

Epochs and stages.	Pacific coast.	Gulf States.	Atlantic States.	Foreign analogues.
OLIGOCENE:				
a. Upper or Chipolan				
Transitional	....	Shell Bluff group (?)	Naparima beds (?)	Tongrian.
b. Lower or Vicksburgian.	Aturia bed	Ocala group Coral limestone Vicksburg Red Bluff	Shell Bluff group (?) Cooper River marl Guallava sandstone	Ligurian.
EOCENE:				
a. Jacksonian	Foraminiferal shales (?)	Zeuglodon beds Moodys Branch beds Marks Mill beds	Santee beds .... Manzanilla beds	Bartonian.
b. Claibornian	Arago beds	White Bluff marl Claiborne sand Newton Ostrea sellæformis beds Lisbon beds Tallahatta	Gatun beds .... Shark River, N. J Wilmington, N. C Orangeburg, S. C	Parisian.
c. Chickasawan (Wilcox)	Kenai group	Hatchetigbee beds (Woods Bluff?) Bashi series Tuscahoma Bells Landing Greggs Landing Nanafalia	Atano beds (?) *a.* Woodstock beds. Pamunkey, Va., Md. *b.* Aquia Creek beds.	Suessonian.
d. Midwayan	Tejon Martinez Puget group	Naheola Matthews Ldg. Sucarnochee Midway limestones	....	Cernaysian.
MESOZOIC	Chico-Shasta	Ripley group	Upper Green marl	Danian.

AGE OF THE BEDS IN VARIOUS STATES FROM WHICH COLLECTIONS OF CORALS HAVE BEEN OBTAINED.

Collections of corals from New Jersey, Maryland, Virginia, South Carolina, Georgia, Alabama, Mississippi, Arkansas, Louisiana, Texas, and California are described in this paper.

New Jersey.—All of the species from New Jersey come from the Shark River beds. Clark regards these beds as the very lowest Eocene.[2] Dall[3]

[1] Eighteenth Ann. Rept. U. S. Geol Survey, Pt. II, facing p. 334.

[2] Upper Cretaceous formations of New Jersey, Delaware, and Maryland: Bull. Geol. Soc. America, Vol. VIII, 1897, p. 354.

[3] Op. cit., p. 344.

says: "This, like the Eocene of North Carolina, is regarded by Harris as newer than that of Maryland and Virginia, which has been included under the name of Pamunkey by Darton." One specimen of a species of Endopachys was found in the material belonging to the Academy of Natural Sciences of Philadelphia. In no other State is a species of this genus known from a horizon below the Claibornian; therefore I am inclined to Harris's opinion that the Shark River beds are higher than the Aquia Creek beds of Darton's Pamunkey formation.

Maryland and Virginia.—In a recent paper[1] Prof. G. D. Harris has advanced the opinion that the Eocene of these States, the Pamunkey of Darton,[2] represents the same horizon as the Bells Landing beds of Alabama. Prof. W. B. Clark[3] has more recently published the opinion that the Maryland and Virginia Eocene deposits "represent the greater portion of the Eocene series of the Gulf, its highest members alone excepted."[4] The corals which have been collected and studied from this region all belong to the same horizon. There is only one species, *Eupsammia elaborata* (Conrad), common to the Alabama region, where it is confined to the Bells Landing and Woods Bluff beds. Since the above was written Professor Clark has sent me some specimens of *Balanophyllia desmophyllum* M.-Edw. and H. from 1 mile southeast of Mason Springs, Maryland. This species ranges from the Bells (Greggs) Landing horizon into the Lower Claiborne.

South Carolina and Georgia.—The collections from these States are insignificant, and sufficient careful paleontologic and stratigraphic work has not been done to make a discussion of the Eocene in them possible.

Alabama, Mississippi, Arkansas, and Louisiana.—These States furnish the type section of the Gulf States Eocene, and practically every horizon of both the Eocene and Lower Oligocene contains species of fossil corals. The Gulf States section in the table of formations is sufficient explanation of the stratigraphic terms.

Texas.—Mr. E. T. Dumble, in the Journal of Geology for September, 1894, summarized what is known concerning the general character and the sequence of the Eocene beds of Texas.

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[1] Am. Jour. Sci., 3d ser., Vol. XLVII, 1894, pp. 301 et seq.
[2] Bull. Geol. Soc. America, Vol. II, Apr., 1891, pp. 439-443.
[3] Johns Hopkins Univ. Circ., Vol. XV, Oct., 1895, pp. 3 and 4
[4] Op. cit., p. 4.

The following subdivisions are recognized:

> 3*d*. Frio clays.
> 3*c*. Fayette sands.
> 3*b*. Yegua clays.
> 3*a*. Marine beds.
> 2. Lignitic beds.
> 1. Wills Point or Basal clays.

1 is the same as the Midway beds of Alabama.

2 contains fossils characteristic of the Lignitic (as defined by Harris in his Arkansas report) of Alabama, i. e., Chickasawan.

3*a*, 3*b*, 3*c*, and 3*d*, all contain fossils belonging to the Lower Claiborne. The Upper Claiborne is not represented.[1] The fossils, as acknowledged by Mr. Dumble, were determined by Prof. Harris.

California.—The Tejon group has been correlated with the Eocene by numerous investigators. A review of the literature on the subject to 1891 has been published by Prof. W. B. Clark in his bulletin on the correlation of the Eocene.[2]

In Science for August, 1893, page 97, Prof. G. D. Harris correlates the fossils from Fort Tejon with the Lower Claiborne. Messrs. J. S. Diller and T. W. Stanton make an additional contribution to the subject in Vol. V of the Bulletin of the Geological Society of America, April, 1894, pages 437 and 438. Stanton has more recently made another contribution to the subject,[3] in which he recognizes an Upper and a Lower Tejon fauna, both Eocene. He shows that the Martinez group of Gabb is a mixture of Upper Cretaceous and Eocene and determines to restrict the name Martinez to the Eocene portion, which corresponds to the Lower Tejon. More stratigraphic work and more study of the faunas of the California Eocene are needed. Dr. J. C. Merriam, of the University of California, is now engaged on such a study, and has published one paper on the subject.[4] He restricts the name Martinez to the Eocene portion of Gabb's Martinez group, his conclusion agreeing with that of Stanton.

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[1] Op. cit., pp. 519-555.

[2] Bull. U. S. Geol. Survey No. 83, pp. 100-106.

[3] The faunal relations of the Eocene and Upper Cretaceous of the Pacific coast: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. 1, 1896.

[4] The geologic relations of the Martinez group of California at the typical locality: Journ. Geol., Vol. V, No. 8, Nov.-Dec., 1897, pp. 767-775.

I describe in this paper two corals—*Faria merriami* and *Stephanocœnia fairbanksi*—both new species, that are doubtfully Cretaceous, and the stratigraphic position of Gabb's "*Astrocœnia*" *petrosa* is not yet known.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF SPECIES.

All doubtful species are omitted from the following table, only those that I recognize as valid appearing in it.

The corals, according to geographic distribution, may be divided into several provinces.

(1) An eastern province, which may be subdivided into (a), Gulf subprovince, extending as far as South Carolina on the Atlantic slope; (b), Virginia, in which State two species common to the Alabama region are found; (c), New Jersey, in which State one species doubtfully common to the Gulf subprovince occurs.

(2) A western, or the Californian province. No species common to the eastern and western provinces are known, although some of the species of one have analogues in the other.

As the greater number of the species occur in the Gulf region, the typical Gulf States section is used to illustrate the stratigraphic occurrence. When the bed from which a species comes can not be correlated with that section, a note of its stratigraphic distribution is given in the column, "Geographic distribution and remarks."

Table showing stratigraphic and geographic distribution of species.

Names of species.	Stratigraphic distribution.													Geographic distribution and remarks.
	Vicksburgian.				Claibornian.		Chickasawan.				Midwayan.			
	Coral limestone.	Vicksburg beds.	Red Bluff beds.	Jacksonian.	Claiborne sands.	Lower Claiborne.	Hatchetigbee beds.	Woods Bluff beds or Bashi series.	Greggs Landing beds.	Nanafalia.	Naheola.	Sucarnochee.	Midway limestone.	
Flabellum conoideum Vaughan												×		Alabama, Arkansas?.
Flabellum conoideum var. matthewsense Vaughan.											×			Alabama.
Flabellum johnsoni Vaughan								×						Alabama.
Flabellum lerchi Vaughan						×								Louisiana, Mississippi, Texas.
Flabellum cuneiforme Lonsdale				×	?	×								South Carolina, Georgia, Alabama, Mississippi, Louisiana, Arkansas, Texas.
Flabellum cuneiforme var. pachyphyllum Gabb and Horn.						×								Alabama, Mississippi, Louisiana, Texas.
Flabellum cuneiforme var. acutiforme Vaughan.						×								Louisiana.
Flabellum cuneiforme var. fragile Vaughan.						×								Alabama.
Flabellum cuneiforme var. wailesi Conrad.				×										Mississippi, Arkansas, Louisiana.
Flabellum cuneiforme var. magnocostatum Vaughan.			×											Mississippi.
Flabellum sp									×					Virginia (Pamunkey formation).
Flabellum mortoni Vaughan														New Jersey (Shark River beds).
Flabellum remondianum Gabb														California (Lower Tejon).
Flabellum californicum Vaughan														California (Upper Tejon).
Flabellum rhomboideum Vaughan			×											Mississippi.
Aldrichia elegans Vaughan				×										Mississippi, Louisiana.
Platytrochus stokesi (Lea)					×	×								Alabama, Mississippi, Texas, South Carolina.
Platytrochus goldfussi (Lea)					×									Alabama.
Platytrochus claibornensis de Gregorio					×									Alabama.
Discotrochus orbignianus M. Edw. and H.						×								Alabama, Mississippi, Louisiana, Texas.
Sphenotrochus nanus (Lea)					×									Alabama.
Sphenotrochus claibornensis Vaughan					×									Alabama.
Turbinolia pharetra Lea				×	×	×								Alabama, Mississippi, Louisiana, Texas.
Turbinolia wautubbeensis Vaughan						×								Mississippi, Louisiana.
Turbinolia acuticostata Vaughan									×					Virginia (Pamunkey formation).
Turbinolia claibornensis Vaughan					×									Alabama.
Turbinolia insignifica Vaughan			×											Mississippi.
Trochocyathus hyatti Vaughan												×		Alabama.
Trochocyathus lunulitiformis (Conrad)				×										Mississippi, Louisiana.
Trochocyathus lunulitiformis var. montgomeriensis Vaughan.				×										Louisiana.
Trochocyathus californianus Vaughan														California (Cretaceous ?)
Trochocyathus stantoni Vaughan														California (Upper Tejon).
Trochocyathus depressus Vaughan						×								Mississippi.
Trochocyathus cingulatus Vaughan													×?	Alabama.

Table showing stratigraphic and geographic distribution of species—Continued.

Names of species.	Stratigraphic distribution.													Geographic distribution and remarks.
	Vicksburgian.				Clabornian.		Chickasawan.				Midwayan.			
	Coral limestone.	Vicksburg beds.	Red Bluff beds.	Jacksonian.	Claiborne sands.	Lower Claiborne.	Hatchetigbee beds.	Woods Bluff beds or Bashi series.	Greggs Landing beds.	Nanafalia.	Naheola.	Sucarnochee.	Midway limestone.	
Trochocyathus clarkeanus (Vaughan)									×					Virginia (Pamunkey formation).
Trochocyathus striatus (Gabb)														California (Upper Tejon).
Trochocyathus zitteli Merriam														California (Martinez group).
Trochocyathus conoides (Gabb and Horn).														New Jersey (Shark River beds).
Paracyathus alternatus Vaughan						×								Alabama, Mississippi, Louisiana, Texas.
Paracyathus granulosus Vaughan								×						Alabama.
Paracyathus bellus Vaughan						×								Mississippi, Louisiana.
Paracyathus rugosus Vaughan								×						Alabama.
Paracyathus cylindricus Vaughan													× ?	Alabama.
Caryophyllia dalli Vaughan				×										Louisiana, Arkansas.
Caryophyllia texana Vaughan								×						Texas.
Steriphonotrochus pulcher Vaughan			×											Mississippi.
Parasmilia ludoviciana Vaughan				×										Louisiana.
Astrohelia neglecta Vaughan			×											Mississippi.
Astrohelia burnsi Vaughan				×										Mississippi.
Oculina vicksburgensis (Conrad)		×	×											Mississippi.
Oculina mississippiensis (Conrad)		×												Mississippi.
Oculina singleyi Vaughan						×								Texas.
Oculina alabamensis Vaughan									×					Alabama.
Oculina harrisi Vaughan			×											Mississippi.
Oculina aldrichi Vaughan			×											Mississippi.
Oculina (?) smithi Vaughan													×	Alabama.
Amphihelia natchitochensis Vaughan						×								Louisiana.
Cœlohelia wagneriana Vaughan									×					Alabama.
Madracis gabbi Vaughan						×								Louisiana.
Madracis johnsoni Vaughan						×								Texas.
Madracis gregorioi Vaughan							×		×					Alabama.
Stylophora minutissima Vaughan														Russell Springs, Georgia (Vicksburgian, Ocala horizon).
Stylophora ponderosa Vaughan	×													Alabama.
Astrangia expansa Vaughan				×										Mississippi, Louisiana.
Astrangia ludoviciana Vaughan				×										Louisiana.
Astrangia harrisi Vaughan				×										Arkansas.
Astrangia wilcoxensis Vaughan													×	Alabama.
Cladocora recreacens Lonsdale				?										Georgia, South Carolina.
Favia merriami Vaughan														California, (Cretaceous?).
Dichocœnia alabamensis Vaughan													×	Alabama.
Haimesiastræa conferta Vaughan								×	×				×	Alabama.
Haimesiastræa petrosa (Gabb)														California, (Eocene?).
Astrocœnia pumpellyi Vaughan														Russell Springs, Georgia (Vicksburgian, Ocala horizon).
Platycœnia jacksonensis Vaughan				×										Mississippi.

Table showing stratigraphic and geographic distribution of species—Continued.

Names of species.	Stratigraphic distribution. Vicksburgian. Coral limestone.	Vicksburgian. Vicksburg beds.	Vicksburgian. Red Bluff beds.	Jacksonian.	Claibornian. Claiborne sands.	Claibornian. Lower Claiborne.	Chickasawan. Hatchetigbee beds.	Chickasawan. Woods Bluff beds or Bashi series	Chickasawan. Greggs Landing beds.	Chickasawan. Nanafalia.	Midwayan. Naheola	Midwayan. Sucarnochee.	Midwayan. Midway limestone.	Geographic distribution and remarks.
Stephanocœnia fairbanksi Vaughan														California, (Cretaceous ?).
Stephanocœnia fairbanksi var. columnaris Vaughan.														
Siderastrea hexagonalis Vaughan													×	Alabama.
Stephanomorpha monticuliformis Vaughan.													×	Alabama.
Mesomorpha duncani Vaughan													×	Alabama.
Balanophyllia desmophyllum M.-Edw. and H.						×		×	×					Alabama.
Balanophyllia desmophyllum var. microcostata Vaughan.										×				Alabama.
Balanophyllia irrorata (Conrad)				×										Mississippi, Louisiana, Texas.
Balanophyllia irrorata var. mortoni (Gabb and Horn).						×								Texas.
Balanophyllia irrorata var. dichotoma (Gabb and Horn).						×								Texas.
Balanophyllia irrorata var. coniformis Vaughan.						×								Texas.
Balanophyllia inauris Vaughan														New Jersey (Shark River beds.)
Balanophyllia ponderosa Vaughan													×	Alabama
Balanophyllia annularis Vaughan									×					Alabama.
Balanophyllia augustinensis Vaughan						×								Texas, Louisiana.
Balanophyllia elongata Vaughan			×											Mississippi.
Balanophyllia caulifera (Conrad)		×	×											Mississippi.
Balanophyllia caulifera var. multigranosa Vaughan.			×											Mississippi.
Balanophyllia baleana (M.-Edw. and H.)								×						Alabama.
Eupsammia elaborata (Conrad)								×	×					Alabama, Virginia.
Eupsammia conradi Vaughan														Virginia, (horizon ?).
Rhectopsammia clairbornensis Vaughan					×									Alabama.
Endopachys maclurii (Lea)				×	×	×								Alabama, Mississippi, Louisiana, Texas, New Jersey ?.
Endopachys maclurii var. tenue Vaughan.						×								Texas, Louisiana.
Endopachys maclurii var. triangulare Conrad.														Mississippi, Louisiana.
Endopachys lonsdalei Vaughan						×								Alabama, Mississippi.
Endopachys shaleri Vaughan														Loc. ? (horizon ?).
Endopachys minutum Vaughan				×										Mississippi.
Dendrophyllia striata Vaughan						×								Louisiana.
Dendrophyllia lisbonensis Vaughan						×								Alabama, Louisiana, Texas.
Dendracis tubulata (Lonsdale)				?										Georgia.
Turbinaria (?) alabamensis Vaughan	×													Alabama.
Porites ramosa (Lonsdale)				?										Georgia, South Carolina.

PROBABLE BATHYMETRIC DISTRIBUTION OF SPECIES.

The studies of various paleontologists and the results of the studies of the bathymetric distribution of recent corals have shown that the fossil coral faunas furnish considerable data concerning the conditions of depth under which deposits containing such fossils were laid down. Using the data which have been accumulated from dredgings an attempt is made to show the probable depths at which the various beds containing fossil corals herein described were deposited.

Genera represented in the Eocene of the United States and depths at which they now live.[1]

		Fathoms.
Flabellum	Shallow water to	1,500
Aldrichia gen. nov.		
Sphenotrochus	Shallow water to	150
Platytrochus, probably extinct.		
Discotrochus, extinct.		
Turbinolia.[2]		100– 220
Trochocyathus		100– 750
Paracyathus	Shallow water to	750
Caryophyllia	Shallow water to	1,500
Steriphonotrochus gen. nov.		
Parasmilia		50– 300
Astrohelia, extinct.		
Oculina	Shallow water to	50
Amphihelia[2]		158– 892
Cœlohelia gen. nov.		
Stylophora	Shallow water.	
Madracis		38– 300
Astrangia	Shallow water to	315
Cladocora	Shallow water.	
Favia	Shallow water.	
Dichocœnia	Shallow water.	
Haimesiastræa gen. nov.		
Astrocœnia	Shallow water.	
Platycœnia gen. nov.		
Stephanocœnia	Reef.	
Siderastrea	Reef.	
Stephanomorpha gen. nov.		
Mesomorpha, extinct.		

[1] Most of the data here given have been taken from Moseley's Deep sea corals, in the Challenger Reports, Zoology, Vol. II, Pt. VII, 1881, pp. 132, 133.

[2] Pourtalès, Bull. Mus. Comp. Zoöl. Harvard Coll., Vol. VI, No. 4, 1880, p. 96.

Genera represented in the Eocene of the United States and depths at which they now live—Continued.

		Fathoms.
Balanophyllia	Shallow water to	400
Eupsammia.		
Rhectopsammia gen. nov.		
Endopachys.[1]		
Dendrophyllia	Shallow water to	750
Dendracis, extinct.		
Turbinaria	Shallow water.	
Porites	Shallow water.	
Total number of genera		36
Recent as well as fossil genera		24
Extinct genera, including the seven new genera		11
Probably extinct		1

Analysis of the recent genera.

Exclusively shallow water	9
Shallow water to 50 fathoms	1
Shallow water to 150 fathoms	1
Shallow water to 315 fathoms	1
Shallow water to 400 fathoms	1
Shallow water to 750 fathoms	2
Shallow water to 1,500 fathoms	2
From 38 to 300 fathoms	1
From 50 to 300 fathoms	1
From 100 to 220 fathoms	1
From 100 to 750 fathoms	1
From 158 to 892 fathoms	1
Data deficient concerning	2
Total	24

Of the twenty-two genera concerning which we have definite information, eighteen occur in water less than 50 fathoms deep, and ten occur only in water less than 50 fathoms deep; all may occur in water 100 fathoms or less in depth, Amphihelia doubtfully excepted. The fauna as a whole is one of only moderately deep or shallow water.

We shall now discuss the probable conditions of depth under which the various beds of the Eocene in the different States were deposited, so far as the corals enlighten us.

[1] In Gulf of California 39 fathoms (coll. U. S. Nat. Mus.).

EOCENE.

MIDWAYAN STAGE.

Midway beds.—The species which I have seen belonging to this horizon all come from one locality, or from the same vicinity—Prairie Creek, Wilcox County, Alabama.

There are eight species referred to these beds:

Oculina (?) smithi Vaughan.
Dichocœnia alabamensis Vaughan.
Haimesiastræa conferta Vaughan.
Stephanomorpha monticuliformis Vaughan.
Siderastrea hexagonalis Vaughan.
Mesomorpha duncani Vaughan.
Balanophyllia ponderosa Vaughan.
Astrangia wilcoxensis Vaughan.

The two following species also are doubtfully referred to them:

Paracyathus cylindricus Vaughan.
Trochocyathus cingulatus Vaughan.

Dichocœnia and Siderastrea are exclusively shallow-water genera; Haimesiastræa, Stephanomorpha, and Mesomorpha are shallow-water types of corals; Oculina lives at a depth of 50 fathoms or less, and Balanophyllia occurs both in shallow and in moderately deep water. We may conclude that the Midway beds in the vicinity of Prairie Creek were deposited in water considerably less than 50 fathoms deep.

Sucarnochee clays and Naheola marls.—These two horizons are represented by only two species, *Flabellum conoideum* Vaughan and *Trochocyathus hyatti* Vaughan.

The collection is not extensive enough to warrant any general conclusion. The water at the time of the deposition of these beds was probably 100 fathoms or more in depth.

CHICKASAWAN STAGE.

Nanafalia Bluff beds.—Only one species, *Balanophyllia desmophyllum* M.-Edw. and H. var. *microcostata* Vaughan, is known from these beds. This genus ranges in depth from shallow water to 400 fathoms.

Greggs Landing beds.—Seven species are known from these beds from Alabama:

Oculina alabamensis Vaughan.
Cœlohelia wagneriana Vaughan.
Madracis gregorioi Vaughan.
Haimesiastræa conferta Vaughan.
Balanophyllia desmophyllum M.-Edw. and H.
Balanophyllia annularis Vaughan.
Eupsammia elaborata (Conrad).

From the genera represented, we infer that the beds were laid down in water less than 100 fathoms in depth.

In Maryland and Virginia, in the Pamunkey formation of Darton, the following species are found:

Flabellum sp.
Turbinolia acuticostata Vaughan.
Trochocyathus clarkeanus (Vaughan).
Balanophyllia desmophyllum M.-Edw. and H.
Eupsammia elaborata (Conrad).
Eupsammia conradi Vaughan.

The shallow-water forms of Alabama are not present; therefore we infer that the water in the Virginia–Maryland region was deeper. The character of the sediments (glauconitic sands) bears out this conclusion.

Bashi or Woods Bluff beds.—From Woods Bluff six species have been collected. They are:

Flabellum johnsoni Vaughan.
Paracyathus rugosus Vaughan.
Paracyathus granulosus Vaughan.
Haimesiastraea conferta Vaughan.
Balanophyllia desmophyllum M.-Edw. and H.
Balanophyllia haleana (M.-Edw. and H).
Eupsammia elaborata (Conrad).

All of these genera excepting Haimesiastraea may occur in shallow or in rather deep water, but probably the water was only moderately deep.

Hatchetigbee Bluff beds.—Only one species, *Madracis gregorioi*, has been seen from these beds. Judging from the association which this species has at Greggs Landing (Bells Landing beds), the inference is that the beds are a shallow-water deposit.

GENERAL CONCLUSIONS REGARDING THE MIDWAYAN AND CHICKASAWAN STAGES.

Fossil corals of these stages from only Alabama and Virginia have been submitted to me for study; therefore any conclusions reached will apply only to those States.

The character of the sediments of any region gives us much data regarding the depths at which the deposits were laid down, but any additional contribution to the subject should be welcome. The data furnished by a study of the corals found in our Eocene deposits lend additional confirmation to the existing opinion upon this subject. These deposits in Alabama are usually of shallow-water origin, and probably none were laid down at a much greater depth than 100 fathoms, while most of them were deposited in water less than 50 fathoms deep. The Maryland-Virginia deposits were almost certainly laid down in considerably deeper water—between 100 and 200 fathoms.

CLAIBORNIAN STAGE.

LOWER CLAIBORNE.

Alabama, Mississippi, and Louisiana.—For Alabama, Mississippi, and Louisiana, excepting Natchitoches, the species are very nearly the same in all of these States for this division of the Claiborne, and apparently all belong to that horizon of the Lower Claiborne called the Lisbon beds.

The following are the species:

Flabellum cuneiforme Lonsdale.
Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Flabellum cuneiforme var. acutiforme Vaughan.
Flabellum cuneiforme var. fragile Vaughan.
Flabellum lerchi Vaughan.
Platytrochus stokesi (Lea).
Turbinolia pharetra Lea.
Turbinolia wautubbeensis Vaughan.
Trochocyathus depressus Vaughan.
Paracyathus alternatus Vaughan.
Paracyathus bellus Vaughan.
Discotrochus orbignianus M.-Edw. and H.
Balanophyllia desmophyllum M.-Edw. and H.
Endopachys maclurii (Lea).
Endopachys lonsdalei Vaughan.
Dendrophyllia striata Vaughan.
Dendrophyllia lisbonensis Vaughan.

No recent species of Platytrochus or Discotrochus are known.

There are no strictly shallow-water genera, but all of the recent genera, excepting Endopachys[1] (whose bathymetric distribution we do not know), Turbinolia, and Trochocyathus, occur in shallow water. Trochocyathus ranges from 100 to 750 fathoms in depth, and Turbinolia from 100 to 220 fathoms.

The data at hand are not sufficient for a more definite determination of depth than is afforded by the Trochocyathus and Turbinolia—i. e., the probable depth is 100 fathoms or more.

The species from Natchitoches, Louisiana, are:

Amphihelia natchitochensis Vaughan.
Madracis ganei Vaughan.
Endopachys maclurii (Lea).
Balanophyllia augustinensis Vaughan.

The depth at which these beds were laid down is probably about the same as that at which the other Lower Claiborne deposition took place.

[1] In our Eocene this genus sometimes occurs associated with shallow-water genera.

Texas.—The following is a list of the Eocene corals of that State by localities. All of the species belong to the Lower Claiborne.

Shipps Ford, and 1 mile below, Bastrop County.

Flabellum cuneiforme Lonsdale.
Platytrochus stokesi (Lea).
Turbinolia pharetra Lea.
Discotrochus orbignianus M.-Edw. and H.
Endopachys maclurii (Lea).

Alum Bluff, Colorado River, 4 miles above Smithville, Bastrop County.

Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Oculina or Astrohelia.
Madracis johnsoni Vaughan.

Smithville, Bastrop County.

Platytrochus stokesi (Lea).
Paracyathus alternatus Vaughan.
Turbinolia pharetra Lea.
Oculina singleyi Vaughan.
Balanophyllia irrorata var. coniformis Vaughan.
Balanophyllia desmophyllum M.-Edw. and H.?

Elm Creek, Lee County.

Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Turbinolia pharetra Lea.
Madracis sp.
Endopachys maclurii (Lea).

West Yegua Creek, Lee County.

Balanophyllia irrorata var. mortoni (Gabb and Horn).

Lexington, Lee County.

Platytrochus stokesi (Lea).
Paracyathus alternatus Vaughan.
Turbinolia pharetra Lea.
Balanophyllia irrorata var. mortoni (Gabb and Horn).

Black Shoals or Colliers Ferry, 1 mile below Milam-Burleson county line.

Paracyathus alternatus Vaughan.
Turbinolia pharetra Lea.
Balanophyllia irrorata var. mortoni (Gabb and Horn).

Moseleys Ferry, Burleson County.

Turbinolia pharetra Lea.
Oculina singleyi Vaughan.
Balanophyllia irrorata var. mortoni (Gabb and Horn).

Wheelock, Robertson County.

Turbinolia pharetra Lea.
Oculina singleyi Vaughan.
Balanophyllia desmophyllum M.-Edw. and H.?

Bold Mound, 9 miles southeast of Jewett, Leon County.

Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Platytrochus stokesi (Lea).
Turbinolia pharetra Lea.

Alabama Bluff, Trinity River, Houston County.

Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Discotrochus orbignianus M.-Edw. and H.
Turbinolia pharetra Lea.
Oculina singleyi Vaughan.
Balanophyllia irrorata var. dichotoma (Gabb and Horn).
Endopachys maclurii (Lea); partly var. tenue Vaughan.

Lewis House, 2 miles east of Alto, Cherokee County.

Turbinolia pharetra Lea.

San Augustine.

Flabellum cuneiforme var. pachyphyllum Gabb and Horn.
Amphihelia natchitochensis Vaughan.
Madracis johnsoni Vaughan.

Upon examining the above lists, from the association of Oculina and the large Madracis with the other species, the conclusion is reached that the beds in which the corals occur were laid down in water probably less than 50 fathoms in depth.

Shark River beds, New Jersey.—The species from these beds are:

Flabellum mortoni Vaughan.
Trochocyathus conoides (Gabb and Horn).
Balanophyllia inauris Vaughan.
Endopachys sp.

The corals indicate a depth of 100 fathoms or more. The presence of large amounts of glauconite would indicate a depth of between 100 and 200 fathoms.

CLAIBORNE SANDS BED.

The species that occur in this bed are:

(?) Flabellum cuneiforme Lonsdale.
Sphenotrochus nanus (Lea).
Sphenotrochus claibornensis Vaughan.
Platytrochus stokesi (Lea).
Platytrochus goldfussi (Lea).
Platytrochus claibornensis de Gregorio.
Turbinolia pharetra Lea.
Turbinolia claibornensis Vaughan.
Rhectopsammia claibornensis Vaughan.
Endopachys maclurii (Lea).

The basis for forming an opinion regarding the depth at which these beds were laid down is not very good. There is an absence of strictly shallow-water forms, but we know that all of the genera that are recent, as well as fossil, also occur in moderately shallow water. As no reef building or strictly shallow-water genera occur in the assemblage, we conclude that the water in which the corals lived was beyond the depth of reefs, probably about 100 fathoms deep.

JACKSONIAN STAGE.

Good collections of corals from the Jacksonian stage have been made in Mississippi and Louisiana. The species from the two States are almost identical. They are:

Flabellum cuneiforme var. wailesi Conrad.
Aldrichia elegans Vaughan.
Turbinolia pharetra Lea.
Trochocyathus lunulitiformis (Conrad).
Trochocyathus lunulitiformis var. montgomeriensis Vaughan.
Caryophyllia dalli Vaughan.
Parasmilia ludoviciana Vaughan.
Astrohelia burnsi Vaughan.
Astrangia expansa Vaughan.
Astrangia ludoviciana Vaughan.
Platycœnia jacksonensis Vaughan.
Balanophyllia irrorata (Conrad).
Endopachys maclurii (Lea).
Endopachys maclurii var. triangulare Conrad.
Endopachys minutum Vaughan.

The depth in which the species lived probably did not exceed 50 fathoms. Astrangia ranges in depth from shallow water to 315 fathoms, but is usually in shallow water. Parasmilia occurs from 50 to 300 fathoms.

LOWER OLIGOCENE.

VICKSBURGIAN STAGE.

Red Bluff beds.—The species found in these beds are:

Flabellum rhomboideum Vaughan.
Turbinolia insignifica Vaughan.
Steriphonotrochus pulcher Vaughan.
Oculina aldrichi Vaughan.
Oculina harrisi Vaughan.
Balanophyllia caulifera var. multigranosa Vaughan.
Balanophyllia elongata Vaughan.

The Oculinæ would suggest a depth of 50 fathoms or less.

Vicksburg beds.—The great abundance of Oculinæ in these beds indicate conditions approaching those favorable to the growth of coral reefs—i. e., shallow-water conditions, or less than 50 fathoms.

Coral limestone at Salt Mountain, near Jackson, Alabama.—Here conditions favorable for reef-making corals obtained. Only two species could be described, because of the poor state of preservation of the material. They are *Stylophora ponderosa* Vaughan and *Turbinaria* (?) *alabamensis* Vaughan. There are many other species in the limestone.

The following is a general section at Salt Mountain:

General section at Salt Mountain, Alabama.

	Feet.
Limestone, with reef corals, contains the two species above mentioned, and other undetermined species, about	75
Hard limestone with triturated shell remains, echinoid spines, etc	20

Section of hill north side of Salt Creek and east side of small draw running into Salt Creek.

	Feet
Bed of *Ostrea vicksburgensis*, many Bryozoa, etc., matrix marly	10
Soft limestone, composed in large part of *Orbitoides mantelli*, contains specimens of Scutella, etc	30

The top of this section is below the bottom of the preceding section.

Smith[1] gives the thickness of the Coral limestone as 150 feet. During my visit to Salt Mountain I found his account of the sequence of the beds absolutely correct, but several aneroid barometer measurements showed his estimate of the thickness of the limestone actually composed of corals too great. One of my measurements made it 90 feet and another 60 feet. I believe his estimate of the thickness of the beds above the *Orbitoides mantelli* zone correct. The corals here seem to have grown on a rising sea bottom.

Pumpelly[2] and Dall[3] have shown that in Florida the Upper Oligocene rests unconformably on the Vicksburgian Lower Oligocene. We do not know the relations of the Upper Oligocene to the Coral limestone in Alabama, but quite probably the elevation that made the coral reef possible carried it above the surface of the water, and it had the same relation to a rising land as the West Indian elevated reefs described by Agassiz and Hill.

Localities in Georgia.—Our collections contain specimens from two localities in Georgia. They are Russell Springs, Flint River, and Jacksonboro. The species from the former locality are *Stylophora minutissima* Vaughan and *Astrocœnia pumpellyi* Vaughan, and from the latter *Cladocora rescrescens* Lonsdale and *Porites ramosa* (Lonsdale).

It is quite probable that both of these localities are in beds of high Eocene or Lower Oligocene age. Russell Springs belongs to the Ocala horizon of the Vicksburg. The corals from them indicate shallow water, a depth not too great for the growth of reef corals.

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[1] Report on geology of Coastal Plain of Alabama: Geol. Survey Alabama, 1894, pp. 107, 108.

[2] Am. Jour. Sci., 3d ser., Vol. XLVI, 1893, pp. 445 et seq.

[3] Bull. Geol. Soc. Amer., Vol. V, 1894, p. 162.

CORALS FROM THE MARTINEZ AND TEJON BEDS OF CALIFORNIA.

Six species have been determined from these beds, viz:

Flabellum remondianum Gabb.
Flabellum californicum Vaughan.
Trochocyathus striata (Gabb).
Trochocyathus zitteli Merriam.
Trochocyathus stantoni Vaughan.
Trochocyathus californianus Vaughan.[1]

It is not known whether *Favia merriami* Vaughan, *Haimesiastræa petrosa* (Gabb), and *Stephanocœnia fairbanksi* Vaughan are Cretaceous or Eocene.

As we do not know the association of these species, very little can be inferred about the bathymetric conditions under which they lived. The simple corals probably lived in water at least 100 fathoms deep; the three compound species probably lived at a depth of less than 50 fathoms.

This introduction has been written for the purpose of showing what assistance may be rendered by accurate paleontologic knowledge in solving some of the problems of the oscillation of the sea bottom in past geologic time. If we possess a minute knowledge of the stratigraphy of a series of beds, and of the lithologic constitution of each part, and have carefully made collections of fossils at every horizon from which they can be obtained, accompanied by exact stratigraphic data, I believe it possible, by using the physical data furnished by stratigraphic knowledge and the paleontologic data obtained by knowing the faunas, to discover with considerable accuracy both the number and the amount of the oscillations that any series of beds has undergone during its deposition. Corals are usually especially good indices of the depth of the water in which they lived, of its temperature, purity, etc.

AFFINITIES OF THE EOCENE AND LOWER OLIGOCENE CORALS OF THE UNITED STATES FOR THOSE OF OTHER COUNTRIES.

Very few of the fossil corals of these two periods are the same as or similar to corals from localities not on the North American Continent. Occasional resemblances between the American and European species are pointed out in the descriptions. In some instances the specific distinction between an American and a closely related European form is not alto-

[1] Since this manuscript was prepared, Doctor Merriam informs me that this species is Cretaceous, being associated with *Coralliochama orcutti* and other Cretaceous species.

gether satisfactory, but in only one instance have I identified an American with a European coral. The analogy between species is usually between those occupying the same relative stratigraphic positions.

There seems no resemblance between the species from the North American Continent and those from the West Indian Islands. Not a single species has been found common to the two regions.

This is not true of the Upper Oligocene and later corals of the Florida region and the West Indian fossil and recent faunas; but usually there is considerable difference in these.

GENERIC AFFINITIES OF THE EOCENE CORAL FAUNA OF THE GULF REGION WITH RECENT FAUNAS.

The following is the geographic distribution of the recent genera found also in our Eocene deposits, taken for the most part from Duncan's Revision of the Genera of the Madreporaria:

Flabellum, almost universal.

Sphenotrochus, Mediterranean Sea and North Africa, coast of Brazil, European coasts of North Atlantic Ocean, South Australian coasts.

Platytrochus, Australian seas (?)

Turbinolia, Caribbean Sea (Pourtalès).

Trochocyathus, West Indies, South American seas.

Paracyathus, Mediterranean Sea, Indian Ocean, Pacific Ocean, California (Pearl Islands), Caribbean Sea, North Atlantic Ocean, Josephine Bank.

Caryophyllia, littoral and deep sea, very general.

Oculina, Indian Ocean, Pacific Ocean (?), Florida, and Caribbean Sea, Bermudas.

Amphihelia, Atlantic Ocean, Caribbean Sea, Mediterranean Sea, Australian seas, Formosa.

Stylophora, Red Sea, Indian Ocean, Cape of Good Hope, Chinese seas, Australian seas (?)

Madracis, Madeira, Florida, Caribbean Sea, Brazil, Isle de Bourbon, Indian Ocean, Adriatic Sea (von Heider).

Parasmilia, Caribbean Sea, Philippines.

Astrangia, East Indies, Florida, Central America, Panama Bay, east and west coasts of North America, Strait of Magellan.

Cladocora, West Indies, Mediterranean Sea, Madeira.

Favia, West Indies, Red Sea, Indian Ocean, Pacific Ocean, Australian seas.

Dichocœnia, West Indies, East Indies.

Astrocœnia, Caribbean Sea.

Stephanocœnia, West Indies.

Siderastrea, Red Sea, Indian Ocean, islands off west coast of Africa, Caribbean Sea.

Balanophyllia, Mediterranean Sea, English Channel (*B. regia*), St. Helena, Madeira, Philippines, Fiji, Japan, Korea, Chinese seas, Australian seas, California, Caribbean Sea.

Eupsammia, Chinese seas.

Endopachys, Australian seas (?), west coast of America (Coll. U. S. Nat. Mus.).

Dendrophyllia, Atlantic Ocean, Cape Verde, Madeira, Mediterranean Sea, Pacific Ocean, Arafura Sea, Chinese and Australian seas, Bay of Panama, California, Caribbean Sea.

The foregoing table shows that the generic relations of our Eocene corals are about equally divided between the mid-Atlantic and the China-Philippine Islands regions. There is a great resemblance between the species of Paracyathus, Balanophyllia, Siderastrea, etc., now found in our West Indian region and the Eocene species of the same genera.

MORPHOLOGY OF THE MADREPORARIAN CORAL SKELETON.

The following account of the principal elements of the coral skeleton is intended as explanatory of the terms used in the descriptive part of this paper. No new elements of structure are described herein, but the material used in illustration has been drawn as largely as possible from hitherto unstudied genera and species, so that this part of the paper would increase our knowledge of some corals, while serving the purpose for which it is especially intended.

The two most important papers on this subject are von Koch's Das Skelett der Steinkorallen, eine morphologische Studie,[1] and Miss Maria M. Ogilvie's Microscopic and Systematic Study of Madreporarian Types of Corals.[2] Miss Ogilvie has also published many of her observations in her monograph Die Korallen der Stramberger Schichten.[3] Wilhelm Volz has given a general account of the subject in his Die Korallen der Schichten von St. Casian in Süd-Tirol.[4]

Besides these workers, many others have made careful observations on the microscopic structure of the coral skeleton. Their works will be referred to as occasion requires. One work, which initiated microscopic

[1] Festschrift für Carl Gegenbaur, Leipzig, 1896, Verlag von Wilhelm Engelmann.

[2] Philos. Trans. Royal Soc. London, Series B, Vol. CLXXXVII.

[3] Palaeontographica, Supplement II, Sect. VII, 1897.

[4] Palaeontographica, Vol. XLIV, Nos. 1 and 2, 1896.

research into the hard parts of corals, should receive special mention. This is Pratz's memoir, entitled Ueber die verwandschaftlichen Beziehungen einiger Korallengattungen mit hauptsächlicher Berücksichtigung ihrer Septalstructur.[1]

ORIGIN OF THE CALCAREOUS DEPOSIT.

The first question concerning the skeleton of corals that engages one's attention is the origin of the calcareous deposit. Von Koch, in Ueber die Entwickelung des Kalkskeletes von Asteroides calycularis und dessen morphologischer Bedeutung, first showed that the calcareous substance is originated by the ectodermal layer. He also considered the skeleton to be secreted by the ectoderm and not formed by the calcification of it. The latter question has been much debated. Von Heider has maintained that the skeleton originates by an actual calcification of the cells,[2] and believes that he has recognized calcareous granules within the cell walls. Bourne doubts the accuracy of this observation and gives another interpretation of the phenomena.[3] Miss Ogilvie has strongly supported the view of von Heider. She has a rather lengthy discussion of the subject in her description of the septum of Galaxea.[4] The following extract shows the character of the ultimate proof given by her:

> It has been frequently mentioned by writers on corals that organic remnants after removal of the polyp, may be found on the skeleton. Wherever on the surface I found such remnants, they consisted of calicoblasts which showed, in shape, size, and contents, the varieties already drawn by Von Heider. The cells were round, or obovate, The contents varied from yellowish organic cell material to the inorganic fibrous condition. Comparison of my own observations on several corals with the figures given by Von Heider left no doubt that the *isolated skeletal element was a calcified calicoblast cell.*

The italics are Miss Ogilvie's.

Further on,[5] in speaking of the dark bands of the growth lamellæ of the septa, she says:

> The highest magnifying power never displays any structure in the case of points or bands that appear dark, but only shows *a general amorphous substance, which I can only regard as the carbonized residue of the originally unchanged organic parts of the calicoblasts.*

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[1] Palæontographica, Vol. XXIX.

[2] Sitzungsb. K. Akad. Wiss., Wien, Vol. LXXXIV, Sect. I, Dec. No., 1881, pp. 652, 653, 658. Von Heider, in this paper, names the skeleton-forming cells calicoblasts.

[3] Quart. Jour. Microsc. Sci., Aug., 1897, pp. 25, 26.

[4] Microscopic and Systematic Study of Madreporarian Types of Corals, pp. 114 to 117.

[5] Ibid., p. 127.

Miss Ogilvie has presented no evidence that these calcareous products of the coral animal contain organic cell material, or that there is "a carbonized residue" in the skeleton. Our knowledge of the origin of the skeletal matter has not, therefore, been advanced by Miss Ogilvie's research.

In working over my own thin sections, I have seen practically all the phenomena described by Miss Ogilvie, but as yet I have been unable to institute a series of rigid tests to determine their meaning.

After this paper had gone to press, Mr. Gilbert C. Bourne's Studies on the Structure and Formation of the Calcareous Skeleton of the Anthozoa[1] came to my notice. A résumé of Mr. Bourne's paper can not now be given here. He proves effectively that the skeleton of the Madreporaria is not originated *by the calcification of* ectodermal cells, but that it is *secreted by* the calicoblasts.

THE BASAL PLATE.

In those corals that are originally attached to some basal object of support, the first-formed skeletal part is the basal plate. This was first discovered and described by von Koch in his study of the development of *Asteroides calycularis.*[2] He secured young larvæ on bits of cork, and observed that the building of the skeleton is begun by the larva forming "a thin circular plate, composed of round or elliptical crystal elements (Krystaldrüsen), which originally have openings between them, but these soon become filled out through a further secretion of lime by the ectoderm."[3] Von Koch states that "this first thin little plate is later more and more thickened through a more or less clearly laminated deposit of new substance by the ectoderm, and not seldom, even in old grown skeletons, it can still be clearly shown in sections through the principal axis of the polyp."[4] In examining young attached specimens of corals, even fossil, the basal plate can sometimes be clearly distinguished. Pl. XXI, fig. 12, shows a very young stage of *Rhectopsammia claibornensis*, in which only the basal plate and a few septa have been developed. Quite frequently, by breaking a young attached coral from its object of support, the basal plate may be seen on the originally attached end of the coral. Theoretically it can not

[1] Quart. Jour. Microsc. Sci. (N. S.), Vol. XLI, Pt. IV, No. 164, Jan., 1899, pp. 499-547, pls. xl-xliii.

[2] Ueber die Entwickelung des Kalkskeletes von Asteroides calycularis und dessen morphologischer Bedeutung: Mitth. Zoolog. Station zu Neapel, 1882, Pt. III, pp. 284 to 292, pls. xx, xxi.

[3] Das Skelett der Steinkorallen. Gegenbaur Festschrift, p. 253.

[4] Op. et loc. sup. cit.

be doubted that at first all corals possessed a basal plate. It seems that in some corals it has been suppressed, and the formation of the skeleton begins with the building of the septa. Such a condition has been described by Lacaze-Duthiers for Balanophyllia.[1]

THE EPITHECA.

The discussion of the epitheca can best be introduced by another quotation from von Koch:[2] "The epitheca is secreted by the outer surface of the pallium and is, as this passes directly into the foot, a continuation of the basis (basal plate), and is separated therefrom in that it does not rest upon an object of support (Unterlage), but makes an angle with this (which may regarded as a plane)." The epitheca is a coating laid down on the outside of the corallum over the ends of the septa and costæ and on the outside of the wall. It presents numerous conditions; it may be transversely wrinkled, covering the whole outer surface of the corallum; it may be highly polished, or it may be present as occasional threads or shreds encircling some coralla at various levels. The height to which the epitheca rises on the outside of the corallum is usually considered to be an indication of the distance the soft parts extended down the outside of the corallum. (See Pl. I, fig. 1.) If the polyp invested the whole corallum, there would be no epitheca; if, when distended, it reached almost to the base, there would be only a little epitheca; if the animal did not protrude itself beyond the calicular cup, the epitheca would reach to the calicular margin—the epitheca keeping pace in its growth with the gradual elevation above the base of the lower edge of the soft parts of the animal. To how great an extent this is proved I am not prepared to say. Ogilvie[3] says: "The epitheca is an external basal structure laid down at the angle of the aboral wall, where it bends toward the oral or peristomal region of the polyp" (figs. 22, 36). Moseley has proved, from species of Flabellum collected during the Challenger Expedition, that the soft parts do not extend beyond the edge of the cup.[4] This fact may be correlated with the epitheca extending to the upper edge of the corallum.[5]

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[1] Arch. Zool. Exp., 3d ser. Vol. V, 1897. I have been unable to consult this paper, and base my reference to it on Bernard's paper in Jour. Linn. Soc., London, Zool., Vol. XXVI, 1898, p. 512.

[2] Op. sup. cit., p. 254.

[3] Micros. and Syst. Stud. Mad. Types of Corals, p. 248.

[4] Deep sea corals: Challenger Reports, p. 162.

[5] Fowler thinks that the polyp of *Flabellum patagonicum*, when fully distended, covers the upper fourth of the outside of the corallum. Quart. Jour. Microsc. Sci., Vol. XXV, October, 1885, p. 586.

Very few observations on this point are known to me, and I have had no opportunity to make any myself. Ogilvie[1] considered the thick extrathecal deposit laid down by many Turbinolids as epithecal in nature. The septa and wall in many corals are externally increased in size and thickness from the outside by the activities of the protruding soft parts. An example is *Eusmilia knorri*, and the reader is also referred to the description and figure of *Paracyathus alternatus*, page 105, Pl. VIII, figs. 11 and 14, and of *Caryophyllia dalli*, page 110, Pl. IX, fig. 2. If the definition of epitheca given by Ogilvie is to be retained, it seems to me very doubtful whether such an external deposit as that described for these species can be considered epitheca. This question will be alluded to again in discussing types of walls.[2]

Pl. I, fig. 2, shows how the epitheca of Manicina is laid down on the projecting outer ends of the septal trabeculæ. The microscopic structure is quite different from that of the septa and wall, but resembles that of the dissepiments. The minute calcareous fibers do not show a definite grouping around certain clearly recognizable points, centers of calcification, but are placed normal to the epithecal surface.

SEPTA.

The basal plate was described first, because it is the first part of the skeleton formed, and the epitheca next, because it is considered the morphologic continuation of the former. After the basal plate, the septa are the skeletal structures next formed.

In order to introduce the discussion of the septal structure, the septa of *Manicina areolata* (Linn.) will be described in considerable detail.

STRUCTURE OF THE SEPTUM OF MANICINA AREOLATA (LINN.).

Examined macroscopically, with the aid of a hand lens, the septum exhibits on the lateral face a large number of elevated striæ that run from the wall to the septal margin. The striæ on the inside of the wall pass upward and inward, i. e., the inclination from the perpendicular is toward the inside of the calice; on the outside of the wall the striæ at first pass upward, bending outward, but soon come into an almost horizontal position. This line, away from which the striæ diverge, is called the area or line of diver-

[1] Op. cit., p. 250.

[2] Bernard, in the paper already alluded to (pp. 501, 505), has given an accurate and detailed account of the epitheca. His statements are in accord with the conclusions of von Koch.

gence. When the septum is viewed with the edge toward one, the striæ are seen to be perfectly symmetrical with reference to the median plane of the septum, one stria standing exactly opposite another. Along the course of each stria are some rather pointed granules. Each pair of opposite striæ ends on the septal margin in a distinct, rather pointed, tooth.

The septum may be divided into two parts: First, that within the wall, the intratheeal portion, or what is usually understood by the septum; and second, the extratheeal portion, or what is usually called the costa. The inner ends of the septa become modified into lobes, called pali.

SECTION PARALLEL TO FLAT SURFACE OF SEPTUM.

(Pl. I, fig. 2.)

Such a section passes radially through the longitudinal axes of the striæ and permits a study of their minute structure. The distance across the striæ is not always the same. They are narrower at the line of divergence, and become wider as they pass away from it. As the septal edge is approached, new striæ are quite often introduced between the old. The distance across four striæ near the line of divergence measures 0.655 mm., or an average of about 0.16 mm. At the edge one stria may measure 0.374 mm. across. Along the axis of each stria is a series of darkish or clouded bodies, and crossing the axis are angular lines with the apex of the angle directed distally. A pair of opposed striæ is a septal trabecula; the dark bodies along the axis are along its axis of calcification; the lines alluded to as crossing the trabecular axis are the lines of trabecular growth, and are formed parallel to the growing edge of the trabecula. Between the trabeculæ are dark lines indicating the lines of their fusion. Examined more closely, minute calcareous fibers that diverge distally from the axis of the trabecula are seen. The dark line of the trabecular axis is composed of a series of roundish bodies—there are about three in the space of 0.032 mm., although they may be slightly more crowded. The fibers converge proximally to these dark points, which mark the axis of the calcification.

CROSS SECTION OF SEPTUM.

(Pl. I, fig. 3.)

In this section the trabeculæ are cut across, and one looks down upon the ends of their axes. There is no necessity to give measurements of the distance from one axis to the next, as, unless the trabeculæ are cut exactly perpendicular to their axes, the measurements will be misleading. The figure well shows the appearance of the section, but much of it has no structural significance. The axis of the trabecula in cross section is either a dark- or a light-colored point. Surrounding this point is a concentric light-colored area, which is composed of calcareous fibers that radiate outward, like the spokes of a wheel, around the central point. In many instances the fibers converge at one point, but in some cases there seem to be several points, two or three, very closely crowded together, each with its group or fascicle of fibers. The first condition is the usual one; the latter is the exception. Running concentrically around the centers and crossing the fibers are very fine, alternately darker and lighter bands—the growth lamellæ.[1] Outside of this lighter area and surrounding the trabecular axis the figure shows a darker area. This darker area has no structural importance. The difference in color is due simply to difference in condition of preservation. A suture indicating the line of fusion between adjacent trabeculæ can be distinctly seen between nearly all the trabeculæ. The granulations on the surface are produced by some fibers passing outward beyond the general surface of the septum.

All septa whose structure has been studied have been found to be composed of trabeculæ more or less completely fused. The various methods of trabecular formation will be briefly outlined.

As yet it has not been determined to what features of structure the greatest systematic weight should be given.

THE AREA OR LINE OF DIVERGENCE.

It was pointed out in describing the structure of the *Manicina areolata* septum that the trabeculæ on one side of the line running parallel to the longitudinal axis of the septum bend toward the interior of the corallum, while on the outside of this line they bend toward the outside. The width of the zone on either side of this line is variable, and in some instances the external one may be very narrow or suppressed altogether. The external zone is usually narrower or suppressed in corals that have a small costal development, with nonexsert septa, or those with septa confluent from one calice to the next. The outer zone is very narrow in Flabellum, and in *Mesomorpha duncani* (Pl. XVIII, fig. 10) there is no line of divergence for an individual

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[1] Cf. Ogilvie, op. cit., pp. 111, 112.

septum of one calice. The trabeculæ in the last-mentioned coral pass upward and slightly inward from a vertical line that indicates the limits between two adjoining calices. The line of divergence in highly arched septa, such as is the case in *Dichocœnia stokesi* M.-Edw. and H.,[1] often coincides with the vertical axis of the arch.

Thus, it seems that the relations of the septal zones, one on each side, to the line of divergence depends on certain mechanical conditions In a septum with a nonexsert margin and a small costal development, one would expect the outer zone to be narrow or even suppressed altogether.

SIMPLE AND COMPOUND TRABECULÆ.

A simple trabecula may be defined as a trabecula composed of a single series of simple calcification centers. Compound trabeculæ may be of two kinds. The Mussa septum may be taken as an illustration of the first.[2] A trabecula does not arise at a line of divergence running parallel with the longitudinal axis of the septum. The septal margin presents large spiniform teeth. Each one of these teeth possesses its line of divergence, so that each tooth has a structure analogous to that of such a septum as Dichocœnia (Galaxea is the coral with which Ogilvie draws comparison).[3] These compound trabeculæ have their origin at a line of divergence corresponding in position with the wall. The second type of the compound trabecula may be illustrated by Orbicella (Heliastræa, auct.). Ogilvie has described the structure of the Orbicellan septum in her work already quoted (pp. 139–146). It differs from Mussa in having smaller compound trabeculæ, and a calcification center is sometimes composed of groups of fascicles which radiate outward from different points in the center. The calcification center itself is compound. To enter into an elaborate discussion of these features is somewhat beyond the purpose of this résumé.

DIRECTION OF THE TRABECULÆ.

The inclination of the trabeculæ with reference to the longitudinal axis of the septum is extremely variable. In many corals the angle between them is at first small, but as growth proceeds the inclination becomes greater. (Compare Pl. I, figs. 2 and 4.)

[1] See p. 140 of this paper.

[2] Ogilvie, Microsc. and Syst. Stud. Mad. Types of Corals, pp. 128–139. Cf. fig. 14, p. 123.

[3] Ogilvie uses the word homologue where I have used analogue. Her use of the word homologue seems to me loose.

There is every stage between this condition and one in which the trabeculæ pass horizontally inward (cf. Platycœnia, p. 150 and Pl. XVII, fig. 9a, of this paper). Miss Ogilvie describes a similar one for Turbinaria (see op. cit., pp. 203-211). Still other instances might be cited, but these serve as examples.

WIDTH OF THE TRABECULÆ.

The trabeculæ of different corals are of varying widths. In the same septum the trabeculæ are narrower at the point of their origin, and become wider as they increase in length. The width of the trabeculæ is extremely important, because it is one of the factors that determines the character of the septal margin. The smallest that I have measured are those of *Haimesiastræa conferta*, which have a width of 0.016 mm., and those of *Eusmilia knorri*, which have a width of 0.048 to 0.069 mm. (Pl. I, fig. 5). Ogilvie says that the trabeculæ of Goniastræa "so far as they can be clearly distinguished, have a diameter of 0.03 mm. to 0.04 mm." "At the same time the surface ridge has a diameter of about 0.15 mm."[1]

The diameter of the trabeculæ in Manicina has already been stated to be from 0.14 mm. to 0.374 mm. A single trabecula in *Antillia ponderosa* (Duncan), from Bowden, Jamaica, may measure 0.83 mm. in diameter; 0.55 mm. is not at all large for one. (See Pl. I, fig. 4.)

INFLUENCE OF WIDTH OF TRABECULÆ ON THE DIRECTION OF THE CALCAREOUS FIBRO-CRYSTALS.

Ogilvie has frequently stated that in such corals as Euphyllia the fibro-crystals stand almost perpendicular to the median septal plane.[2] She does not seem to have studied Euphyllia herself, but refers to Bourne's paper On the Anatomy of Mussa and Euphyllia and the Morphology of the Madreporarian Skeleton.[3] I have not studied Euphyllia, but have studied Eusmilia. Pl. I, fig. 5a, shows how the fibro-crystals converge downward along the axis of a trabecula. The cross section (Pl. II, fig. 2) shows the fibers with an arrangement more or less perpendicular to the median septal plane. There also seems to be a plane center of calcification—i. e., calcification along a plane. The latter is merely an appearance. In the cross section the trabecular axes can be distinguished as in Manicina, though not so easily. They measure about the same distance across in both the radial

[1] Ogilvie, op. cit., pp. 148, 149. [2] Op. cit., pp. 160, 161. [3] Quart. Jour. Microsc. Sci., Aug., 1897.

and transverse sections. When the trabecular axes are very close together and the septa are quite thick, after passing a slight distance away from the axis, by simple mechanical crowding, the fibers must necessarily be almost parallel one to another, and near the area of divergence they stand perpendicular to the median septal plane; exterior to the area of divergence they diverge outward, interior to it they diverge inward. It seems to me that the arrangement of the fibers of a septum is a function of the size of the trabeculæ, thickness of the septa, and the trabecular inclination, and that it has no importance except when taken as an index to some other character of the septum.

COMPACTNESS OF SEPTA.

If the trabeculæ composing a septum are continuous and fuse completely, a compact septum is the result; but should the continuity of a trabecula be broken, or should the fusion between adjacent trabeculæ be incomplete, septal perforations are produced. The greater number of corals described in this paper have solid septa. Pl. XXI, fig. 7, *Eupsammia elaborata*, and Pl. XXIII, fig. 3, *Turbinaria* (?) *alabamensis*, show corals with perforate septa. Pratz[1] has described in detail the structure of several perforate septa, viz, Cyclolites, Astræomorpha, Leptophyllia, and his so-called Thamnastræa. We may inquire a little more closely into the causes which produce a compact or perforate septum. In all of the septa whose structure I know the fibro-crystals as seen in longitudinal, tangential, and radial section pass outward from the median septal plane and converge proximally (downward) along the trabecular axis. In order that the fibers of adjacent trabeculæ may unite, they must possess a certain lateral elongation as they diverge from the trabecular axis. Very often the fibers bending outward from the trabecular axis must be longer than those passing along the axis to the next calcification center. If the calcification centers are elliptical or elongate in the direction of the axis of the trabecula, complete fusion will be facilitated. Among some corals[2] the fibers are often not long enough laterally to meet those of the next trabecula. The consequence is compact trabeculæ, which fuse where calcification centers are opposed, but pores are left in the interspaces between the trabeculæ where no calcification centers stand opposite. When septal pores are formed in

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[1] Op. et loc. cit.

[2] Cf. Pratz's fig. 4 of a septum of Cyclolites, section parallel to the flat surface of the septum.

this way, they may exist near the septal margin, but as the coral increases in age they may be completely closed by further growth of the skeletal elements.[1]

There are instances in which septal pores are produced by the discontinuity of the trabeculæ. Miss Ogilvie[2] says: "The irregular shape of the septal pores in Eupsammia is due to the fact that the growth parts of one trabecula may be disconnected, and also the growth parts of adjacent trabeculæ." Attention is called to the same condition in Balanophyllia and Endopachys described on pages 163 and 189, respectively, of this paper.

SEPTAL MARGINS.

The usual descriptive terms applied to the margins of septa are smooth or entire, finely dentate, coarsely dentate, spinose, etc. The character of the margins may be traced to two causes. One is the trabecular structure of the septum, and the second is the mode of trabecular growth. The general statement may be made that a septal dentation is due to a trabecular axis projecting beyond the curve that limits complete trabecular fusion.

Septa with so-called entire margins may be divided into three classes. The first are those with septa composed of trabeculæ that are formed parallel to the septal margin. Platycœnia (see p. 150) has the trabeculæ directed horizontally inward; therefore the upper septal margin is smooth, but the inner margin is dentate. The second type of entire margin is illustrated by Flabellum. The septum is composed of ascending trabeculæ, but the axis of the trabecula grows no more rapidly than the nonaxial portion, and the resultant form of margin is a continuous curve. Occasionally, in Flabellum or Trochocyathus, a trabecular axis may project slightly and form a crenation. The crenate margins will be discussed later. The third type of smooth margin may be illustrated by Eusmilia. The trabecular constitution of the septum has already been described. The smooth margin in this instance is due to the extremely minute size of the trabeculæ. Pectinia and probably Haimesiastræa are other instances. The septa of *P. mæandrites* really have very minutely crenate margins. An examination of a thin section parallel to the flat surface of a septum

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[1] Koby, Mon. polyp. jurass. de la Suisse: Mém. Soc. pal. Suisse, Vol. XVI, p. 557.

[2] Op. cit., p. 196.

showed distinct lines of growth crossing the trabeculæ in a crenate fashion.

Crenate margins are due to the projection of the axial portion of the trabecula, but the fibro-crystals terminate along a rounded curve. The curve is sometimes a semicircle, the center being below the trabecular apex.

It should be noted here that in corals which typically have septa with entire margins, the fusion of the trabeculæ may not always keep pace with their growth, and thus sometimes a trabecula or several trabeculæ may produce a dentation composed of one or several trabeculæ. *Caryophyllia dalli* (Pl. IX, fig. 2c) and *Parasmilia ludoviciana* (Pl. IX, fig. 9) are illustrations. Quite often young septa may have dentate margins, while the margins of the older septa may be entire (cf. Endopachys).

Septal dentations are of two kinds. The first is typified by Galaxea or Manicina. Each trabecula ends on the septal margin in a distinct simple tooth. The amount of prolongation of the teeth is variable. In the former genus the teeth are quite short, while in the latter they may be rather long. The second kind forms the coarsely toothed or spined septa. Mussa is probably the best illustration. Each compound trabecula forms a large tooth or spine, and each minor component trabecula of the compound trabecula has its minute dentation on the large one. Pl. I, fig. 4, illustrates the dentation of a septum of *Antillia ponderosa* (Duncan) from the Bowden beds (Oligocene) of Jamaica. There are large teeth, each of which possesses secondary dentations corresponding to the constituent trabeculæ.

LATERAL ORNAMENTATION OF SEPTA.

This subject is best introduced by considering the structure of granulations. Ogilvie has given a thoroughly satisfactory treatment of these. They are formed by the projection of fascicles of fibro-crystals beyond the general septal surface. A granulation may correspond to one or to several combined centers of calcification; in fact, a granulation may be derived in part from the calcification centers of several trabeculæ.

The arrangement of the granulations on the septal faces corresponds to the courses of the trabeculæ, but is sometimes due to the fact that a granulation is formed from calcification centers belonging to several trabeculæ. The trabecular courses may not be easily recognized at first.

Miss Ogilvie has divided septa, according to their ornamentation, into two classes—(a) striated septa; (b) ridged septa. The descriptive terms indicate the character of the ornamentation. The striæ or fine lines on Turbinolia, Eupsammia, and some other septa (see *Trochocyathus lunulitiformis*, Pl. VII, fig. 4; *Discotrochus orbignianus*, Pl. V, fig. 19a; and description of *Dichocœnia stokesi*, p. 140) are due to simple trabeculæ, which often have elongate granulations placed along their courses. A particularly good illustration of a striated septum is *Trochosmilia hilli* Vaughan.[1] Ridged septa are due to the septa being composed of compound trabeculæ. Such a trabecula is thicker along its axial portion and thinner on the sides. The result is a ridge of greater or less width, corresponding to that of the compound trabecula. The granulations of such a ridge follow the distribution of the calcification centers. The genus Mussa is a good illustration of septa of this class. Attention is especially called to Ogilvie's work already cited.

The striæ or ridges present different characters in different corals. They may vary in the sharpness of the summit and also in width, and striæ may be opposite or alternate in position. Simple descriptive adjectives readily suggest themselves for the characterization of these features.

Ogilvie does not take into consideration all of the classes of septa that may be recognized. In Paracyathus, for instance, though the septa show striæ around their upper edges and enable one to discover the direction of the trabeculæ, deeper down in the corallum the granulations have fused from one trabecula to the next to such an extent that they are often connected and arranged in curves parallel to the septal margin. (See *Paracyathus bellus*, Pl. VIII, fig. 20.) A good descriptive term for such septa has not suggested itself.

The ornamentation of the septal faces of Haimesiastræa (Pl. XVI, fig. 4) is peculiar. There are no granulations and no raised striæ, but gentle undulations that cross the trabeculæ.

PALI.

Pali are lobes or teeth occurring on or near the inner ends of septa, and possess some recognizable differentiation from the main body of the septum. *Trochocyathus lunulitiformis*, Pl. VII, figs. 4 and 8; *T. hyatti*, Pl. VI, fig. 20; *Paracyathus alternatus*, Pl. VIII, fig. 11a; *Caryophyllia dalli*, Pl. IX,

[1] Bull. Mus. Comp. Zoöl. Harvard Coll., Vol. XXXIV, 1899, p. 233, pl. xxxvi, fig. 1.

fig. 2b; *Oculina vicksburgensis*, Pl. X, fig. 8a; and *Cœlohelia wagneriana*, Pl. XII, fig. 19b, indicate different kinds of pali. In the cross section of paliferous corals the pali may usually be recognized by the modified thickened inner ends of the septa. Pl. VIII, fig. 7, *Trochocyathus zitteli*, is an illustration of this.

The treatment of these structures by von Koch is so brief and excellent that it is quoted in full:

> The pali (or Pfählchen) are not equal in value to the preceding skeletal parts but can be considered simply as appendages, differentiations of the septa. This has long been known of the so-called false pali (Cladocora, etc.); for one can here easily see on the grown skeletons that the palus is only a lobe divided from the septal surface by an indentation of greater or less depth. I believe that the same is also the case with the so-called true pali; at least this can be proven for *Caryophyllia cyathus*, which serves as the type of corals with true pali. There the young skeletons of less than 24 septa possess no distinct pali (fig. 5). First, after this stage, they occur, and then indeed as indistinct (unverkennbar) lobes of the septa, thus as false pali (Pl. I, fig. 13), and first on old, thickened skeletons do they appear in that individualization which the much copied and generally known figure of Milne-Edwards gives.[1]

The structure of the pali does not differ from that of the septa in any essential way.[2]

SYNAPTICULÆ.

Synapticulæ are rods or bars that connect two adjacent septa. Examples of the rod-like forms are illustrated by the drawings of *Mesomorpha duncani* (Pl. XVIII, fig. 8e) and of *Stephanomorpha monticuliformis* (Pl. XVIII, figs. 6 and 7). The bar-shaped synapticulæ are typically developed in Fungia.[3] Structures similar in character are shown in this paper by Pl. VII, fig. 4, *Trochocyathus lunulitiformis;* Pl. VII, fig. 16, *T. depressus;* Pl. VIII, fig. 20, *Paracyathus bellus;* and Pl. V, figs. 19 and 19a, *Discotrochus orbignianus*.

Synapticulæ have their origin in the fusion of two opposed granulations or of two opposed combined series of granulations across an inter-

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[1] Op. cit., p. 259. Von Koch adds in a footnote: "Nach der gewöhnlichen Darstellung sollen die Pali in der Regel dem ersten Septencyclus fehlen. Ich konnte vielfach konstatiren (z. B. bei Caryoph. rugosa, Morph. Jahrb. 1880, etc.), dass die Pali anfangs vor den Septen des ersten Cyklus stehen und bei den älteren Thieren vor denen des zweiten."

[2] See description of *Dichocœnia stokesi*, p. 140; *Oculina diffusa*, p. 116; also Ogilvie, op. cit., pp. 149 and 153, description of the palus of Goniastræa.

[3] Cf. Ogilvie, op. cit., p. 172, fig. 37.

septal loculus. The granulations that go to form synapticulæ are usually more enlarged than the other granulations. Pratz recognized two different types of synapticulæ, basing their differentiation upon whether two granulations fuse directly across the interseptal loculus or whether a new center of calcification is introduced to effect the junction. To the former kind he gave the name false or pseudosynapticulæ, and to the latter true synapticulæ or simply synapticulæ.[1] Much has been written about the validity of this distinction and its systematic value. Pl. II, fig. 1, represents a section of Siderastrea copied from Ogilvie (op. cit., fig. 71, p. 244).[2] Whether synapticulæ are true or false seems to depend on spacial relations within the interseptal loculi. If the septa are crowded or near their inner margins where their surfaces are close together, the opposed granulations can fuse directly, one to the other; but if the two opposed septal faces are somewhat remote, additional calcification centers are needed to effect the fusion. The figure of Siderastrea shows this well.[3] (See Pl. II, fig. 1.)

Therefore, in my opinion, whether synapticulæ are true or false is of no special systematic importance.

THE WALL (THECA).

The wall of a simple coral or of a corallite of a colony is that part of the skeleton that cuts off more or less completely the interseptal loculus from peripheral communication with the outside.

The minute structure of the walls of corals is of very many types. The oldest type is where the ends of the septa did not fuse distally, but simply had their outer ends bound together by an epithecal covering.[4] The figure of *Rhectopsammia claibornensis* (Pl. XXI, figs. 12 and 13) shows that this coral passes through this stage in its early development (the basal plate and epitheca being considered as homologous).

The next type of wall may be considered the pseudotheca of von Heider.[5] This is formed by the septa becoming distally so much thickened

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[1] Op. cit., p. 9 (Vol. XXIX, p. 89).

[2] For criticisms on this subject, see Bernard, Geol. Mag., Mar. and Apr., 1897, p. 176; and Vaughan, Bull. Mus. Comp. Zoöl. Harv. Coll., Vol. XXXIV, 1899, p. 248.

[3] Von Koch in his Das Skelett der Steinkorallen, p. 260, says in a footnote: "Das Vorkommen von ächten und unächten Synapticula zwischen denselben Septen wurde von mir bei *Fungia* nachgewiesen (Fig. 7). Aus dieser Figur lässt sich auch ersehen (Fig. 3b), dass blosse Höckerchen der Septen ein eigenes Krystallisations-centrum besitzen können." (Morph. Jahrb., Vol. XVI, 1890, pp. 687-688.)

[4] See Ogilvie, op. cit., p. 218, fig. 72.

[5] Arbeiten aus dem Zoölog. Inst. zu Graz., Vol. 1, No. 3, 1886, p. 178.

that they fuse together. The following species illustrate this kind of wall: *Manicina areolata* (Pl. I, fig. 3, part of figure), *Eusmilia knorri* (Pl. II, fig. 2), *Caryophyllia cornuformis* (Pl. II, fig. 3), *Haimesiastræa petrosa* (Pl. XVII, fig. 5), *Dichocœnia alabamensis* (Pl. XV, fig. 4b), and others.

The eutheca of von Heider is formed by new centers of calcification being introduced between the distal ends of the septa to effect fusion. This type of wall is illustrated by *Caryophyllia communis* (Pl. II, fig. 4), and *Oculina diffusa* (Pl. II, fig. 5).

There has been considerable difference of opinion among various students of coral morphology as to the systematic value of eutheca and pseudotheca. Therefore I have taken occasion to study the mural constitution of a considerable number of genera, to determine, if possible, the amount of importance that should be attached to its structure.

Caryophyllia communis (Pl. II, fig. 4) and *Caryophyllia cornuformis* (Pl. II, fig. 3) will show that the character of the wall is not of generic importance unless the genera be separated on that feature alone. I would call special attention to the difference in spacial relations in these two cross sections. In the coral where the septa are remote from one another the theca is a true theca, but where the septa are crowded a pseudotheca is present. Spacial relations seem to be the determining factor.

Pl. V, fig. 8, representing a section of *Platytrochus stokesi*, illustrates another instance of pseudotheca among the Turbinolidæ. This section is described on page 74 of this paper and need not be further noticed here.

An examination of the walls of several genera placed by Ogilvie in her Amphiastræidæ was made because in defining the family she says "true theca present."[1]

Pectinia mæandrites (Linn.) possesses in some instances undoubted true theca, but in others the theca seems false, formed by the fusion of the distal ends of the septa. *Dendrogyra cylindrus* Ehr., the type species of the genus, possesses an absolutely typical pseudotheca. The section of *Eusmilia knorri* M.-Edw. and H., is extremely interesting, because in the same slide there are both true theca and false theca. Pl. II, fig. 2, is drawn from a place where false theca is present. In other places the true thecal centers of calcification are perfectly distinct and are arranged in lines perpendicular to the median septal planes. The wall undergoes peripheral secondary thickening,

[1] Op. cit., p. 334.

i. e., thickening external to the calcification centers, through the activity of the inner face of the edge zone.

I can not be sure that Ogilvie would have included Dichocœnia in her Amphiastræidæ, but she probably would have. Its structure is discussed in considerable detail on page 140, in the descriptive portion of this paper. The wall is a typical pseudotheca.

The following description of the wall of *Euphyllia glabrescens* (Chamisso and Eysenhardt) is quoted from Bourne:[1]

> The centers of calcification are present as conspicuous dark lines running down the center of each septum. The primary and secondary septa are but slighly thickened toward the peripheral ends, the theca being mainly composed of the heads of the tertiary septa. Fig. 7 shows that in the upper part of the caylx the tertiary septa project from a stouter thecal piece, the two together forming a T, of which the thecal portion is the crosspiece. There are no sutures separating the septal from the thecal portion. Lower down in the calyx the tertiary septa die out altogether, but the crosspieces representing their thecal portions remain, and then the section has precisely the appearance figured by Fowler in Lophohelia. From the relations which obtain in Euphyllia, I am not disposed to think that the intercalated pieces figured by him are essentially thecal structures sharply distinguished from septa.[2]

An examination of the walls of a considerable number of genera of the so-called Astræidæ has shown the same variability as in the above-described Eusmilid genera; therefore it does not seem necessary to describe the occurrence of eutheca and pseudotheca among them to get at a general conclusion.

Before stating such a conclusion I wish to note the character of the wall in *Lophohelia prolifera* (Pallas).[3] This species possesses a true theca, and has both ento- and ecto-cœlic septa and tentacles, according to Fowler;

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[1] Op. cit., pp. 27, 28.

[2] The following quotation from von Koch (Das Skelett der Steinkorallen, p. 265) is apropos in this connection: "In der Struktur der Mauer findet sich ein Unterschied, der wohl in dem Verhältniss der Septen zu den Parietes und der dadurch modificirten Ablagerung von Verdickungsschichten seine Erklärung findet: Kommen zwei Parietes auf einen Interseptalraum so sind auf dem Querschnitt des Kelches zwischen je zwei Septen zwei dunkle Trennungslinien zu bemerken, die ein Mauerstück einschliessen, das von keinem Septum durchkreuzt wird (sogenannte Eutheca), kommt aber auf einen Interseptalraum nur ein Paries, so findet sich zwischen zwei Septen nur eine Trennungslinie, und die Mauerstücke erscheinen nach der Lagerung der Krystallisationslinien als Anhänge der Septen (sogenannte Pseudotheca [fig. 16]). Da das Einschieben neuer Septen nicht mit der Vermehrung der Parietes gleichzeitig zu erfolgen braucht, so kann derselbe Kelch in einer gewissen Höhe sich nach dem zweiten, ja es können sogar beiden Typen an demselben Querschnitt vorkommen (also Eutheca und Pseudotheca nebeneinander), wenn ein Theil der Peripherie in seiner Entwickelung etwas vorgeeilt oder nachgeblieben ist (Taf. I, fig. 18). Die Theca kann durch spätere Ablagerung, besonders auf der Aussenseite, sehr verdickt werden (Taf. I, fig. 21)."

[3] Fowler, Quart. Jour. Microsc. Sci., Vol. XXVIII, No. 109, Aug., 1887, pp. 6–10.

there is in each interseptal loculus a mesentery (paries), but still, in apparent contradiction to von Koch, the theca is the so-called true theca (eutheca).

From the great variation not only in the same species, but in a section of a single corallite, no special systematic importance can be attached to the theca being of the so-called true or false variety. True theca marks the Anlagen of new septa, as von Koch and Bourne have shown, or occurs in calices where the septa are distant from one another and their outer ends are not sufficiently thickened to effect peripheral fusion. True theca is correlated with two factors in the growth of the individual coral—the first factor is simply a stage in the development of the septa, and the second is merely that of spacial relation. The character of the theca will vary with the variability of these two factors In the case of the first, the variability will depend upon the retardation or acceleration of the distal and proximal (thecal) portion of the young septum with reference to the free inner portion, and in the second upon the distance between the septa. These two factors may be to a large extent functions of each other.

Before ending the discussion of the wall of the so-called "Madreporaria Aporosa," a few words will be added on the wall of the Turbinolid corals. Ogilvie,[1] in her definition of the family, says: "A true theca or pseudotheca is present peripherally; in all cases coalescent with the epitheca." On page 250 she says: "In many Turbinolidæ the deposit of calcareous matter on the outside of the thecal centers of calcification becomes very great, and may be either compact or show hollow spaces." The character of the epitheca in Turbinolids is variable; in *Paracyathus bellus* (see Pl. VIII, figs. 16 to 18) it consists merely of occasional encircling shreds, while in Flabellum it is closely applied to the wall, often highly polished and porcellanous in nature. There are many Turbinolids in which there is no vestige of an epitheca, e. g., Platytrochus, Discotrochus, etc. I do not see more reason for calling the external thickening of the wall and peripheral ends of the septa of such corals as *Paracyathus alternatus* (p. 105) epitheca than I can for calling the internal growth of these parts by the same name. In corals possessing an edge zone the peripheral parts of the skeleton should grow just as those parts within the wall. If the epitheca is formed at the bend between the aboral body wall and oral body wall, we must try at least to distinguish

[1] Op. cit., p. 333.

between the deposits formed at this angle and that laid down by the broad inner surface of the edge zone.

The relations of the soft parts of the Turbinolidæ to the skeletal parts needs much more study, and until such studies have been made we can not know the homologies of all the skeletal structures of the group. In fossil species soft parts can not be observed, but comparisons can be made with recent corals. Such a comparative study leads me to the belief, above stated, that the extratheeal thickening of many Turbinolid corals is formed in the same way as in Eusmilia, by the inner face of the edge zone applied against the outside of the corallum wall and peripheral ends of the septa, and is not epitheca according to the accepted definition of the latter. The fact that dissepiments[1] sometimes aid in the formation of the corallite wall, or assist in giving it strength, has been noticed by several authors.[2] The wall of a West Indian Lithophyllia (*L. lacera* or *cubensis*, I am not decided about the relations and synonymy of these two so-called species) is strengthened by dissepiments. The relations of dissepiments to the wall of *Stephanocœnia intersepta* are described on page 153.

Many corals may have perforate walls, because the septa may not be uniformly thickened throughout their length in the thecal ring, or the fusion of the septa may not be effected by the introduction of the so-called true thecal calcification centers. In some Turbinolids, e. g., genus Turbinolia, there are regular rows of pores between the costæ. Pores occur also in Trematotrochus, and there are intercostal dimples in at least some species of Sphenotrochus (cf. *Sphenotrochus nanus*, p. 84). The intercostal pores may not be regular, but only occasional, as is noticed in *Paracyathus bellus*, page 108. Such occasional perforations may occur in almost any normally imperforate wall, and have no special significance; it is only when they occur constantly that they are of systematic importance.

The walls of such corals as Alveopora belong in the last class. Bernard has described the structure of this genus with great care.[3] The wall is formed by the fusion of interlocking septal spines.

[1] For discussion of dissepiments, see p. 53 of this paper.

[2] Ogilvie, op. cit., p. 251; Bernard, On the affinities of the Madreporarian genus Alveopora with the Paleozoic Favositidæ: Jour. Linn. Soc., London, Zool., Vol. XXVI, 1898, p. 506.

[3] Loc. sup. cit., pp. 499–500.

SYNAPTICULAR WALL.

The descriptive term tells how such a wall is formed. The synapticulæ are usually grouped in a definite zone, so as to form a perforate wall. Stephanomorpha possesses such a wall. Fungia is a typical example. The walls of the Eupsammidæ are synapticulate (cf. descriptions of *Balanophyllia irrorata*, p. 163, and *Eupsammia elaborata*, p. 182). It is scarcely necessary to state that the synapticulate and imperforate walls grade into each other.

COLUMELLA.

The columella is the result of an attempt of the coral zooid to build a central basal support for itself. Three different kinds may be recognized. First, the false columella is formed by the fusion of the inner ends of the septa into a more or less compact mass. The variation of this class of columellæ is in the degree of solidity—if the septa fuse simply by a few processes without secondary thickening, the columella will be weak and spongy; if they fuse firmly by their inner margins and are then secondarily thickened, a large strong columella will be the result. Second, the lamellar columella is where the axial space of the corallite is occupied by a lamella. Very often it can be shown that this kind of a columella is merely a differentiated portion of some large septum, and such is almost certainly its origin in all cases.[1] Third, the true columella is of several kinds. In a considerable number of genera it is a single style that rises from the bottom of the calice; in some others it consists of a varying number of rods or more or less flattened and twisted pieces that have their origin at the bottom of the calice.

DISSEPIMENTS.

Dissepiments are the thin calcareous partitions by which the coral zooid cuts itself off from the lower part of the corallite cavity which it can no longer occupy. As growth proceeds along the upper portion of the skeleton the zooid is continually being lifted upward, and a space below it is left vacant. Dissepiments are formed to give basal support to the zooid. The dissepiments are arched, the highest part usually being at the wall. The distance apart is usually quite regular, as it represents the amount of a growth period.[2]

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[1] Cf. Ogilvie, op. cit., p. 245.

[2] Ogilvie, op. cit., p. 241.

If the dissepiments at the end of a growth period are formed in a plane perpendicular to the vertical axis of the corallite, they are called tabulæ.

The microscopic structure of dissepiments is quite different from anything described in the preceding, excepting epitheca. No calcification centers could be detected in any dissepiments. They are composed of fibro-crystals standing at right angles to the secreting surface, and show a more or less distinct lamination parallel to the secreting surface. An enlarged section of a dissepiment is shown in Pl. II, fig. 6, *Thysanus excentricus*, and in Pl. II, fig. 2, *Eusmilia knorri*. These specimens are not quite so satisfactory as the material I have of *Diploria cerebriformis*, on which the above notes are based. The method of growth of the dissepiments is especially well illustrated by the specimens of *Haimesiastræa conferta* (Pl. XV, figs. 6 and 8). The formation begins against the septal faces and extends across the interseptal loculus until the two parts meet and fuse. A distinct suture indicating the place of fusion can nearly always be seen in good fresh specimens.[1]

REMARKS ON THE CLASSIFICATION OF CORALS.

The classification of corals is in a most unsatisfactory condition, and no classification that will stand the test of thorough criticism has as yet been proposed. It would require too much space to review all the systems that have been suggested. In this paper the following family names are used: Turbinolidæ (in which family Parasmilia is included), Oculinidæ, Stylophoridæ, Astrangidæ, Astrocœnidæ, Fungidæ, Eupsammidæ, and Madreporidæ. The name Astreidæ has properly no place in the classification of corals, as there is no genus bearing the name Astrea (see p. 154). Therefore I have not used it, and several genera that hitherto would have been referred to it, as formerly understood, I have not placed in any family. The whole classification of corals from beginning to end must be worked over, and in my opinion many of the old families must be divided into several if not many families. A new classification must be based on a knowledge of three things: First, the comparative anatomy or morphology of the corals, i. e., an intimate knowledge of the skeletal structures and their relations to the soft parts; second, the post-embryonic development of the corals; third,

[1] The methods of reproduction and the combination of zooids into colonies will not be discussed, as any late text book on paleontology will give a general idea of the subject.

their succession in geologic time. No one has approached the subject in this manner. Bernard is working along these lines, but his work is not far advanced. The past classifications have been based on some particular features, usually of the skeleton, without reference to the whole structure and history of the organisms. The classification of Milne-Edwards and Haime was based on the gross morphology of the skeleton; that of de Fromentel on the mode of growth. Duncan based his on a combination of the general skeletal features and mode of growth, but evidently did not seek to find what characters were of phylogenetic import. Von Heider and Ortmann based theirs on the structure of the wall, which has been shown to possess almost no systematic value. Ogilvie was carried away by her researches into the microscopic structure of the septa of corals, mixing with her results the false principles used by Pratz, von Heider, and Ortmann in their attempts at classification. She has made but small contribution to formulating a true system of classification. The work of all these, and of many other investigators, has continually added to our knowledge of corals, until now we understand fairly well the whole make-up of the coral skeleton and much of the relations existing between the skeleton and soft parts, even if there is still a great deal to be learned. As our knowledge of fossil faunas increases, we know more and more of the succession of the various species, genera, etc., in time. Therefore, probably before many years, someone may be able to give us a classification based on the actual phylogenetic grouping of the various genera.

If the above represents the status of the question of classification, it is evident why I have not adopted or proposed any system. I will state that I believe the family Turbinolidæ should be divided into several families. Flabellum has not as much in common with Platytrochus or Discotrochus as it has with Eusmilia. I have projected a revision of the Turbinolid genera, but it is not in a condition for presentation.

There is no means of determining how many different types of corals are represented by the old Astreid family.

Under these conditions the only possible thing to do was to describe my material with all the care possible, so as to aid in the future work of rearranging the various coral genera.

DESCRIPTIONS OF SPECIES.

Order ALCYONARIA Milne-Edwards and Haime.

Family PENNATULIDÆ M.-Edw. and H.

Genus GRAPHULARIA M.-Edw. and H.

GRAPHULARIA PERPLEXA (de Gregorio.)

Pl. II, figs. 7 to 8b (reproduced from de Gregorio.)

1890. *Corallium perplexum* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 253. pl. xliv, figs. 5 a, b, c and 6 a, b, c.

"Cor. cylindraceum lævigatum, ad sectionem rotundatum, lateribus tenue compressum."

Translation: "Cor. cylindrical, smooth, with round section, sides much compressed."

M. de Gregorio adds the following observations: "This is a very interesting species, because this genus is very poorly represented in the Tertiary strata. The section shows a slightly radiating structure and a kind of central nucleus. The external surface is polished: however, it appeared to me tuberculous, but upon examining it better, I perceived that its irregularities were produced by occasionally attached foreign bodies. I possess only two specimens."

Neither the locality nor the geological occurrence is given.

Order ZOANTHARIA Milne-Edwards and Haime.

Suborder ZOANTHARIA SCLERODERMATA M.-Edw. and H.

Family TURBINOLIDÆ M.-Edw. and H.

Genus FLABELLUM Lesson.

FLABELLUM CONOIDEUM sp. nov.

Pl. III, figs. 1 to 4.

1894. *Flabellum conoideum* Vaughan nom. nud. Rept. geol. Coast. Pl. Ala.: Ala. Geol. Survey, 1894, p. 248.

Attached by a small short pedicel. Slightly compressed conical in shape. No lateral wing or lateral processes. Cross section elliptical, rounded at the ends of the longer transverse axis, not angular, as is usually the case with the others of our Eocene species of Flabellum. Obscure costæ correspond to the primary and secondary septa. Lines of growth are well marked; sometimes corresponding to them are girdling, rather shallow, depressions. The wall is thin at its upper edge, but thick in its lower portion, owing to internal calcareous deposit. Epitheca well developed, extending to the upper edge of the corallum wall. Septa slightly exsert, margins entire; inner free portion undulated, sides granulate. In the adult there are 16 principal septa. Septal arrangement four complete cycles, members of the fifth cycle appearing near the ends of the longer transverse axis. In the specimen illustrated in Pl. III, fig. 1a, there are 72 septa, which are divided as follows:

First cycle	6
Second cycle	6
Third cycle	12
Fourth cycle	24
Fifth cycle	24
Total	72

Of the 16 principal septa, 12 belong to the first and second cycles, and 4 to the third cycle. The septa of the third cycle near the termini of the longer transverse axis join the columella. In moderately young specimens, such as illustrated in Pl. III, fig. 3, there are three complete cycles, and members of the fourth cycle are appearing near the ends of the longer transverse axis of the calice. The septa of the third cycle (Pl. III, fig. 3) have just reached the columella as thin lamellæ. In Pl. III, fig. 4, these youngest principal septa have become much thickened. The study of young forms of this species clearly shows that the explanation given by Semper[1] for the number of principal septa in Flabellum, intermediate between 12 and 24, and further amplified by von Marenzeller,[2] holds for this species, as well as for the ones they studied.

The columella is typical for the genus, i. e., is formed by the fusion of septal trabeculæ. Calice not very deep.

[1] Zeitschr. für wiss. Zoolog., Vol. XXII, 1872, pp. 243 et seq.
[2] Zool. Jahrb. 1887, Vol. III, Pt. I, pp. 25–50.

Measurements of three specimens are as follows:

	1a	2	3b
	Mm.	Mm.	Mm.
Greater transverse diameter of calice	17.75	12	10
Lesser transverse diameter of calice	16	9	9
Height of corallum	13.5	10	13.3
Depth of calice	5		

a Pl. III, fig. 1. b Pl. III, fig. 2.

Localities.—Prairie Creek and Matthews Landing, Alabama.

Geologic occurrence.—Black Bluff (Sucarnochee) and Matthews Landing (Naheola) beds.

Types.—United States National Museum.

No other species of Flabellum known to me presents the characters outlined above. The subconical form without any sharp angle at the termini of the longer transverse axis of the calice and complete absence of any lateral processes are the most salient characters.

FLABELLUM CONOIDEUM var. MATTHEWSENSE var. nov.

Pl. III, figs. 5 to 6a.

Differs from typical *F. conoideum* in having well-developed costæ, corresponding to the first and second cycles of septa, but grades directly into the typical form of the species.

All of the specimens of this variety that were examined have only 12 principal septa each. The epitheca is decidedly of the character of that of *F. lerchi.* It is highly probable that the latter species is a descendant of this variety.

Locality.—Matthews Landing, Alabama.

Geologic occurrence.—Matthews Landing (Naheola) beds.

Types.—From collection of Mr. T. H. Aldrich in the United States National Museum.

Specimens.—In collections of Wagner Free Institute of Science, Philadelphia.

The coral obtained by Mr. Harris from the Midwayan stage of southern Arkansas, and noted by him in his Tertiary Geology of Southern Arkansas,[1] pages 49 and 54, pl. iii, fig. 6, seems from the figure to be a conical-shaped Flabellum. The figure shows three cycles of costæ, the first cycle being

[1] Ann. Rept. Geol. Surv. Ark. for 1892.

the most prominent, the second less, and the third the least prominent. The base is terminated by a small pedicel. The specimen seems to be a costate variety of *Flabellum conoideum*, and probably is referable to variety *matthewsense*.

The exact locality of the specimen was "2 to 3 miles north of Bradford, on the St. Louis, Iron Mountain and Southern Railway."[1]

FLABELLUM JOHNSONI sp. nov.

Pl. III, figs. 7 to 7b.

This species is described from a single specimen. Form triangular, cuneate: attached by a pedicel 2 mm. high. The cross section is subelliptical, with subacute angles at the ends of the longer transverse axis. No marginal wings, but the edges are irregular. Costæ not prominent, seven or eight on each face, distinct, but low, with rounded transverse profile. Very fine girdling lines of growth, some girdling depressions. Septa rather thick, with granulate sides, arranged in six systems, four complete cycles and 16 of the fifth cycle in the systems next the ends of the longer transverse axis. Apparent arrangement eight systems of four complete cycles each. Interseptal loculi filling with internal calcareous deposit. Columella formed of septal trabeculæ. Greater diameter, about 14 mm.; lesser diameter, about 10 mm.; height, 13 mm.

Locality.—Woods Bluff, Alabama. (C. W. Johnson.)

Geologic occurrence.—Woods Bluff beds.

Type.—Wagner Free Institute of Science, Philadelphia.

The distinct pedicel and few low costæ characterize this species. It probably is an ancestral form of the *Flabellum cuneiforme* group, to be described later.

FLABELLUM LERCHI sp. nov.

Pl. III, figs. 8 to 9a.

1895. *Flabellum lerchi* Vaughan nom. nud. Am. Geol., Vol. XV, p. 217.
1896. *Flabellum lerchi* Vaughan nom. nud. Bull. U. S. Geol. Survey No. 142, p. 19.

Attached by a very short pedicel, almost sessile. Shape subconical, cross section elliptical, varying considerably in the amount of compression. The external surface is highly polished, the epitheca well developed and porcelain-like. Corresponding to the principal septa (first and second

[1] Harris, op. et loc. sup. cit.

cycles) are distinct subacute ribs. The ribs are so undulated by the lines of growth that they have the appearance of a row of pustules when viewed from the side. Angles at the end of the longer transverse axis of the calice sharp. Septa slightly exsert, usually in four cycles, those of the first two cycles fusing by their inner margins to form the columella. Sometimes as many as 18 septa may reach the columella. The number is usually less. I have not seen any specimen with five complete cycles. Their free inner portions are thrown into undulations, along the crests of which are granulations arranged in checkered rows. The columella is solid or shows but few vesicles.

	1 *a*	2 *b*	3
	Mm.	*Mm.*	*Mm.*
Greater transverse diameter of calice	11.5	....	17
Lesser transverse diameter of calice	8.25	....	9
Height of corallum	8.5	13	....
Depth of calice	3.5	5	....

a Pl. III, fig. 9, 9a. *b* Pl. III, fig. 8.

Localities.—Pittman's mill, Claiborne Parish, Louisiana; western Jackson Parish and 10 miles northwest of Winnfield, Louisiana; St. Maurice and SE. ¼ of SE. ¼ sec. 19, T. 19 N., R. 7 W., Louisiana; Gonzales, Texas; Newton, Mississippi.

Geologic occurence.—Lower Claiborne.

Types.—In the collection of the Louisiana geological survey; also, United States National Museum.

Specimens.—In the collections of the United States National Museum and of T. H. Aldrich.

Named for Dr. Otto Lerch, former State geologist of Louisiana.

The species can be easily recognized (1) by its entire lack of any lateral wing above the pedicel; (2) by the fewness of its principal septa; (3) by the distinct, rather prominent costæ; and (4) by its glossy porcellanous epitheca.

FLABELLUM CUNEIFORME Lonsdale.

Pl. III, fig. 12 and fig. 10; fig. 10 drawn from cast of one of Lonsdale's original specimens; var. pachyphyllum, Pl. III, figs. 11, 13–18; var. acutiforme, Pl. III, figs. 19, 20; var. fragile, Pl. III, fig. 21; var. wailesi, Pl. III, figs. 22 to 23a, and Pl. IV, fig. 1 to 3a; var. magnocostatum, Pl. IV, figs. 4 and 4a.

Anthophyllum cuneiforme Conrad. MSS. (teste Lonsdale).

1845. *Flabellum* (?) *cuneiforme* Lonsdale. Quart. Jour. Geol. Soc. London, Vol. I, p. 512.

1848. *Flabellum cuneiforme* Milne-Edwards and Haime. Annales sci. nat., 3d series, Vol. IX, p. 266.

1851. *Flabellum cuneiforme* Milne-Edwards and Haime. Polyp. foss. des Terr. Pal., p. 32.

1857. *Flabellum cuneiforme* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 82.

1861. *Flabellum cuneiforme* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 89.

1866. *Flabellum cuneiforme* Conrad. Check List, p. 2.

1890. *Flabellum* sp. de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 257, pl. xliv, figs. 23, 24.

Corallum attached by a short pedicel; shape cuneate, compressed, especially in the lower portion. Often there is just above the pedicel a well-marked though not large wing, which becomes obsolete in the upper portion of the corallum. Septa of the first, second, and third cycles have corresponding to them costæ, which are sometimes tuberculous in appearance. The costæ are largest on the middle of the lateral faces. Epitheca fairly well developed, but usually not highly polished. There are girdling lines of growth, and often encircling band-like depressions. The wall frequently has a very irregular surface, due to encircling lines of growth and band-like depressions crossing the costæ. The edges of the corallum are irregular, and as high as the wing extends they are acute. Septa rather thin, in five cycles of six systems, fifth cycle not always complete. The appearance is of 24 systems of three cycles each. The first three cycles form the columella by the fusion of their inner margins. Their sides are ornamented with granules arranged in checkered rows; inner margin transversely undulated. Interior of the corallum in lower portion filling up. Calice deep. Height of corallum, 24.5 mm. This specimen is represented in Pl. III, fig. 12.

Localities.—Claiborne, Alabama; Lonsdale cites Eutaw Springs, Wilmington, and Cave Hall, South Carolina. The varieties are widely distributed in Alabama, Mississippi, Louisiana, Arkansas, and Texas.

Geologic occurrence.—Claibornian stage.

This species is so extremely variable that it is almost impossible to characterize it. The following four or five varieties, which at first appear to be distinct species, can be distinguished.

I saw in the collections of the Geological Society of London specimens of *Flabellum cuneiforme* from Lonsdale's original material. These specimens are probably the types. They are casts in a yellow argillaceous limestone; no locality is given. I was permitted to make rubber squeezes from the casts, and Pl. III, fig. 10, represents one of them. No further remarks seem necessary. In the United States National Museum is a cast of a Flabellum from Eutaw Springs, South Carolina. In size, shape, etc., this cast agrees in toto with Conrad's *Flabellum wailesi*. This is interesting, as the specimen comes from one of Lonsdale's original localities. Because of the fragmentary character of the material *F. cuneiforme* was originally based upon, we can not fix the exact variety of the species that was Lonsdale's type, but we can be sure that it was either what Conrad called *F. wailesi* or a form between var. *wailesi* and var. *pachyphyllum*.

FLABELLUM CUNEIFORME var. PACHYPHYLLUM Gabb and Horn.

Pl. III, figs. 11 and 13 to 18.

1860. *Flabellum pachyphyllum* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, p. 388.

1895. *Flabellum cuneiforme* var. *pachyphyllum* Vaughan. Am. Geol., Vol. XV, p. 213.

1896. *Flabellum cuneiforme* var. *pachyphyllum* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 48.

This variety may be recognized by its compressed cuneate form, rather thick wall and septa, its smooth external surface, and its polished and thick epitheca. It passes directly into the form figured in Pl. III, fig. 18, which lacks the lateral wings entirely, whose sides diverge at a wide angle, and approaches the form that I have named var. *acutiforme*.

Localities.—Northwestern Louisiana, Texas, Mississippi; 4 miles northeast of Quitman, Clarke County, Mississippi; McLeod's mill, Clarke County, Mississippi; Wautubbee Hills, Mississippi; 8 miles west of Enterprise, Clarke County, Mississippi; 10½ miles south of west of Enterprise, Clarke County, Mississippi; 4 miles west of Newton, Mississippi; 3½ miles southeast of Quitman, Clarke County, Mississippi; 2 miles southeast of Hickory, Newton County, Mississippi; Coffeeville, Alabama; sec. 17, T. 18 N., R. 6 W., Bienville Parish, Louisiana; Pittman's mill, SW. ¼ of SE. ¼, sec. 19, T. 19 N., R. 7 W., Louisiana; SE. ¼ of SE. ¼ of sec. 26, T. 19 N., R. 9 W., Webster Parish, Louisiana, on road from Minden to Mount Lebanon; Rayburn's well, sec. 29, T. 17 N., R. 5 W., Louisiana; Mount Lebanon, Louisiana; Holstun's, sec. 17, T. 18 N., R. 5 W., Louisiana; Bold Mound, 9 miles southeast of

Jewett, Texas; Elm Creek, Lee County, Texas; San Augustine, Texas; 1 mile below Shipps Ford, Bastrop County, Texas; Alabama Bluff, Trinity River, Houston County, Texas.

FLABELLUM CUNEIFORME var. ACUTIFORME var. nov.

Pl. III, figs. 19 and 20.

This species has almost no lateral wings just above the pedicel. Its form is triangular, and the sides meet at a decidedly acute angle, about 50°. The basal portion of the corallum is compressed and slender.

	Mm.
Greater diameter of calice	26.25
Lesser diameter of calice	12
Height of corallum	33

Localities.—St. Maurice, Louisiana; and Mississippi.

Geologic occurrence.—Lower Claiborne.

Types.—United States National Museum.

FLABELLUM CUNEIFORME var. FRAGILE var. nov.

Pl. III, fig. 21.

This is a variety found abundantly at McLeod's mill, Suwonlovey Creek, Clarke County, Mississippi; it presents some peculiarities of note. The coralla are compressed, attached by short pedicels; a small lateral wing exists on the edges of the lower half of the corallum, above the pedicel. Low, rounded distinct costæ correspond to every fourth septum. The epitheca is not polished, and the impressed lines marking the median septal planes are nearly always very distinct. The bottom of the corallum not filled up by internal deposit, as in var. *pachyphyllum*. The corrallum is quite fragile and tends to break across along the growth curves. The variety is usually smaller than the other varieties, but it grades directly into *pachyphyllum*.

Additional locality.—Bakers Bluff, Alabama (collection of T. H. Aldrich).

Geologic horizon.—Claibornian, or immediately below the Claiborne sands horizon.

Types.—United States National Museum.

FLABELLUM CUNEIFORME var. WAILESI Conrad.

Pl. III, figs. 22 to 23a; Pl. IV, figs. 1 to 3a.

1855. *Flabellum wailesi* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1866. *Flabellum wailesi* Conrad. Check List, p. 21.
1886. *Flabellum wailesi?* Aldrich. Prelim. Rept. on Tert. Foss. of Ala. and Miss., p. 49.
1890. *Flabellum wailesi* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 256.
1894. *Flabellum wailesi* Harris. Tert. geol. south. Ark.: Ann. Rept. Geol. Surv. Ark., 1892, Vol. II, p. 172.
1895. *Flabellum cuneiforme* var. *wailesi* Vaughan. Am. Geol., Vol. XV, p. 223.
1896. *Flabellum cuneiforme* var. *wailesi* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

This variety may be recognized by its size, which is usually larger than the other varieties of the species, by its very thin wall, its very thin septa, and its thin epitheca. Impressed lines radiating from the pedicel and corresponding to the septa are seen beneath the epitheca. The epitheca is frequently broken away. Crossing the ends of the septa are minute transverse lines of growth, as illustrated in Pl. III, fig. 23a. Conrad in his original description mentioned "the impressed radiating lines."

The sides usually diverge at a greater angle than is usual in *F. cuneiforme*. In the collection of the Philadelphia Academy of Natural Sciences there is a variety of this form labeled in manuscript by Conrad "*F. percarinatum*." It is subtriangular in outline, is slightly more elongated than is usual in the variety, and the costæ in the middle of the faces are rather large. A subvariety is almost conical and quite slender. (See Pl. IV, figs. 3, 3a.)

Localities.—Jackson and Vicksburg, Mississippi; Montgomery, Louisiana; three-quarters of a mile above Vinces Bluff, Saline River, Arkansas; Hammaker's well, sec. 8, T. 12 S., R. 9 W., Arkansas; Wadworth's well, Long Prairie, Arkansas.[1]

Geologic occurrence.—Jacksonian and Vicksburgian stages.

This variety of *F. cuneiforme* bears considerable resemblance to *Flabellum sedecimcostatum* Sokolow.[2] Dr. Sokolow has kindly compared specimens of both, and writes me that he finds the following points of difference:

All the specimens of Flabellum from Jekaterinoslaw are more compressed from the sides (von Seiten mehr gedrückt) and also more conical; the edges of the calices, and therefore the lines of growth also, are decidedly less curved than in *Flabellum*

[1] Ark. localities, fide Harris, vide op. sup. cit.

[2] Die unteroligocäne Fauna der Glauconitsande bei der Eisenbahnbrücke von Jekaterinoslaw: Mem. du Comité Géologique (Russia), Vol. IX, No. 3, 1894, pp. 100–101, fig. 13 (in Text), pl. ii, figs. 2a, b, c.

cuneiforme: the ribs of *Flabellum sedecimcostatum* are somewhat weaker and more of a size (however, my specimens are more worn). Therefore, it is my opinion that, although *Flabellum sedecimcostatum* is very near *Flabellum cuneiforme*, still there is more of a basis for not identifying these two species.

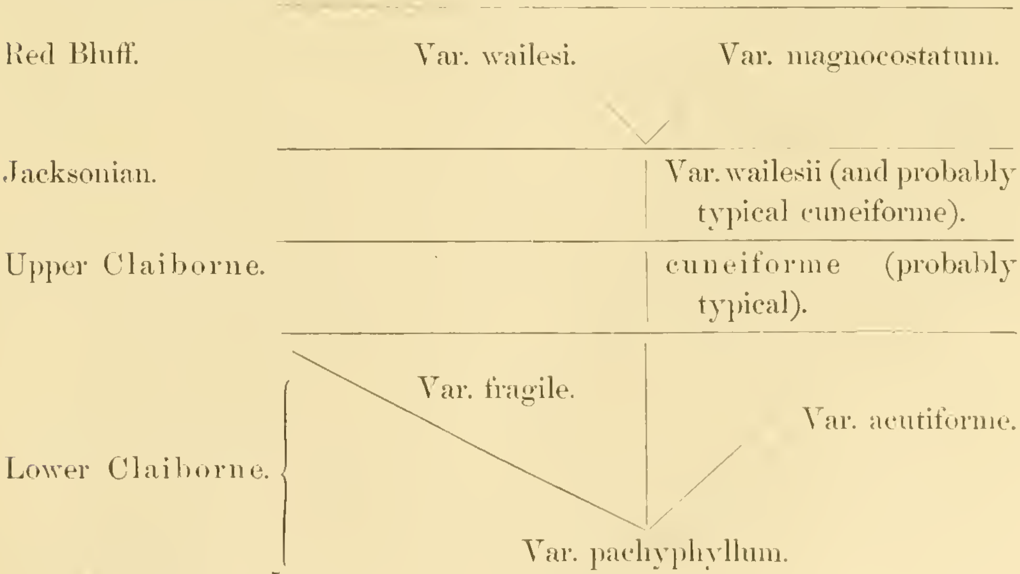
The comparison is made in speaking of the relations between *Trochocyathus discoides* Sokolow and *Trochocyathus lunulitiformis* (Conrad), (see page 94 of this paper). The amount of compression of *F. cuneiforme* var. *wailesi* varies much, so that apparently the only basis for separating the two species lies in the character of the costæ. Whether or not this will hold, must be determined by further work.

Flabellum cuneiforme var. magnocostatum var. nov.

Pl. IV, figs. 4 and 4a.

In the Red Bluff beds, exposed at Garlands Creek, Mississippi, a curious variety of *Flabellum cuneiforme* is found. This variety is characterized by having a thick wall and four or five very prominent costæ on the faces. It grades into forms without prominent costæ and with thin walls, passing directly into var. *wailesi*.

These varieties of *Flabellum cuneiforme* occur in a definite geologic succession, and were it not for the presence of intermediate forms, we should be obliged to consider them distinct species. They are a series of connected forms, and we may confidently represent their genetic relations by the following diagram:



Since *F. pachyphyllum* is the radical from which the other varieties are derived, it appears that the species should bear that name, and the other names be referred to varietal positions. The name *cuneiforme* is the oldest, and according to the law of priority it must stand for the species.

It is quite probable that *Flabellum johnsoni* Vaughan is the ancestral form of this series.

Flabellum sp.

Prof. W. B. Clark sent me six indeterminable specimens of a species of Flabellum collected at Aquia Creek, Virginia. The specimens occur in association with *Eupsammia elaborata* (Conrad).

Corallum compressed cuneiform, attached by a short pedicel, with slightly developed marginal wings above the pedicel. The dimensions of the two largest specimens, whose outer surface is unfortunately so very much corroded that its detail is destroyed, are:

	1	2
	Mm.	*Mm.*
Greater diameter of calice	14	13
Lesser diameter of calice	9	7
Height of corallum	15	14+

Distinct costæ correspond to the larger septa. The number of the septa was not determined with certainty, but is about forty.

This may be a new species, but has a resemblance to some varieties of *F. cuneiforme*, especially to the older varieties of that species.

Flabellum mortoni sp. nov.

Pl. IV, figs. 7 to 10.

This is one of the species confused with "*Turbinolia*" *inauris* Morton, in the collection of the Academy of Natural Sciences of Philadelphia.[1]

Corallum cuneiform, base small, edges and faces converging toward it; cross section elliptical. The following gives the dimensions of a series:

	1	2	3	4	5	6
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	19.5	....	....	18.5	16	15.75
Lesser diameter of calice	12.5	13.5	14	12.5	12	12
Height of corallum	16	21	20	19.5	15.5	14+

[1] Vide p. 171 of this paper.

Specimens 1 to 3 are the types, and are in the United States National Museum; 4 to 6 are in the collection of the Academy of Natural Sciences of Philadelphia.

The outer surface of the corallum is covered by a smooth, polished epitheca; costæ may be absent or very slightly developed. In the latter case they are low, usually flattish, and correspond to the intercostal areas. The septa in the upper part of a corallum are thin; in the lower portion they have undergone some secondary thickening, but apparently not to so great an extent as in some of the other species, viz, *F. cuneiforme* var. *pachyphyllum* or *F. remondianum*. The actual number of septa in an adult calice can not be made out with certainty because of the infilling of the calices with foreign material (glauconitic sand) and the decomposition of the septa. There are about 70. Pl. IV, fig. 10, represents a cross section of a corallum. Its dimensions are: Greater diameter, 13 mm.; lesser diameter, 7 mm. The free margins of the septa show transverse undulations; septal faces granulate. Columella quite poorly developed, false.

Locality.—"Upper part of second bed of green sand of Cook, or lower part of the third, Williams', Squankum, New Jersey." (Meek and Hayden.) The specimens in the Academy of Natural Sciences of Philadelphia bear on the accompanying label only "New Jersey."

Horizon.—Shark River beds—probably Claibornian.

Types.—United States National Museum.

This species seems to have as its nearest relative some of the varieties of *F. cuneiforme*. Its surface is much smoother, the costæ being much less developed, and none of the specimens that I have seen show any marginal wings.

FLABELLUM REMONDIANUM Gabb.

Pl. IV, figs. 5 and 6.

1864. *Flabellum remondianum* Gabb. Geol. Surv. of California, Paleontology, Vol. I, p. 207, pl. xxvi, fig. 199.

1893. *Flabellum remondianum* Boyle. North Amer. Mesozoic Invert.: Bull. U. S. Geol. Survey No. 102, p. 127.

1896. *Flabellum remondianum* Vaughan. Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, pp. 1036–1037, pl. lxiii, figs. 1 and 2.

1897. *Flabellum remondianum* Merriam. Journ. Geol., Vol. V, pp. 770, 773.

The following is Gabb's description: "Polypidom triangular, convex on the sides, acute and straight on the lateral margins; sides marked by eight or nine prominent radiating ribs, with regularly concave interspaces. Upper surface unknown."

Mr. T. W. Stanton collected near Benicia, California, many casts and specimens of this species embedded in sandstone. From the study of this material the following description has been prepared:

Form cuneate, triangular, and compressed; the cross section shows acute, alæform projections at the ends of the longer transverse axis. On the sides in the upper portion of the corallum there are nine subacute prominent costæ, along the crests of which are usually minute tubercles; in the lower portion of the corallum the costæ are very indistinct. Occasionally between the prominent costæ are fainter ones. The septa in a section of a corallum that was studied were thin, 78 or 81 in number. There were only 22 of the fourth cycle, it being incomplete between one septum of the first cycle and the septum of the second cycle, which corresponds to the middle of one lateral face. There were 32 septa of the fifth cycle, intercalated in the systems between the primary septa at the ends of the longer transverse axis and the primaries standing nearest the middle of the lateral faces. Apparently there are a few members of the sixth cycle in two of the systems next the termini of the longer transverse axis. The sides of the septa are granulate. Lower portion of corallum entirely filled by calcareous deposit. Columella parietal.

	1	2
	Mm.	*Mm.*
Longer transverse axis of calice	21	14
Shorter transverse axis of calice	8	....
Height of corallum	....	11

Locality.—Army Point, near Benicia, California.

Horizon.—"Martinez and Tejon." (Dr. J. C. Merriam.)

Specimens.—United States National Museum.

The character of the costæ and the alæform projections are the best criteria by which to separate this species from the triangular varieties of *F. cuneiforme*, to which it is closely related.

FLABELLUM CALIFORNICUM sp. nov.

Pl. IV, figs. 11 to 12.

Form cuneate, but usually curved in the plane of the shorter transverse axis of the calice. Attached by a very short pedicel. Cross section compressed, elliptical. Surface costate; costæ not very prominent; five on each side, slightly larger than the others. Slight girdling depressions. Septa about 52.

	1	2
	Mm.	*Mm.*
Greater diameter of calice	12.5	12
Lesser diameter of calice	7.5	7
Height of corallum	12	13.5

Locality.—Two and a half miles northeast of Clayton, Contra Costa County, California. (T. W. Stanton.)

Geologic occurrence.—Tejon beds (upper part), above coal horizon.

Types.—United States National Museum.

The size and shape of the species, its indistinct costæ, and the usually curved form of the corallum make it easily identifiable. This is the only curved species that I know from the Eocene of the United States.

The specimens are poorly preserved, and do not permit all of the details of the structure to be worked out.

FLABELLUM RHOMBOIDEUM sp. nov.

Pl. IV, figs. 13 to 14.

Shape, subcuneiform; seen from the side its outline subtriangular; transverse outline of adult, as seen from above, rhomboid; both the edges and the faces diverge at wide angles. The median portion of the faces is abruptly swollen, as if it had been pushed out from within. Marginal wings rudimentary or absent. The corallum is attached by a short pedicel. There are no costæ. The epitheca is very thin, pellicular, and scales off easily; it extends, however, to the calicular margin. When the epitheca is broken away, impressed lines corresponding to the septa are revealed; transverse lines of growth arranged en chevron. Wall thin and weak.

Septa thin, weak, with granulate sides. The principal septa vary from 20 to 24, between each pair of which there are three smaller septa. Between each pair of septa there is often a row of small pits.[1] Interseptal loculi not filled with stereoplasm. The columella appears to be a basal deposit laid down around the ends of the septa, and entirely independent of them. The columellar substance is merely plastered on the septal margins and has an independent origin. (See Pl. IV, fig. 14.) The columellar space is not solidly filled.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	19	....	13.5
Lesser diameter of calice	16	13	12
Height of corallum	15	13.5	13.5

Localities.—Red Bluff, and near Shubuta, Mississippi.

Geologic occurrence.—Vicksburgian stage, Red Bluff beds.

Types.—From collection of T. H. Aldrich in the United States National Museum.

Specimens.—United States National Museum.

Genus ALDRICHIA gen. nov.

Corallum simple, small, elongate, compressed, attached by a very short and small pedicel. Costæ well developed, granulate. Calicular fossa shallow. The columella in the lower part of the corallum consists of a few trabeculæ that reach across from some septa to those opposite; higher in the corallum, lobes arising on the inner portion of the septa unite to the septa and to one another. These pali-like lobes give to the upper surface of the columella a papillate appearance. There are no true pali, and no essential columella. Septa very slightly exsert, not very numerous, in type species 18 to 24.

The septal composition, as made out, is as follows:

At the wall a notch divides the inner portion of the septum from the outside costal portion. This is similar to the condition seen in Platytrochus. The septa are solid, with granulate sides. Looked at one way, the granules

[1] These pits are probably for the insertion of the mesenterial muscles.

appear arranged in rows or curves sloping downward and outward from the columella; in other places they seem arranged in curves parallel to the septal margin. But the granules have another arrangement across the curves, and where each row of granules perpendicular to the margin (in the septal plane) emerges at the surface is a corresponding dentation. Except near the columella, the septal teeth are directed outward; near the columella, they are directed inward. In a ground section parallel to the septal face the calcification centers have one arrangement in nearly horizontal lines or curves, evidently parallel to the septal margin, and another arrangement in diverging lines perpendicular to the transverse lines or curves. The calcification centers are nearer together in the lines parallel to the septal margin than in those perpendicular to it. Summing up, the septa are composed of trabeculæ completely fused, with an area of divergence situated interior to the wall, and have dentations corresponding to the points of emergence of the trabeculæ on the septal margin. It should be added that the septal dentations are not acute, but are rounded.

The origin and character of the columella have already been described.

Wall.—The ground cross section of a corallum that I have studied is not thoroughly satisfactory, but as the material at my disposal is limited, this section must suffice. The septa, where they are rather remote, seem to project through the wall, and between the distal ends a piece is inserted to effect the fusion. Apparently a true theca is present. But in other places, where the septa stand near together, it appears that the outer ends of the septa are enlarged sufficiently to join with each other directly and form a pseudotheca. Apparently the above is the constitution of the wall, but it can not be asserted positively that this is correct. The occurrence of true and false theca alongside each other is not remarkable, as was pointed out in the introductory chapter on the morphology of the coral skeleton (p. 491).

Aldrichia elegans sp. nov.

Pl. IV, figs. 15 to 19.

Corallum small, straight, or slightly curved in the plane of the longer transverse axis of the calice; elongate; cross section, compressed elliptical; attached by a small, short, nipple-like pedicel. Some specimens may ultimately become free. The costæ are well developed, granular, rather broad, those next the edges of the corallum often slightly broader than those on the middle of the lateral faces; correspond to all cycles of septa. Intercostal furrows not very deep. Septa from 18 to 24 in number, very slightly exsert. Their surfaces are beset with small, rather blunt, spines. The columella is trabecular, and in the lower portion of the corallum is very poorly developed; in the upper portion it is reinforced by lobes sent up from the inner ends of the septa. Upper surface papillate. Calice very shallow.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	1.7	2	2
Lesser diameter of calice	1	1.25	1.75
Height of corallum	4.3	3.2	6

Localities.—Dry Creek, Jackson, Mississippi; Montgomery, Louisiana.

Geologic occurrence.—Jacksonian stage.

Types.—From collection of T. H. Aldrich in the United States National Museum; and Wagner Free Institute of Science.

Specimens.—United States National Museum and Wagner Free Institute of Science, Philadelphia.

In the character of its columella this little species resembles the species of Platytrochus.

The following observations were made on a specimen with 18 costæ and 18 septa: It is slightly curved in the plane of the longer transverse axis of the calice, and one side of the corallum is a little more convex than the other. Of the 18 costæ 12 persist to the top of the pedicel, and there are faint indications of 6 on the pedicel. The septal arrangement is in six systems, each system containing two complete cycles, and there are six septa of the third cycle. The septa of the third cycle arise, one on each side of three septa of the first cycle. These three septa of the first cycle are the two at the ends of the longer transverse axis of the calice and one on the more convex side of the corallum. This method of intercalation of the septa of the third cycle would make the corallum bilaterally unsymmetrical, i. e., seven septa would lie on one side of a plane through the vertical axis of the corallum parallel to the longer transverse axis of the calice, and nine would lie on the other side. In order to maintain the bilateral symmetry, a twisting takes place, by which one of the tertiary septa stands at one end of the longer transverse axis of the calice. As a result of this twisting, eight septa lie on each side of a plane through the vertical axis of the corallum parallel to the longer transverse axis of the calice.

In specimens with 24 septa there are three complete cycles in six systems.

Genus PLATYTROCHUS Milne-Edwards and Haime.

1848. *Platytrochus* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 246.
1857. *Platytrochus* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 71.
1884. *Platytrochus* P. M. Duncan. Jour. Linn. Soc., London, Vol. XVIII, p. 18.

The following is the characterization of the genus given in the Histoire Naturelle des Corallaires:

Le polypier est simple, droit, cunéiforme et ne présente aucune trace d'adhérence. La columelle est essentielle, fasciculée et terminée par une surface papilleuse. Les cloisons sont débordantes, larges, très-peu inégales et fortement granulées latéralement. La muraille est nue, mais présente des côtes de deux sortes; celles qui occupent le milieu de chaque face du polypier s'élargissent à mesure qu'elles s'élèvent; celles qui sont situées sur les côtés sont, au contraire, plus fortes et beaucoup plus larges vers la base que près du calice; de sorte que les bords latéraux du polypier sont presque parallèles.

The first intimation that this characterization of the genus was faulty was given by de Gregorio when he described *Platytrochus claibornensis*, in his Monographie de la Faune éocénique de l'Alabama. In speaking of the columella of that species he says, "Columella ficta, irregulari, palis efformata." From a study of longitudinal sections of *Platytrochus stokesi* and *P. claibornensis*, I can assert that the columella is not essential, as both Milne-Edwards and Haime and Duncan state. De Gregorio is mistaken when he says "palis efformata," for there are no true pali.

On the inner margins of the septa there are small pillar-like lobes. The papillate axis of the corallum, hitherto denominated the papillate termination of the columella, is nothing but these lobes derived from the inner terminations of the septa. These lobes are inclined inward, so that along the inner border of a septum a series of lobes ranged one above another can be distinguished. As any given lobe would increase in height, due to its inclination, it would approach an axial position. When the lobes approximate one another closely, they frequently fuse. In some instances apparently the ends of opposed septa fuse across the axial space. In Platytrochus there is no essential columella, i. e., the columella is not a separate element of the corallum structure, having an existence independent of the septa.

The columella in this genus is derived in the same way as in the new genus Aldrichia described in this monograph. (See Pl. IV, fig. 24.)

In the definition of the genus Platytrochus the following modification must be made:

Columella false, formed by the fusion of lobes from the inner margins of the septa, or by the fusion across the axial space of the inner margins of the septa.

This necessitates the removal of Platytrochus from the alliance Placotrochoida to which Duncan referred it.

The mode of costal increase is very important. This is noted on page 76, in the description of *P. goldfussi*.

The following notes on the structure of the septa and wall may be added:

The septal margin is divided by a notch at the wall into a portion internal to the wall and one external thereto. The septa are solid, and are composed of ascending trabeculæ, whose courses are marked by rows of granulations. There is a line of trabecular divergence approximately halfway between the wall and columella. Each trabecula, where it emerges at the septal margin, has corresponding to it a prominent tooth. The teeth are not especially sharply pointed.

The columella has already been described in detail.

Wall.—In the distal portion of a septum there are several sets of calcification centers alongside one another, and between the enlarged ends of the septa a line of fusion can be distinguished (see Pl. V, fig. 8). The theca is false. In the thin inner portion of the septa there is a single series of calcification centers, and in the thicker distal portion there are several series of centers.

Platytrochus stokesi (Lea).

Pl. IV, figs. 20 to 24; Pl. V, figs. 1, 1a, and 8.

1833. *Turbinolia stokesii* Lea. Contrib. to Geol., p. 194, pl. vi, fig. 207.
1838. *Turbinolia stokesii* Michelotti. Spec. zoophyt dil., p. 56.
1845. *Endopachys* (pars) Lonsdale. Quart. Jour. Geol. Soc. London, Vol. 1, p. 514, figs. b and c.
1848. *Turbinolia stokesii* Bronn. Index Pal., p. 1316.
1848. *Platytrochus stokesii* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 247, pl. vii, fig. 7.

1850. *Platytrochus stokesii* d'Orbigny. Prodr. de Pal., étage 25, num. 1245.
1851. *Platytrochus stokesii* Milne-Edwards and Haime. Polyp. foss. des Terr. Pal., p. 29.
1857. *Platytrochus stokesii* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 72.
1861. *Platytrochus stokesii* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 93.
1866. *Platytrochus stokesii* Conrad. Check List, p. 2.
1881. *Platytrochus stokesii* Quenstedt. Röhren- u. Sternkorallen, p. 941, pl. clxxix, fig. 75.
1886. *Platytrochus stokesii* Aldrich. Prelim. Rept. on Tert. Foss. of Miss. and Ala., p. 49.
1886. *Platytrochus stokesii* Meyer and Aldrich. Jour. Cincinnati Soc. Nat. Hist., Vol. IX, No. 2, p. 50.
1890. *Platytrochus stokesii* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 254, pl. xlv, figs. 1–14.

Shape short cuneate, transverse outline elliptical, base emarginate. Costæ 24, corresponding to all of the septa. The nine costæ on the middle portion of a face converge toward the base, and become narrower as the base is approached; the marginal costæ, i. e., those at the ends of the longer transverse axis, and those standing immediately next them, become wider toward the base. The costæ next the marginal ones are the larger, and are very much expanded inferiorly. All of the costæ are granular; the seven in the middle of a face begin as a single row of granules; they later become three granules alongside one another. The eight intercostal furrows on the middle portion of a face are nearly straight; the furrows immediately outside of those do not converge uniformly toward the base, but near the basal end of the corallum usually bend outward. Septa 24, three cycles. Those of the first and second cycle meet the columella. The septa of third cycle fuse by their inner margins to the sides of those of the first. The surface beset with sharp granules. The upper margins of the septa crenate-dentate and the inner portions undulated. No true pali present. Columella described in discussing the genus.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Greater transverse diameter of calice	5.8	5.75	5.75
Lesser transverse diameter of calice	4	4.5	4.25
Height of corallum	5.5	6.5	7

Localities.—Claiborne, White's marl bed (Monroe County), Lisbon and Gosport, Alabama; South Carolina;[1] Lexington, Lee County, Texas; Bold Mound, 9 miles southeast of Jewett, Texas; 1 mile below Shipps Ford, Bastrop County, Texas; Newton and Wautubbee, Mississippi. Meyer and Aldrich cite Jackson, Mississippi (vide op. sup. cit.).

Geologic occurrence.—Claibornian in general.

The distinctive characters of this species will be noted after the following:

PLATYTROCHUS GOLDFUSSI (Lea).

Pl. V, figs. 2 to 7.

1833. *Turbinolia goldfussii* Lea. Contrib. to Geol., p. 195, pl. vi, fig. 208.
1838. *Turbinolia goldfussii* Michelotti. Spec. zoophyt. dil., p. 57.
1848. *Turbinolia goldfussii* Bronn. Index pal., p. 1315.
1848. *Platytrochus goldfussii* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 248, pl. vii, fig. 9.
1850. *Platytrochus goldfussii* d'Orbigny. Prodr. de Pal., étage 25, num. 1245.
1851. *Platytrochus goldfussii* Milne-Edwards and Haime. Polyp. foss. des Terr. Pal., p. 29.
1857. *Platytrochus goldfussii* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 72.
1861. *Platytrochus goldfussii* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 93.
1866. *Platytrochus goldfussii* Conrad. Check List, p. 2.
1890. *Platytrochus goldfussii* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 255, pl. xlv, figs. 16–20.

Shape cuneate, cross section elliptical, base compressed, usually rounded, sometimes emarginate. Costæ rather wide, granulate, from 24 to 36 in number. The nine ribs and their derivatives nearest the median portion of the lateral faces are widest in their upper portions, there consisting of about three granules alongside of one another; they converge toward the center of the base, becoming narrower as they approach it, and near their origin consist of only one row of granules. The marginal costæ and those standing immediately next are wider, are composed of a large number of granules, and increase in breadth as the base is approached. The costæ next the median costa of a lateral face sometimes trifurcate.[2] The intercostal furrows near the middle of a face are straight; those bordering the marginal costæ, and usually those standing next to them (i. e., eight in all, four to each face), are usually curved in such a manner that their termini approach the

[1] Specimens in the Mus. of Comp. Zool., Cambridge, Mass.

[2] The mode of costal and septal increase is the same in Platytrochus as in Sphenotrochus (see pp. 82–84).

middle of the base. Septa 24 to 36 in number. Columella with a papillate upper surface.

	1	2	3	4[a]
	Mm.	*Mm.*	*Mm.*	*Mm.*
Longer transverse axis of calice	4.5	4.3	4	4.3
Shorter transverse axis of calice	3	3	2.7	3.2
Height of corallum	6.8	5.6	5	6

[a] The base of this specimen is 5 mm. wide, exceptionally broad.

Localities.—Claiborne, Alabama, and White's marl bed, Monroe County, Alabama.

Geologic occurrence.—Upper Claiborne.

This species can usually be separated from *P. stokesi* by its more elongate form, but that character will not hold always. The following three distinctions, I believe, are of constant value: (1) the surface of *P. stokesi* is rougher than that of *P. goldfussi*; (2) the intercotal furrows of *P. stokesi* are deeper and wider than in *P. goldfussi*; (3); the number of the costæ in *P. stokesi* never exceeds 24, while there may be more in *P. goldfussi*. I carefully examined 360 specimens of *P. stokesi* to ascertain whether the number of the costæ was constant. The young specimens of these two species resemble one another very closely, indicating their near relationship.

Platytrochus claibornensis de Gregorio.

Pl. V, figs. 9 to 12.

1890. *Platytrochus claibornensis* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 255, pl. xlv, figs. 21–22.

Original description :

Plat. cuneatus, compressus, subflabellatus; calice elliptico; septis 44, paulo irregularis; columella ficta, irregulari, palis efformata: costis angustis, confluentibus, subgranulosis, paulo sinuosis. Haec species differt a duabus praecedentibus propter costas et septa multo magis numerosa, angusta, et minus regulares. Multo magis rara est quam iis.

Translation :

Plat. cuneate, compressed, subflabellate; with elliptical calice; 44 septa, slightly irregular; columella false, irregular, formed of the pali; costæ narrow, confluent, subgranular, slightly sinuous. This species differs from the two preceding on account of its much more numerous, narrow, and less regular costæ and septa. Much rarer than they.

M. de Gregorio has characterized this species very well. The costæ in this species are very different from those of the two preceding. Throughout most of their length the costæ of *P. stokesi* and *P. goldfussi* are made up of a double or triple row of granules; but those of *P. clairbornensis*, except next the edges where they are thick and confused, show scarcely any granulations, and the granules are usually in a single row. The costæ, except near the edges, resemble very closely those of Sphenotrochus.

The columella in this species is identical in its general characters with those of the two preceding. In a longitudinal section it is seen that additions are made to it by paliform lobes, which arise from the septa and are slightly inclined inward. Later these pseudopali are united to the septa by cross connections between them, leaving the line of fusion indicated by a row of holes. Seen from above, the columella has a papillate surface.

	Mm.
Greater diameter of calice	3.6
Lesser diameter of calice	2
Height of corallum	5

Locality.—Claiborne, Alabama.

Geologic occurrence.—Claiborne sands.

A grain of sand is frequently included in the base of a specimen.

Genus DISCOTROCHUS Milne-Edwards and Haime.

1848. *Discotrochus* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 251.

1857. *Discotrochus* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 76.

1883. *Discotrochus* Zittel. Traité de Pal., Vol. I, p. 275.

1884. *Discotrochus* P. M. Duncan. Revision of the Genera of Madreporaria: Jour. Linn. Soc., London, Vol. XVIII, p. 30.

"Corallum simple, discoid, free, without any trace of the place of fixation. Calice somewhat flat, columella fasciculate and papillate on its surface. Septa slightly exsert. The wall horizontal, naked, and presenting simple costæ."[1]

The wall is, at least in part, a pseudotheca. The columella is composed of several erect rods (or erect trabeculæ) that fuse from place to place one to another or to the septa by crossbars. The septal trabeculæ next the columella are erect, and sometimes, by becoming separate from the main

[1] Hist. Nat. des Corall., loc. cit.

septal mass, reinforce the columella. Passing outward, the trabeculæ bend more and more from the columella. The septal margins are crenate. There are processes extending inward from the wall similar to those seen in *Trochocyathus lunulitiformis* and *T. depressus*. Synapticulæ (pseudo) are sometimes present near the places of fusion of the higher to the lower cycles of septa. Where the septa come very close together the lateral granules sometimes fuse across the interseptal loculi.

Discotrochus orbignianus Milne-Edwards and Haime.

Pl. V, figs. 13 to 19b.

1848. *Discotrochus orbignianus* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 252, pl. vii, fig. 6.
1851. *Discotrochus orbignianus* Milne-Edwards and Haime. Polyp. foss. des Terr. Pal., p. 30.
1857. *Discotrochus orbignianus* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 76.
1861. *Discotrochus orbignianus* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 93.
1881. *Discotrochus orbignianus* Quenstedt. Röhren- und Sternkorallen, p. 948, pl. clxxix, fig. 95.
1895. *Discotrochus orbignianus* Vaughan. Am. Geol., Vol. XV, p. 213.
1896. *Discotrochus orbignianus* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 48.

The following is a translation of the original description:

Corallum very flat; lower surface concave in its central portion, horizontal near the edges. Costæ unequal, rather large, slightly prominent, indistinct in the central part, which is separated from the flat marginal portion by a small circular rim. Calice somewhat flat, or very slightly convex, with fossa scarcely indicated. Columella moderately developed. Five orders of septa; six equal systems. Septa unequal, slightly elevated, regularly convex above, moderately thin, crowded together; those of the fourth and fifth orders larger than the tertiaries. The faces covered with very large grains, almost equally spaced, but disposed in series sensibly vertical. Height, 1.5 mm.; diameter, 6 mm. Fossil from Alabama. Collection Alcide d'Orbigny.

This description is so excellent that I do not change it.

The young individuals of this species present certain peculiarities worthy of note. A series of young specimens are represented in Pl. V, figs. 14 to 16a. The youngest specimens that I have are disk-like, or, differently expressed, resemble a section of a small cylinder. The specimen shown in Pl. V, fig. 14, is 4.5 mm. in diameter and about 1 mm. high. It has an almost perpendicular wall and shows no sign of attachment. In the next stage the costæ around the base begin to project beyond the perpendicular wall and to form with the septa an arch extending through and over the wall. A continuation of this mode of development ultimately results in the normal adult form, as shown in Pl. V, figs. 17, etc.

There is considerable variation in the curving of the septal margins around the periphery of the corallum. In some specimens the peripheral part of the corallum is quite thin, the costal margin being rounded so abruptly into the septal margin that they almost make an angle with one another. In other specimens the periphery of the corallum is quite thick, the costal margin then passing by a gentle curve into that of the septum. This is the only especially noteworthy variation that I have noticed.

Additional localities.—Upper layer, Sowilpa Creek and Coffeeville Landing, Tombigbee River, Alabama; Wautubbee Hills, Mississippi; 2 miles southeast of Hickory, Newton County, Mississippi; 3 miles northeast of Newton, Newton County, Mississippi; 1 mile south of Hickory, Mississippi; 6 miles west of Desoto Station, Clarke County, Mississippi; 1 mile south of Hickory, Mississippi; 8 miles south of Hickory, Mississippi; railroad 4½ miles east of Newton, Mississippi; near Mount Lebanon, Louisiana; Pittman's mill, Claiborne Parish, Louisiana; Shipps Ford, Bastrop County, Texas; Alabama Bluff, Trinity River, Houston County, Texas.

Geologic eccurrence.—Lower Claiborne.

The only other species of this genus known to me are *Discotrochus michellottii* M.-Edw. and H., from the Miocene of Turin, *Discotrochus duncani* Reuss, Miocene of Austro-Hungary, and *Discotrochus ? alternans* Sokolow, Lower Oligocene of Jekaterinoslaw, southern Russia.

Genus SPHENOTROCHUS Milne-Edwards and Haime.

SPHENOTROCHUS NANUS (Lea).

Pl. V, figs. 20 to 24, fig. 22 (?).

1833. *Turbinolia nana* Lea. Contrib. to Geol., p. 195, pl. vi, fig. 209.
1838. *Turbinolia nana* Michelotti. Spec. zoophyt. dil., p. 55.
1848. *Sphenotrochus ? nanus* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 246.
1861. *Sphenotrochus ? nanus* de Fromentel. Introd. à l'Étude de Polyp. foss., p. 93.
1890. *Platytrochus nanus* Lea sp. dub. de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 255.

Description of Lea's type, in the Academy of Natural Sciences of Philadelphia.—Form cuneate, transverse outline elliptical. Strong costæ of nearly equal prominence corresponding to all of the septa; those on the lateral faces corresponding to the septa of the first cycle[1] trifurcate a short distance above the base. This method of trifurcation is shown in Pl. V, fig. 20. Septa in three cycles, 24 in number. Those of the first two cycles reach the columella. Their surfaces granulate. Columella lamelliform. Seen from the side it presents an outline like the base of a cordate leaf. The central projection seen from above shows that it consists of two elongate little knobs, one on each side of the vertical axis, i. e., along the shorter transverse axis of the calice. These little knobs are shown in the upper surface view of the calice, Pl. V, fig. 20a.

	Mm.
Greater transverse axis of calice	1.8
Lesser transverse axis of calice	1
Height of corallum	2.7

Locality.—Claiborne, Alabama.

Geologic occurrence.—Claiborne sands.

Pl. V, figs. 20 and 20a, are drawn from Lea's original type. Lea's figure is not absolutely correct in the details of the costæ. In the side view (Pl. V, fig. 20) the specimen was turned a little. Lea's type is a young specimen.

The following additional notes are based on material in the United States National Museum.

The measurements for the large specimen (Pl. V, fig. 22) are:

	Mm.	
Greater transverse axis of calice	5	(or more).
Lesser transverse axis of calice	3	
Height of corallum	7.3	

The costa are rounded in profile and are granular.

This specimen might be *Sp. clailornensis* sp. nov. Its state of preservation is not perfect.

In order to get an accurate comprehension of the species, it seems best to trace its development as closely as the material at my disposal will permit.

The specimen which shows the youngest stage of all the specimens that I possess is 2 mm. high. It shows four costæ originating at the bottom of the base; two other costæ, one standing at each end of the longer transverse axis, are introduced very soon after, making six. One more costa is

[1] In this description the cycles are denominated as traditionally understood.

soon developed on the middle of each lateral face, making eight. In the next succeeding stage eight more costæ are introduced, bringing the number up to 16. The next stage possesses 24 septa. Each costa standing next the median costa of each lateral face has another costa introduced on each side of it—four costa on each face, eight in all. These eight, added to the 16 previously developed, make 24.

The next young specimens to be described being attached do not permit the costal development to be followed so closely.

The youngest specimen, or at least the smallest, is 1.5 mm. high, and is attached to a sand grain. It shows 16 costæ extending to the object of support. Soon after this a costa is introduced on either side of each one of the four costæ standing next the median costæ of the lateral faces. So that the young coral, only 1.5 mm. high, has already (so called) three cycles of septa and as many costæ. Twelve septa (every other one) reach the columella.

The specimen next in size to the one last described is about 2.75 mm. high. It has the same number of costæ and septa. The costæ are not very tall, are somewhat thin, and have a rounded edge. On the flat side are striations that run in a horizontal direction. At this stage no costa shows a tendency to become especially thicker than the others. The columella is as represented in the figure of the calice of Lea's type, Pl. V, fig. 20. Most of the twelve large septa show a thickening on the inner margin, just before joining the columella, and at the thickening a small tooth can be distinguished.

The next stage is represented by a specimen of the following dimensions:

	Mm.
Greater diameter of calice	2.3
Lesser diameter of calice	1.75
Height of corallum	4.25

The calice of this specimen is represented by Pl. V, figs. 21 and 21a.

The costæ are rather low, flat or rounded in profile, and possess minute granulations. At this stage ten additional costæ have been added, one costa on each side of each of the four costæ on the faces of the corallum, next the septa at the ends of the shorter axis of the calice; and two more costæ have arisen, one on each side of one costa of the last cycle standing next the one on the middle of the face. The costæ standing at the ends of the longer transverse axis, and those standing immediately next to these have become wider than the others. Along the edges of each wider costa is a double row of granulations, one on each side of the summit. Where I could find granulations along the summits of the narrower costæ there was only a single row. On the sides of the costæ are the striations already noted.

Passing to the septa: There are 34 septa; on one side of a vertical plane through the longer axis of the calice there are 15, while on the other side there are 17. This asymmetry is surely only temporary. The thickenings of the septa near their inner termini have progressed so far that they have fused to a considerable extent and have formed an apparent lamina on each side of the real columella, which is very distinct and absolutely typical.

The last stage would probably be represented by the large specimen already noted, and whose measurements are given. (Pl. V, fig. 22.)

The base of this specimen is broken, so it can be seen that it is solid. The costæ at the termini of the longer transverse axis of the calice and those standing next have become decidedly wider than the others. In fact, the three costæ nearest each end of the longer transverse axis on each face are wider than those on and near the median portion of the lateral faces.

There are now 40 costæ and a corresponding number of septa. The last eight costæ have arisen, one on each side of each costa, standing on each side of each secondary costa at the ends of the shorter transverse axis of the calice.

The descent of the costæ and corresponding septa can be summarized thus:

First cycle + second cycle	4+4
Third cycle, on each side of each member of first cycle	8
Fourth cycle, on each side of the four that stand next the secondaries on the middle of the lateral faces	8
Fifth cycle, on each side of the four quaternaries that stand next the secondaries on the middle of the lateral faces	8
Sixth cycle, introduced in same relative position	8
Total	40

By an examination of the figures most of these features can be distinctly seen. New septa and new costæ are introduced at four points only,

i. e., on each side of the costa or septum standing next the one in the vertical plane of the shorter diameter of the calice.

All the septa in this large specimen seem to reach the columella, but the calice is not perfect. The thickening near the inner ends of the septa has progressed still further, so there appears to be a lamina on each side of the columella and joined to it by prolongations of the septa through the lamina. The columella itself presents no peculiar characters.

In both the young and old specimens, in the intercostal furrows are pits, arranged in double rows, and they apparently perforate the wall.

The details of the septal structure as interpreted from a study of the flat surface of a septum are as follows:

The septal margin, generally speaking, would be described as entire, but it shows delicate crenations, the crenations corresponding to the emergence at the surface of rows of granules. The septa are solid, made up of completely fused ascending trabeculæ. There is a line of divergence at the interior edge of the wall. Interior to this line the trabeculæ pass upward, inclining slightly inward; exterior to it they bend outward at a considerable angle. The arrangement of the granules, the delicate, faint striations around the septal margins, and the direction of the marginal crenations were used to determine the trabecular constitution.

It should also be noted that the septa seem to join pali, which stand between the septa proper and the columella. In the longitudinal section are four vertical rows of pores. The two external rows indicate the demarcation between septa and pali; of the other two rows, one is on each side of the columella and indicates the lines of junction by cross projections between it and the pali. (See Pl. V, fig. 23.[1])

Specimens.—United States National Museum; Philadelphia Academy of Natural Sciences, Lea's type.

There has been much misunderstanding concerning this little species, probably because it is so rare. M. de Gregorio seems to have had no specimen of it. The systematic position given to the form by Milne-Edwards and Haime is undoubtedly the correct one. M. de Gregorio confused it

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[1] Some notes on the soft parts of the recent *Sphenotrochus rubescens* are given by Fowler in the Quart. Jour. Microsc. Sci. (N. S.), Vol. XXVIII, No. 111, Feb., 1888, pp. 421–424. He states that the soft tissues are outside the theca, there is no peripheral lamellæ of the mesenterics, and the costæ correspond to entocœlic septa.

with forms of Platytrochus, but it does not possess the broad marginal costæ nor the columella characteristic of that genus.

Milne-Edwards and Haime, from Lea's figure, considered the species very close to *Sphenotrochus milletianus* (Defrance). From the figure of *Sp. milletianus*, given by Michelin,[1] the two forms appear very distinct. The sides of *Sp. milletianus*, at the end of the longer transverse axis, are subparallel; the corallum may possibly be narrower at the calicular margin. The sides of *Sp. nanus*, however, taper to the base.

SPHENOTROCHUS CLAIBORNENSIS sp. nov.

Pl. VI, figs. 1 to 3a; Pl. V, fig. 22 (?).

Corallum cuneiform; cross section compressed elliptical; base rather narrow or quite wide, but in the latter case narrower than the length of the greater transverse diameter of the calice. In the base a sand grain is sometimes included. Measurements of four specimens give the following:

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	3.75	4.5	5	5
Lesser diameter of calice	2	2.3	3	2.5
Height of corallum	5	6	7	7.5

The calicular margin is considerably lower at the ends of the longer transverse axis than at the ends of the shorter. The two costæ, one at each end of the longer transverse axis, and the costæ standing immediately next these two—six in all—are wider than the others, and are densely granulate. The other costæ are narrow, and are simple costal plates, or may be in part a single row of granules, or may be partly composed of a double row of granules. All three conditions are represented. The mode of costal development is identical with that already described for *Sphenotrochus nanus*, i. e., new costæ are introduced at only four points, on each side of the costæ standing next the costæ at the ends of the shorter transverse axis of the corallum. The costæ correspond to the septa. There are 40 septa in specimen No. 3 of the above table of measurements; in specimen No. 4 there are 36. Very many of the septa reach the columella. The upper margins

[1] Iconographie Zoophytologique, pl. lxxiv, fig. 1.

are somewhat, though not very greatly, elevated above the wall, and are entire; there are no dentations, and if crenations are present they are very faint. The inner septal edges are thickened and have a decided tendency to fuse laterally. The septal faces are covered by many small granulations, which are arranged in more or less regular curves parallel to the upper septal margin, and possess also a linear arrangement. The inferred trabecular constitution is the same as in *Sp. nanus*. The columella is lamellar, but is peculiar in that it terminates above in about six elongated knots, which are arranged with their longer axes in the plane of the longer diameter of the calice. The calicular fossa is not very deep.

Locality.—Claiborne, Alabama. (Burns, Schuchert, and L. C. Johnson.)

Horizon.—Claiborne sands.

Types.—United States National Museum.

This species can be easily distinguished from *Sp. nanus* by (1) the tendency of the costæ to be granular, (2) the upper termination of the columella (cf. figures), and (3) its larger size, though there may be an occasional overgrown specimen of *Sp. nanus*.

Genus TURBINOLIA Lamarck.

Turbinolia pharetra Lea.

Pl. VI, figs. 5 to 10.

1833. *Turbinolia pharetra* Lea. Contrib. to Geol., p. 196, pl. vi, fig. 210.
1838. *Turbinolia pharetra* Bronn. Leth. geog., Vol. II, p. 900.
1838. *Turbinolia pharetra* Michelotti. Spec. zoophyt. dil., p. 64.
1848. *Turbinolia sulcata* Bronn (partim). Ind. Pal., p. 1316.
1848. *Turbinolia pharetra* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. IX, p. 235.
1850. *Turbinolia pharetra* d'Orbigny. Prodr. de Pal., étage 25, num. 1242.
1852. *Turbinolia pharetra* Ferd. Roemer. Die Kreidebildungen von Texas, p. 5.
1857. *Turbinolia pharetra* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 63.
1861. *Turbinolia pharetra* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 91.
1866. *Turbinolia pharetra* Conrad. Check List, p. 2.
1886. *Turbinolia pharetra* Aldrich. Prelim. Rept. on Tert. Foss. Ala. and Miss., p. 49.
1890. *Turbinolia pharetra* de Gregorio. Mon. de la Faune éocénique l'Ala., p. 254, pl. xliv, figs. 12–19.
1895. *Turbinolia pharetra* Vaughan. Am. Geol., Vol. XV, p. 213.
1896. *Turbinolia pharetra* Vaughan. Bull. U. S. Geol. Survey No. 142, pp. 48, 49.

Shape elongate, conical. Wall a true theca. Costæ 24 in number, rather prominent, rounded in profile but not flattened, margins simple, entire.

At the calicular opening they are of equal size. Near the base 12 of the costæ are larger, the intermediate ones becoming very insignificant; only 6 are prolonged to the basal tip. Intercostal furrows perforated by a double row of pores.

Septa moderately exsert, with entire margins, in three cycles, 24 in number, their surfaces granulate. Columella strong, terminated above in a hexagonal star, which projects slightly above the upper margins of the septa. The septa of the first cycle fuse to the rays of the star.

When a corallum of *Turbinolia pharetra* is cut longitudinally across the septal planes, i. e., tangentially, it is seen that the septal surface is transversely fluted (see Pl. VI, fig. 10). When the flat surface of a septum is examined, an extremely curious ornamentation meets the eye. Sloping downward from the wall, at an angle of about 45°, are regularly spaced, parallel rows of granules. Near the base of the corallum there are two granules in each row; near the top four or five is the usual number. The length of the rows is about half the distance between the wall and the columella. Along a middle vertical line on the side of the septum a series of swellings on the septal surface begins. These are spaced similarly to the rows of granules and are in a certain sense continuations of them. A row of granules and a septal swelling together form a series. Where the granules cease the septal swelling begins, but the latter do not run in the same direction as the former. They swing into a horizontal position and continue to the columella. The swellings are simply the septal undulations. (See Pl. VI, fig. 5.)

In order to show the striking difference between *Turbinolia pharetra* and *Turbinolia sulcata* Lamarck, with which it has been compared, a longitudinal section of *Turbinolia sulcata* is represented on Pl. VI, fig. 4.

	1	2	3	4	5	6
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Diameter of calice	2.25	2.6	2.6	2.8	2.2	3.5
Height of corallum	6.2	6.5	5.6	7	5.3	6.2

Specimen No. 6 is the one from which Pl. VI, fig. 9, was drawn. It belongs to a variety quite abundant in the Lower Claiborne horizons of

Louisiana and Texas. It is shorter and thicker than typical *Turbinolia pharetra* and the costæ are somewhat sharper. Although some minor differences can be pointed out, it does not seem possible, in view of the hundreds of specimens that I have examined, to separate it from *Turbinolia pharetra*.

Localities.—Eocene of Alabama, Mississippi, Louisiana, and Texas; 1 mile below Shipps Ford, Bastrop County, Texas; Lexington, Lee County, Texas; Bold Mound, 9 miles southeast of Jewett, Texas; Lewis House, 2 miles east of Alto, Texas; Alabama Bluff, Trinity River, Houston County, Texas; Moseleys Ferry, Brazos River, Burleson County, Texas; Black Shoals, or Colliers Ferry, and Smithville, Texas; Elm Creek, Lee County, Texas; Gosport, Claiborne, near Pugh's, Sowilpa Creek, and T. A. Rumbley's, Monroe County, in Alabama; Jackson, Mississippi; Holstun's well, 5 miles southeast of Gibbsland, Louisiana; Rayburn's well, sec. 29, T. 17 N., R. 5 W., Louisiana; Montgomery, Louisiana.

Geologic occurrence.—Upper and Lower Claiborne and Jacksonian stage.

Milne-Edwards and Haime say: "This species has the same form as *Turbinolia sulcata*, from which it differs by its ribs, which are not very prominent, but large, especially in the lower portion. The intercostal furrows are however rather large."[1] The very striking differences in the lateral ornamentation of the septa have been shown. The columella also is very different. In fact, the two species have very little in common.

TURBINOLIA WAUTUBBEENSIS sp. nov.

Pl. VI, figs. 11 to 12.

Shape conical, with a subobtuse base. Cross section circular. Costæ 48 in number; 24 correspond to the 24 septa, and 24 are rudimentary costæ. At the calicular margin the costæ corresponding to the septa are all of the same size, while the rudimentary costæ are smaller. As the base is approached the costæ corresponding to the septa become much larger and more prominent; about one-third of the distance from the calicular margin to the base the rudimentary costæ become smaller; then all of the costæ grow smaller until, about 1.3 mm. from the apex, those corresponding to the primary and secondary septa become larger and more prominent again, those corresponding to the tertiaries becoming much finer. At this second enlarge-

[1] Hist. Nat. des Corall., Vol. II, p. 63.

ment the rudimentary costæ disappear. The primary and secondary costæ seem to continue to the apex of the base. All of the costæ are rather compressed; their margins are entire and smooth. The intercostal furrows are perforated. The wall is rather thin. Septa 24, in three cycles, six systems, somewhat exsert, faces undulated, granular.

The ornamentation of the sides of the septa is of the same type as in *T. pharetra*, but shows very important differences in the minor details. The first difference is that the ornamentation of *T. wautubbeensis* is less regular. The rows of granules on the outer portion of the septum slope downward and inward, but extend more than halfway across the septal face. In the rows the granules are not so absolutely regular as in *T. pharetra*. Another difference is that the transverse undulations of the septa are less pronounced than in *T. pharetra*. A close examination of the margin of a septum showed that the granular arrangement, and by inference the trabecular constitution of the septa, is of the same general type as all the preceding corals here discussed. The granules are formed in curves parallel to the upper septal margins. On the inside of the wall corresponding to the highest point in the arch of the septal margin there seems to be an area of divergence. The outward-directed granules can be seen distinctly only at the septal margin. The columella projects far above the corallum wall; presents a star-shaped outline when seen from above. Diameter, 4 mm.; height, 9 mm.; columella projects 1 mm. above the corallum wall.

Localities.—Wautubbee, Mississippi; Claiborne, Alabama (Lisbon horizon); Holstun's, 5 miles southeast of Gibbsland, Louisiana.

Geologic occurrence.—Lower Claiborne.

Types.—Pl. VI, figs. 11 to 11b, from collection of T. H. Aldrich in the United States National Museum; Pl. VI, fig. 12, from United States National Museum.

TURBINOLIA ACUTICOSTATA Vaughan.

Pl. VI, figs. 13 to 13b.

1895. *Turbinolia acuticostata* Vaughan. Johns Hopkins Univ. Circ., Vol. XV, No. 121, p. 6.

1896. *Turbinolia acuticostata* Vaughan. Bull. U. S. Geol. Survey No. 141, p. 89.

Conical in shape, as is usual in the genus. Size small. Costæ tall and thin, with crenate margins. Beginning with 6, 6 additional costæ are soon developed, making 12, between which, in the intercostal furrows, are double rows of perforations. The 12-costal condition exists for about 1.5 mm. from the base, when 12 additional costæ are introduced. The costæ on the basal portion of the corallum are very slightly larger than those on the upper portion; they are not so prominent on the basal portion as in *Turbinolia pharetra*. In the extreme upper portion 24 rudimentary costæ are introduced, making the total number 48—twice as many costæ as septa. In the intercostal furrows, after the development of the rudimentary costæ there are only single rows of perforations; during the 24-costal stage there are double rows of alternating perforations in the intercostal furrows. The septa are 24 in number, in three cycles. Those of the third cycle fuse, about halfway between the corallum wall and the columella, by their margins to the sides of those of the first cycle. Their sides are beset with distant, sharp, small spines. The septa are thin and weak. Columella ends in a small, slender, hexagonal style. Height, 6.5 mm.; diameter of calice, 3 mm.

Localities.—Potomac Creek, Virginia; Popes Creek, Maryland.

Geologic occurrence.—Pamunkey formation, Aquia Creek beds.

Type.—Johns Hopkins University.

The crenate character of the costæ distinguish this species from the other Eocene Turbinoliæ with rudimentary costæ.

TURBINOLIA CLAIBORNENSIS sp. nov.

Pl. VI, fig. 14 to 16b.

Corallum small, conical, with acute delicate costæ, the margins of which are entire. Around the calice there are 48 costæ, 24 correspond to septa, and as many are rudimentary. The rudimentary costæ are initiated about 3½ mm. from the base. The costæ of the first and second cycles are very slightly enlarged near the base of the corallum. There are three complete cycles of septa. Their surfaces are covered with distinct conical spines. The primary septa reach and fuse to the columella. The upper termination of the columella is not a star, but compressed, a little excavated on the sides below the upper surface, and slightly granulate. Height of corallum, 5 mm.; diameter, 3 mm.

Locality.—Claiborne, Alabama.

Geologic occurrence.—Claiborne sands.

Types.—Pl. VI, figs. 16 to 16b, specimen on which the above description is based, from collection of T. H. Aldrich in United States National Museum; Pl. VI, figs. 14 and 15, United States National Museum.

Since the foregoing description was written, I have found several specimens in the United States National Museum. A study of these permits considerably more detail to be added to the description. The ornamentation of the septal faces is quite different from that of *T. pharetra* and *T. wautubbeensis*. The septa are very slightly undulated transversely, and that is only along the inner portion. The septal surface, as a whole, is flat. The granules, although originally introduced in curves parallel to the septal margins, are not introduced regularly, so they do not show any very definite arrangement. The smaller septa are joined to the larger by a series of processes placed one above another, thus leaving a series of pores. This is quite different from the condition met with in *T. sulcata*, where the smaller septa fuse solidly by their margins to the sides of the larger.

A specimen much larger than the one from Mr. Aldrich's collection has the following dimensions: Diameter of calice, 4 mm.; height of corallum, 9 mm. Figs. 14 and 14a, Pl. VI, are drawn from it. The only special peculiarity of this specimen is that the columellar upper surface is apparently reinforced by several thickened processes from the septa.

The distinguishing features of the species are the presence of (1) rudimentary costæ; (2) the entire margins of the costæ; (3) the simple enlarging, without a notch, of the costæ in the basal portion; (4) the compressed granulate (not stellate) termination of the columella; (5) the size.

Turbinolia insignifica sp. nov.

Pl. VI, figs. 17 to 18.

This is a minute coral, conical in shape. Costæ rather tall, compressed, their sides near junction with corallum wall fluted, corresponding to intercostal perforations. Margins apparently almost smooth. Around the upper margin of the corallum there are 20 well-developed costæ and 20 rudimentary costæ (twice as many costæ as septa); 6 septa continue without any change to the very apex of the base. On the apex of the base is a minute star-like body, the rays of which alternate with the costæ of the first cycle (i. e., the 6 more prominent costæ). The costæ of the second cycle are notched 0.5 or 0.75 mm. above the base. There are costæ corresponding to the septa of the third cycle, and after the second cycle of septa is fully developed rudimentary costæ usually exist. The septa developed between the first and second cycles of septa do not always correspond to the rudimentary costæ found between those two cycles. When a septum develops in this way, a costa corresponding to it is developed. Therefore we have both a rudimentary costa and a regular costa alongside each other in the same interval between two costæ of the first and second cycles, respectively. The intercostal furrows are always perforate, and when the rudimentary costæ are not present there are double rows of perforations.

A distinguishing feature of this species is that in the basal portion the costal terminations are not enlarged. Of the 12 costæ that extend to the base, 6 do not change at all and 6 are simply notched about 0.5 mm. above the base.

The septal arrangement is simple: it is six systems and three cycles. In two systems of the larger specimen that I have examined the third cycle is not complete. The septa of the third cycle fuse by their margins to the sides of those of the first cycle. Excepting the first cycle, the septa are thin; their sides are beset with small spines.

The specimens are not well enough preserved to permit the details of the columella to be fully made out, but we can be sure that the upper termination is a style and not a strongly stellate pillar, the rays of which join the inner ends of the septa of the first cycle, such as is characteristic of *T. pharetra* and *T. wautubbeensis*. The columella of *T. insignifica* has a rather prominent upper termination. Diameter, 2 mm.; length, 3.5 mm.

Locality.—Old Red Bluff Station, 3½ miles south of Shubuta, Mississippi. (F. Burns, collector.)

Geologic occurrence.—Red Bluff beds.

Types.—United States National Museum.

The character of the columella above noted, the peculiarities of the costæ in its basal portion, and its very small size serve to distinguish this species.

Genus TROCHOCYATHUS Milne-Edwards and Haime.

TROCHOCYATHUS HYATTI sp. nov.

Pl. VI, figs. 19 to 21; Pl. VII, fig. 1.

Shape short, trochiform; cross section circular. Free in adult; on the base a scar as if the corallum were attached in its younger stages. Granular costæ corresponding to all of the septa, sometimes obscured by the epithecal deposit. On the upper part of the wall, when not covered by epitheca, they are very distinct; those corresponding to the septa of the first two cycles the largest. Epitheca thick, usually not reaching to the upper margin of the theca. Septa in four cycles, six systems, exsert, especially those of the first two cycles; there are sometimes small septa of the fifth cycle; their surfaces granular and undulate. Those of the third cycle fuse by their inner edges to those of the second cycle. Pali in two crowns, present before the first three cycles of septa, undulate, with granular surface. Columella composed of ascending rods or trabeculæ which present a papillate upper surface.

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm*
Diameter of calice	11.8	10	11.8	11
Height of corallum	10	8	8.5	6

Localities.—Black Bluff and Prairie Creek, Alabama.

Geologic occurrence.—Black Bluff (Sucarnochee) beds.

Types.—United States National Museum.

The following additional notes on the septa may be added: The septa are composed of ascending trabeculæ, which possess a line of divergence. The courses of the trabeculæ are indicated by rows of granules. The rows of granules do not stand opposite one another on opposite sides of the septum, but alternate in position. The septal margins are usually entire or nearly so, but occasionally the trabeculæ project slightly on the margin and make obscure dentations, especially on the septa of the higher cycles near the wall. The costæ are serrate or granulate. Near the places of fusion of septa by their margins to the sides of lower cycles synapticulæ sometimes occur. The wall seems to be formed by the fusion of the distal ends of the septa, or it may be an eutheca.

Trochocyathus lunulitiformis (Conrad).

Pl. VII, figs. 2 to 4, and fig. 9.

1855. *Turbinolia lunulitiformis* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1895. *Trochocyathus lunulitiformis* Vaughan. Am. Geol., Vol. XV, p. 223.
1896. *Trochocyathus lunulitiformis* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

Corallum subdiscoid; base convex, attached by its central portion; transverse outline circular; costæ distinct, granulate, slightly alternating in size, corresponding to all cycles of septa. Septa in four cycles, six systems. Surfaces densely granulate. Pali before all the septa except the last cycle, their surfaces granulate. Calice circular fossa not very deep. Columella fascicular, its upper surface papillate. Diameter, 9.5 mm.; height, 4 mm.

Localities.—Jackson, Mississippi; Montgomery, Louisiana.

Geologic occurrence.—Jacksonian stage.

Conrad's description of this species was extremely poor, and he published no figure. There can be no doubt, however, that he meant this form.

Trochocyathus lunulitiformis var. montgomeriensis var. nov.

Pl. VII, figs. 5 to 8.

This variety can be distinguished from the typical forms of *Trochocyathus lunulitiformis* (1) by having a flatter base; (2) by being more depressed; and (3) by its costæ being more prominent and more strongly alternated in size. Diameter, 8 mm.; height, 2.5 mm.

Locality.—Montgomery, Louisiana.

Geologic occurrence.—Jacksonian stage.

Types.—United States National Museum.

The following gives more detail concerning the wall, septa, etc.: There is no epitheca. The wall is formed by the direct fusion of the distal portion of the septa, without the intervention of secondary calcification centers (Pl. VII, fig. 9). The septa are composed of trabeculæ; slightly above the wall is a line of divergence. The pali seem to possess their own trabeculæ and centers of calcification, separate from those of the septa. In the septa the courses of the trabeculæ are indicated by rows of granules, which are at the same time arranged in curves parallel to the septal margins. There is the same alternation in position of the rows of granules already noted in *Trochocyathus hyatti*. As the trabeculæ approach the septal margin they diverge, the space between adjacent trabeculæ becoming larger. In the intervening space new trabeculæ may be introduced. The septal margins, especially in the more exterior portion, are minutely serrate or crenate, the serræ corresponding to the emergence of the trabeculæ at the surface. The margins of the interior half (roughly speaking) are so-called entire, i. e., the trabeculæ terminate in a practically smooth continuous curve.

Projecting interiorly from the wall are processes that in cross section have the structure of synapticulæ—the so-called pseudosynapticulæ (see Pl. VII, fig. 9). The appearance on the side of a septum is shown in Pl. VII, fig. 4.

The columella is composed of several rods that rise upward from the base; they fuse by cross processes, and their upper terminations produce the papillate upper surface of the columella.

There appear to be synapticulæ also, formed by the fusion of granules standing opposite each other on adjacent septa. The granules on the septa are long. Those on adjacent septa usually alternate with each other in position; sometimes, however, they stand opposite; quite often they will fuse, forming the so-called pseudosynapticulæ.

This species is extremely close to *Trochocyathus discoides* Sokolow,[1] so close that after Dr. Sokolow had kindly compared specimens of *Tr. lunulitiformis* with *Tr. discoides* he wrote me as follows:

> I have from Jekaterinoslaw only a single injured specimen of Trochocyathus. A comparison of this specimen with those that you have sent me shows no difference on the under (outer) side. I have also found no differential character in the septa. But the columella of my specimen is somewhat wider than that of *Trochocyathus lunulitiformis*, and the upper surface of the columella of my specimen is more irregularly papillary (warzig); also the pali are somewhat more strongly developed. But as I have only one and that an incomplete specimen, I can not establish that my *Trochocyathus discoides* is without doubt a new species, and will not oppose placing *Trochocyathus discoides* in the synonymy.

While in St. Petersburg in the summer of 1897, through the courtesy of Dr. Sokolow I had the privilege of examining the type of his *discoides*. The septa of his species seem to me thinner than in *Tr. lunulitiformis*. For the reasons that he has given, and on account of the one I have stated, it appears better to not place his species in the synonymy of Conrad's; but the resemblance between the two is most striking, and ultimately

[1] Die unteroligocäne Fauna der Glauconitsande bei der Eisenbahnbrücke von Jekaterinoslaw: Mém. du Comité Géologique (Russia), Vol. IX, No. 3, 1894, pp. 92–94, fig. 7 (in text), pl. I, fig. 5a–d.

they may be shown to be the same. Should the latter prove true, Sokolow's name should stand, as Conrad did not describe his species sufficiently clearly and did not figure it at all. Sokolow wrote a splendid description of his species, and published exquisite figures of it.

TROCHOCYATHUS CALIFORNIANUS sp. nov.

Pl. VII, figs. 10 to 13.

Corallum discoid, attached at the middle of the base, which is almost flat, very slightly convex or concave. Measurements of four specimens are:

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Diameter of corallum	6	6	7	7
Height of corallum	2.25	2	2.75	2.5

Costæ correspond to all septa. They are low, rather thick at the wall, but with a subacute edge, finely granulate, and equal. There is no perceptible alternation or difference in size. There are three complete cycles of septa, and very nearly all the members of the fourth. They are thin, their upper margins arched from the wall to the calicular fossa. Peripherally, occasional dentations on the margins; faces granulate. Pali are present. They are thin, and before some septa broad, but the details can not be ascertained. Calicular fossa shallow, calice widely open. Columella fascicular, composed of erect rods rising from the base.

Locality.—San Joaquin coal mine, California.

Geologic horizon.—Cretaceous ?

Types.—Four specimens sent to me by Dr. J. C. Merriam, University of California, and returned to him. One specimen has been presented by Dr. Merriam to the United States National Museum.

This species is extremely close to *Tr. lunulitiformis;* in fact, the specific differences here pointed out are not thoroughly satisfactory. The specimens of *Tr. lunulitiformis* have the cycles of costæ indicated by corresponding sizes, or they alternate in size. The costæ of *Tr. californianus* are, as above stated, equal. This difference seems good, but when more specimens of the latter have been discovered, and the details of the pali and columella can be worked, still other differences may be found.

This species, as well as *Tr. lunulitiformis* (Conrad), should be compared with *Tr. discoides* Sokolow, from Jekaterinoslaw, southern Russia.

One of the type specimens of the *Tr. californianus* shows an interesting feature, probably an abnormality. Apparently a bud is being formed from the calicinal region. Pl. VII, fig. 13, represents the condition.

TROCHOCYATHUS DEPRESSUS sp. nov.

Pl. VII, figs 14 to 17.

Form subdiscoid, or bowl-shaped; transverse outline subcircular, slightly irregular. Base convex, calice wide open and moderately deep. There is no sign of attachment, although the base is disfigured in eight of the nine specimens that I have examined. Costæ corresponding to all cycles of septa not very prominent, but distinct to the base. In size they are subequal; every fourth is usually slightly more prominent than the three intervening. They are slightly acute, and along the crest is a single series of granules. Their sides also are granulate.

Septa numerous, about 80. The arrangement is extremely difficult to make out, as the primaries and secondaries are of the same size. They project very slightly above the upper margin of the wall. The free margins of the septa, after rising a little above the wall, lie in a horizontal plane for about one-fourth the diameter of the calice; then they fall to the bottom of the calice in a curve parallel to the corallum wall. They are considerably thicker near the wall. The sides are highly ornamented. The pattern of ornamentation is extremely complicated. It is shown in Pl. VII, fig. 16. Two zones of different kinds of ornamentation can be recognized. An outer, in which there are projections from the corallum wall. Between these projections are small, closely crowded granules They are arranged, in not very distinct rows, subparallel to the upper margin of the septa at the wall and to the processes extending inward from the corallum wall. The second zone consists of elongated granules that slope upward and inward, making an angle of approximately 45° with the septal margin. The general scheme is very well represented in Pl. VII, fig. 16. The interpretation of this arrangement of granules is that there is a line of trabecular divergence along a line extending lengthwise just about the middle of the septum; above this line the trabeculæ are directed upward (i. e., inward); below they are directed outward or downward (morphologically, outward). The rows of granules on opposite faces of a septum are opposite, and when the edge of a septum is viewed from above they give the appearance of striations extending down the sides of the septum and across its margin. Around the fossa the margins are entire, but external to the fossa they are gently and finely crenate. In the region of the wall the septa are much thicker, and there are many minute granules along the edges and free portions. Pali before all cycles of septa except the last; small, with rounded upper margins, sides granulate. Columella fascicular.

	1	2	3
	Mm	*Mm.*	*Mm.*
Greater diameter of calice	11.75	10.75	9.75
Lesser diameter of calice	11.5	9.75	9
Height of corallum	3.5	3.5	4

Locality.—Six miles west of Desoto Station, Clarke County, Mississippi. (F. Burns, collector.)

Geologic occurrence.—Lower Claiborne.

Types.—United States National Museum.

The only closely related species is *Tr. lunulitiformis*. *Tr. depressus* is easily recognized by its more irregular transverse outline and its more excavated calicular fossa.

Trochocyathus stantoni sp. nov.

Pl. VII, figs. 18 and 18a.

Form discoid; base flat, with a scar in the center as if it were attached, covered by epitheca which reaches to the calicular margin. Twenty-four costæ of equal size; apparently there are 24 smaller costæ alternating with the large ones. Septa arched, projecting high above the flat base, side granulated, margins slightly undulated transversely. The arrangement is in four complete cycles of six systems, the total number being 48. Those of the first, second, and third cycles of about the same size; the fourth cycle smaller. Calicular fossa deep. Pali present, but the details could not be made out. Character of the columella could not be ascertained.

The measurements are: Diameter of base, 14.25 mm.; height, 5.75 mm.; depth of calice, more than 2 mm.

Locality.—Two and a half miles northeast of Clayton, Contra Costa County, California. (Collected by T. W. Stanton.)

Geologic occurrence.—Tejon group, above the coal horizon.

Type.—United States National Museum.

This species is founded upon one specimen embedded in an indurated, coarse-grained, glauconitic sandstone. It was with great difficulty that enough of the matrix was removed to permit as many details of the septa and pali to be ascertained as are stated above. The base is eroded so that the character of the costal ornamentation can not be described fully. There can scarcely be a doubt about the generic determination of the species, notwithstanding our ignorance of some details. The other discoid species of the genus are *Tr. californianus*, *Tr. lunulitiformis*, and *Tr. depressus*. *Tr. stantoni* is the only one whose septa arch high above the corallum wall, and the only one that has the base covered by epitheca. An examination and comparison of the figures will make these differences apparent. The great differences in the costæ also will be readily recognized.

TROCHOCYATHUS CINGULATUS sp. nov.

Pl. VII, figs. 19 to 19b.

Form short cornute, basal portion small, subpedicellate, curved in plane of lesser diameter of the calice. Transverse section subelliptical. Scar of attachment preserved. Corallum wall ornamented by 42 low, distinct, granulate costæ, corresponding to all cycles of septa, and alternating in size. Epitheca appears to be entirely absent. There are several girdling depressions and bands, giving the species a cingulate appearance.

Septa are moderately strong, thicker near the wall, and sometimes thicken somewhat before joining the columella, 42 in number: 21 principal septa with alternating smaller ones. The various cycles are extremely difficult to make out. Their sides are ornamented with rather prominent spines, which usually appear to be truncated. Columella fascicular. Greater diameter of calice, 8.5 mm.; lesser diameter of calice, 8 mm.; height, 9.5 mm.

Locality.—Prairie Creek, Wilcox County, Alabama. (L. C. Johnson, collector.)

Geologic occurrence.—In the lower beds of the Chickasawan stage, or in the Midwayan stage.

Type.—United States National Museum.

This pretty little species is described from a single specimen, but it is utterly distinct from any other of our Eocene corals, and is very easily recognized, simply by its short cornute form and the lower alternating costæ.

The calice is not well preserved, the margins of the septa being broken away. The columella is apparently essential, although it is frequently fused to the ends of the septa. Near their inner terminations, just before they join the columella, the septa become thicker and fuse by slight lateral outgrowths or by their margins. Pali are present, but their details could not be made out.

TROCHOCYATHUS CLARKEANUS (Vaughan).

Pl. VII, figs. 20 to 23.

1895. *Paracyathus* (?) *clarkeanus* Vaughan. Johns Hopkins Univ. Circ., Vol. XV, No. 121, p. 6.

1896. *Paracyathus* (?) *clarkeanus* Vaughan. Bull. U. S. Geol. Survey No. 141, p. 89.

Corallum conical, usually slightly curved. Cross section elliptical. Nearly always showing a distinct area of attachment, which is variable in size. Costæ not very prominent; acute; 48 in number, corresponding to all the cycles of the septa; nearly equal in size. In young specimens those corresponding to the last cycle of septa are smaller than those earlier developed. No epitheca was observed and is most probably absent. Septa thin, not exsert, sides granulated; 48 in number, arranged in six systems of four cycles each; those of the first three cycles reach the columella; the fourth cycle fuse by their inner margins to the sides of the third cycle. Calicular fossa shallow. Pali apparently before all of the cycles of the septa except the last, small and thin, and appear to be arranged in two crowns. Rudimentary dissepiments apparently present. Columella fascicular; upper surface papillate.

The measurements of the two specimens are:

	1	2
	Mm.	*Mm.*
Greater diameter of calice	7	7.75
Lesser diameter of calice	6	5.5
Height of corallum	12.5	9.75

Localities.—Potomac Creek and Aquia Creek, Virginia.

Geologic occurrence.—Pamunkey formation, Aquia Creek beds.

Types.—Johns Hopkins University.

Specimens.—United States National Museum.

The specimens on which this species is founded are all imperfect. I could not obtain accurate details concerning the characters of the columella or of the pali, but the species seems to present all the essential characters of Trochocyathus, and is therefore referred to that genus. There is no other species of coral with which it could be confused; therefore critical notes are unnecessary.

TROCHOCYATHUS STRIATUS (Gabb).

Pl. VII, fig. 24; Pl. VIII, figs. 1 to 3.

1864. *Trochosmilia striata* Gabb. Geol. Surv. California, Palæontology, Vol. I, p. 207, pl. xxvi, fig. 195.
1893. *Trochosmilia striata* Boyle. North Amer. Mesozoic Invert.: Bull. U. S. Geol. Survey No. 102, p. 290.
1897. *Trochosmilia striata* Merriam. Journ. Geol., Vol. V, p. 771.

The following is the original description: "Elongate, slender, curved, section circular or subcircular; epithelium rudimentary, surface marked by numerous prominent striæ, usually rounded, of variable size, and often showing a well-marked alternation of larger and smaller ones. Surface of calice unknown."

Locality.—Division B,[1] near the coal mine at Mount Diablo, California.

Mr. Stanton obtained a considerable number of specimens of this species in Contra Costa County, California. From a study of these specimens I can give more information concerning the characters of the species, and can determine its generic position with reasonable certainty. The form of the corallum was described well enough by Gabb. The costæ are rather prominent, subacute, alternating in size, and correspond to all cycles of septa. No epitheca was seen on any of the specimens. Septa rather thick, the inner terminations of all except the last cycle thickened, 44 in number (in thin section studied), two half systems of the fourth cycle being incomplete. Their sides granulate. The interseptal spaces devoid of dissepiments. Columella fascicular, upper surface papillate. The thickenings on the inner ends of the septa without doubt represent pali. Therefore, there are pali before all septa, except those last introduced, and they are arranged in two

[1] B is the upper division of Gabb's section, and was supposed to be Cretaceous.

rather regular crowns. It can scarcely be doubted that the species is a genuine Trochocyathus.

The size and relations of the dimensions of different specimens are so variable that we give no measurements; the figures give the same data in more comprehensive form.

Locality.—Near Clayton, Contra Costa County, California. (Stanton.)

Horizon.—Tejon beds (upper part).

TROCHOCYATHUS ZITTELI Merriam.

Pl. VIII, figs. 4 to 7.

1897. *Placosmilia* n. sp. Merriam. Journ. Geol., Vol. V, p. 770.

Doctor Merriam very kindly sent me six specimens of this species, and on that material the following description is based.

The form of the corallum is short cornute, curved in the plane of the shorter transverse axis of the calice.

The following are measurements of five specimens:

	1	2	3	4	5
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	10	15	14.5	15.5	21
Lesser diameter of calice	8.5	9.5	11.5	12.5	13
Height of corallum	12	21	21	19	24

The best preserved of the five specimens showed at the base a small nipple-like pedicel, with a minute scar of attachment. Another specimen showed some slight sinuosity of the wall parallel to the vertical axis of the corallum near the calicular margin. Costæ correspond to all septa; they are distinct but not very prominent, have rather broad bases, with somewhat acute edges. They are quite regularly alternately larger and smaller in size; are granulate, the granulations rather large, often a distinct row along the summit of a costa. Septa numerous; 72 were counted in the cross section of a specimen whose greater diameter is 15.5 mm. and lesser diameter 13.5 mm. Considering six as the number of the primary cycle, there would be four complete cycles and half the members of the fifth, but the various cycles are not distinctly indicated. The septa are not very long, somewhat or decidedly thicker at the wall, inner portion thin, and are usually very flexuous. A few granulations on the septal faces. There are distinct pali, with an elongate elliptical cross section before all septa except those of the last cycle, and are arranged rather definitely in two crowns. The wall and septa become secondarily thickened. Columella composed of a few ascending more or less twisted laminæ. Calicular fossa rather deep.

Locality.—Martinez, California.

Horizon.—Martinez group.

Types.—Collection of Dr. J. C. Merriam, University of California. Specimens upon which the above description and figures in this paper are based are in the United States National Museum.

Trochocyathus conoides (Gabb and Horn).

Pl. VIII, figs. 8 to 10.

1860. *Trochosmilia conoides* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, p. 399, pl. lxix, figs. 12 and 13.

The original description is: "Resembles closely *Tr. mortoni* (i. e., *Balanophyllia irrorata* var. *mortoni*), above described, differing in its much more robust form and the finer striæ exteriorly, which are granulous."

Locality.—"Cretaceous, N. J."

The type of this species is, fortunately, in the Academy of Natural Sciences of Philadelphia, and the authorities of that institution very kindly loaned it to me. The type is a miserable fragmental specimen, and from what Gabb writes of it one would suspect it to be related to Balanophyllia. Fortunately there are specimens of the same species mixed with Morton's "*Turbinolia*" *inauris* in the Philadelphia Academy collections, and there is also a specimen in the United States National Museum. All of the specimens without doubt come from the same locality. A specimen of *Flabellum mortoni* sp. nov. is in the vial with Gabb's type, both labeled "Types"! This species is with it in all of the lots of specimens. It is possible that *Tr. conoides* may be the same as Morton's discarded "*Turbinolia*" *inauris.* The following description is not based on the type, as it is not well enough preserved to serve as a basis for a specific diagnosis, though the specimen can, as already stated, be identified:

Corallum short cornute, rapidly increasing in diameter, curved in the plane of the shorter transverse axis of the calice; cross section elliptical.

The following table gives measurements of several specimens:

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	16	20	14	19
Lesser diameter of calice	12	16	13	15.5
Height of corallum	20	26	15	....

Specimen 2 is represented by Pl. VIII, figs. 8 and 8a. The corallum wall is solid and apparently is covered by a thin, firm, pellicular epitheca, that is applied to the wall in the same way as is the epitheca in Flabellum. It has this appearance, but there is not sufficient material well enough preserved to determine the point positively. The outer surface of the corallum wall usually shows several longitudinal undulations, there being more on the concave than on the convex side. Besides these there are low rounded costæ. There are some longitudinal raised striæ or longitudinal rows of small low granules on the outer surface of the corallum. Septa, in cross section (Pl. VIII, fig. 10), about 64, cycles and systems not very distinct. The first and second cycles and some members of the third reach the columella space. The members of the third cycle usually fuse by their inner margins to the sides of those of the second, thus inclosing the members of the fourth cycle. When members of the fifth cycle are present, those of the fourth will fuse to the sides of those of the third, thus inclosing the members of the fifth. The septal grouping does not seem to be absolutely regular, but the tendency to form septal groups is well pronounced. The septa are thin, somewhat flexuous near the center, thicker at the wall. All of them, excepting the youngest members of each system (i. e., those of the fifth cycle and those of the fourth cycle where none of the fifth is present), have distinct elongate elliptical or clavate thickenings on their inner ends. These are probably pali. They are arranged in two rather definite crowns. Septal faces granulated, no endotheca. Columella small, composed of a few more or less twisted ascending laths, to which the larger septa fuse by their flexuous inner margins.

Localities.—New Jersey, Philadelphia Academy label; near Squankum, New Jersey (Meek and Hayden), United States National Museum.

Horizon.—Shark River beds, probably Claibornian.

Types.—Academy of Natural Sciences of Philadelphia; specimen in the United States National Museum.

I found one specimen of the species in the United States National

Museum material from near Squankum, New Jersey; therefore we know both the horizon and locality of the species accurately. The matrix of the specimens is a coarse-grained glauconitic sand, with some finer light-colored calcareous material. The interseptal loculi are occasionally quite deceptive in appearance. They are often filled with grains of glauconite, between which are shreds of the lighter-colored material. The result of this is to give, quite frequently, the appearance of a very well developed endotheca. This appearance is described, because it might deceive one who is not accustomed to handling corals that have suffered from the effects of fossilization. This species, strange to say, seems to have its nearest ally in *Trochocyathus zitteli* Merriam, from Martinez, California. The resemblance is not very great, as a comparison of the descriptions and figures of the two species will show. Attention is directed especially to the difference in the characters of the costæ.

Genus PARACYATHUS Milne-Edwards and Haime.

Paracyathus alternatus sp. nov.

Pl. VIII, figs. 11 to 14b.

Form compressed conical, with the base truncated, attached at the truncation. In one specimen the place of attachment has been almost completely covered by a subsequent calcareous coating, leading to the inference that in the adult stage the individuals may be free. Costæ corresponding to all of the septa, distinct, acute, subacute, or rounded in profile, granulate, alternating in prominence. Wall rather thin and not of uniform thickness. Septa slightly exsert in four cycles, six systems, in some systems members of the fifth cycle. Those of the first two cycles reach the columella, those of the third cycle fuse by their edges to the sides of the second; sometimes the fourth fuse similarly to the third. Surfaces granulate. Pali before all the septa except the last cycle, bilobed, granulated on sides. Rudimentary dissepiments present. Columella fascicular, papillate. Depth of calice about one-third the length of the corallum.

	1	2
	Mm.	*Mm.*
Greater diameter of calice	8	8
Lesser diameter of calice	6	6.75
Height of corallum	7	8

These measurements represent the usual size of adult specimens. Several varieties, with sizes indicated, are figured in Pl. VIII, figs. 11 to 14.

Localities.—Near Mount Lebanon, Louisiana; Holstun's well, Louisiana; SW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ sec. 19, T. 19 N., R. 7 W., Louisiana; Rayburn's well, sec. 29, T. 17 N., R. 5 W., Bienville Parish, Louisiana; Newton, Enterprise, and Wautubbee, Mississippi; 3 miles northeast of Newton, Mississippi; 2 miles southeast of Hickory, Newton County, Mississippi; 8 miles south of Hickory, Clarke County, Mississippi; 8 miles west of Enterprise, Mississippi; 1 mile south of Hickory, Mississippi; $4\frac{1}{2}$ miles east of Newton, Mississippi; upper layer, Sowilpa Creek, Alabama; Smithville, Texas; Black Shoals, or Colliers Ferry, 1 mile below the Milam-Burleson county line, Texas; Lexington, Lee County, Texas.

Geologic occurrence.—Lower Claiborne (Lisbon horizon).

Types.—United States National Museum.

Specimens.—Museum of Comparative Zoology, Cambridge, Mass.; T. H. Aldrich's collection; and Wagner Free Institute of Science.

Additional notes on the wall septa, etc.—The wall is a pseudotheca, i. e., formed by the fusion of the distal ends of the septa. The septa have thickenings at right angles to the septal plane in the mural region. A thickening from one septum meets that of the opposed septa, and the two fuse. A little line, indicating the place of fusion, could be seen between nearly every pair of septa in the cross section. The septal thickenings to form the wall are not usually exactly in a ring, but the thickening on one side of a septum may be interior or exterior to the thickening on the other side.

The septa are composed of completely fused ascending trabeculæ, which possess a line of divergence coinciding in position with the wall. The courses of the trabeculæ are indicated by rows of granules. The rows on opposite sides of a septum do not stand opposite, but alternate in position. The septal margins interior to the wall are entire; exterior to it the trabeculæ frequently project slightly along their axes, making obscure dentations. No synapticulæ were seen; the septa are usually rather far apart, so the granules do not fuse across the interseptal loculi.

Three minor varieties of this species may be recognized, but they are not of sufficient importance to merit naming. Variety *a*, the typical form represented by Pl. VIII, fig. 11; variety *b*, the specimen with very wide base and low rounded costæ, represented by Pl. VIII, fig. 14; variety *c*, larger than variety *a*, and the costæ are more prominent and more acute, represented by Pl. VIII, fig. 12. The intergradation between all the forms is complete.

This species is very close to *Paracyathus crassus* M.-Edw. and H.,[1] from the English Bracklesham beds. I was able to examine specimens of *Paracyathus crassus* in the British Museum (Natural History). The size, character of costæ, and general external appearance furnish no criteria for specific differentiation. The pali seem to furnish a good basis for separation. In *P. crassus* they are thin, weak, transversely fluted, and have a small inner tooth. The pali of *P. alternatus*, as Pl. VIII, fig. 11a, shows, are stout, with a strong distinct inner lobe. Should this character ultimately prove insufficient for the differentiation of the species, *P. alternatus* must become a synonym of *P. crassus*.

Paracyathus granulosus sp. nov.

Pl. VIII, figs 15 to 15b.

This species is extremely close to *P. alternatus;* therefore a differential diagnosis is given. The two ultimately may be united. The general form is indicated by the figure. The view of the calice from above, looking down upon the columella and pali, is characteristic of the genus. The pali are undulate, granular, and some have small wing-like lateral expansions.

The transverse outline of the calice in *P. alternatus* is elliptical, while in *P. granulosus* it is practically circular. With increasing height *P. alternatus* increases more rapidly in diameter than *P. granulosus;* therefore the base of attachment is proportionately larger in the latter species. The costæ of *P. granulosus* are not prominent, not very acute, not strongly alternated in size, and are densely and minutely granulate. In *P. alternatus* a deposit of callous is laid down upon the original costæ on the lower portion of the corallum. This callous is costate, its costæ corresponding to the original costæ. The costæ of *P. granulosus* are not covered by a subsequent deposit of callous. Greater diameter of calice, 6.1 mm.; lesser diameter of calice, 6 mm.; height of corallum, 7.2 mm.

Locality.—Lower layer Woods Bluff, Alabama.

Geologic occurrence.—Woods Bluff beds.

Type.—From collection of T. H. Aldrich in the United States National Museum.

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[1] Mon. Brit. Foss. Corals, Palæontogr. Soc., 1850-1854, p. 23, pl. iv, figs. 1, 1a-1c.

PARACYATHUS BELLUS sp. nov.

Pl. VIII, figs. 16 to 20.

1895. *Paracyathus bellus* Vaughan nom. nud. Am. Geol., Vol. XV, p. 217.
1896. *Paracyathus bellus* Vaughan nom. nud. Bull. U. S. Geol. Survey No. 142, p. 19.

Form rather elongate, slightly curved, attached by a rather broad base, cross section nearly circular, enlarging very little in diameter with increasing height. Costæ corresponding to all cycles of septa, no noticeable alternation in size. Along the summit of each costa there is a single row of regular granules. Intercostal furrows narrow. Epitheca rudimentary, occasional shreds or bands girdling the corallum. Wall not very thick. The number of septa varies from 24 to 36; the latter seems the usual number. Sides of the septa densely granulate, the granules elongated and disposed in curves parallel to the septal margins. Pali before all of the septa except those of the last cycle. Seen from above they are very difficult to distinguish from the papillate surface of the columella. They are small, slender, weak, with granulations similar to those on the septa. Columella fascicular, its upper surface papillate. Calice shallow.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Diameter of calice	4.7	4.5	5
Height of corallum	7	11	8.5

Localities.—Enterprise, Newton, and Wautubbee, Mississippi; 2 miles southeast of Hickory, Newton County, Mississippi; 8 miles south of Hickory, Clarke County, Mississippi; 8 miles west of Enterprise, Mississippi; 1 mile south of Hickory, Mississippi; 4½ miles east of Newton, Mississippi; 10 miles northwest of Winfield, Louisiana; St. Maurice, Louisiana.

Geologic occurrence.—Lower Claiborne.

Types.—From collection of T. H. Aldrich in the United States National Museum.

Specimens.—United States National Museum.

The wall apparently is formed by the distal fusion of the septa. The fusion is not always complete, so perforations in the wall are quite frequent. The septal structure is identical with that of *P. alternatus*, excepting the presence of many pseudosynapticulæ. The septa are crowded so the granules often fuse across the interseptal loculi. There are some projections extending inward from the wall, and the granules are elongated in curves parallel to septal margin. The latter is true to a less degree in *P. alternatus*.

This species resembles *Paracyathus caryophyllus* (Lamarck)[1] quite closely in its form and in the character of the costæ. A study of specimens of the latter in the British Museum (Natural History) showed it to be a decidedly larger species, and its calice is deeper.

PARACYATHUS RUGOSUS sp. nov.

Pl. VIII, figs. 21 to 21b.

Only one specimen of this species has come under my observation, and it can be best characterized by a differential description.

Looked at superficially, the species resembles *P. bellus;* the first difference is that the corallum of *P. rugosus* enlarges more rapidly in diameter as it increases in height. The costæ of *P. rugosus* are composed entirely of a series of subtriangular plates whose upper angles project a little. The costæ are very rough, and if the end of the finger is drawn along them from the calicular margin toward the place of attachment, the projecting points will catch in it. The costæ correspond to all cycles of septa, and there is no alternation in size. Septa in three cycles. Pali as usual in the genus. Diameter of calice, 4 mm.; height of corallum, 9 mm.

Locality.—Lower bed, Woods Bluff, Alabama.

Geologic occurrence.—Woods Bluff beds.

Type.—From collection of T. H. Aldrich in the United States National Museum.

PARACYATHUS CYLINDRICUS sp. nov.

Pl. IX, figs. 1 to 1b.

This species is extremely close to *P. bellus*. In shape its base is proportionately broader. The principal difference between the two species is in the character of their costæ. In *P. bellus* the intercostal furrows are very narrow; they are not so wide as the costæ; in *P. cylindricus* the costæ are not so prominent as in *P. bellus*, and the intercostal furrows are much wider. The costæ are low, acute, equal in size, granulate; there are gran-

[1] Milne-Edwards and Haime, Mon. Brit. Foss. Corals, Palæontogr. Soc., 1850–1854, p. 24, pl. iv, fig. 2, 2a–2c.

ules also in the intercostal furrows. The granulations usually are not seen, owing to having been worn slightly. The number of costæ and septa is from 32 to 36, the same as in *P. bellus*.

	1	2
	Mm.	*Mm.*
Diameter of calice	4.6	4.3
Diameter 1.5 mm. above base	4	....
Diameter of base, about	3	3
Height of corallum	8	5

Locality.—Wilcox County, Alabama. (L. C. Johnson, collector.)

Geologic occurrence.—Lower Eocene, probably Midwayan.

Types.—United States National Museum.

Genus CARYOPHYLLIA Lamarck.

CARYOPHYLLIA DALLI sp. nov.

Pl. IX, figs. 2 to 2c.

1896. *Caryophyllia* n. sp. Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

Shape subconical, enlarging rapidly in the upper portion of the corallum. Cross section elliptical. Costæ correspond to all the cycles of septa, very prominent, those corresponding to the first three cycles of septa much larger than those corresponding to the fourth cycle. Wall thick; the lower part of the corallum is covered by a calcareous coating. Apparently, when the animal was fully expanded it extended on the outside of the corallum entirely to the base. Septa in four cycles; the first two cycles reach the columella. The fourth cycle fuse by their inner margins to the sides of the third cycle. Their surfaces granulate. Their upper margins project considerably above the upper margin of the wall, and connect with upward extensions of the costæ. The septa of the last cycle are dentate (cf. Pl. IX, fig. 2c). One septum of the second cycle, which has its margin intact, is dentate, while another of the same cycle has an entire margin. The septal margins are, in all cases where preserved, except one, dentate or crenate. Pali, with granular surfaces, before the septa of the third cycle. Columella made up of twisted pieces. Calice not very deep. Greater transverse diameter of calice, 16 mm.; lesser transverse diameter of calice, 13 mm.; height of corallum, 22.5 mm.

Localities.—Creole Bluff, Montgomery, Grant Parish, Louisiana; Vinces Bluff, Saline River, Arkansas.

Geologic occurrence.—Jacksonian stage.

Type.—United States National Museum.

The very large but acute costæ easily characterize this species. They are sometimes fully 1 mm. in height.

Caryophyllia should have septa with entire margins, but there is evidently so great a variation within this specimen itself in the character of the septal margins, that it does not seem possible to refer it to another genus, when, excepting this peculiarity, every other feature is typical for that genus.

CARYOPHYLLIA TEXANA sp. nov.

Pl. IX, figs. 3 and 4.

Corallum attached, a short pedicel and scar of attachment usually present; form short cornute, curved in plane of the shorter axis of the calice; transverse outline elliptical. Costæ corresponding to all cycles of septa; not prominent, regularly alternating in size; rather acute, surface granulate. The presence of epitheca doubtful. Septa project but little above the upper margin of the corallum wall, in at least four cycles, rather stout, sides granulate. Margins entire. Septa composed of completely fused ascending trabeculæ, with line of divergence at the wall. Pali present, stout, well developed. Details difficult to discover, because of the poor state of preservation of the interior of the specimens. Apparently in one crown before the tertiary septa. (It is because of this arrangement of pali that the species is referred to Caryophyllia.) Details of the columella can not be made out from the material in hand.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	15	12	12
Lesser diameter of calice	13	9	9
Height of corallum	17	13.5	8.5

Locality.—San Augustine, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—Collection of Wagner Free Institute of Science, Philadelphia.

This species is represented in the collection of the Wagner Institute by ten specimens, including fragments. They were embedded in a glauconitic sandy clay, and the interior portions have rotted away to such an extent that the details of the septa, pali, and columella could not be ascertained as fully as was desired. The generic determination seems certain, and the species is so characteristic that it can be easily recognized. The low costæ separate it immediately from *Caryophyllia dalli*, whose costæ are very prominent. The septal margins are widely different, as the descriptions of the two species show. The specimen represented in Pl. IX, fig. 3, is interesting, because it shows apparent reproduction by budding. I was unable to decide whether there was gemmation, or whether one coral had simply attached itself to the other for support; probably the latter is the case.

Genus STERIPHONOTROCHUS gen. nov.

This genus need not be described at length, because a single character separates it from Ceratotrochus as represented by *C. duodecimcostatus*. The following description of the type species of the genus, *Steriphonotrochus pulcher* sp. nov., will show its external resemblance to *C. duodecimcostatus*, and the similarity in the character of the columella. The septal margins of Ceratotrochus are entire, without any indication of dentations or crenations, as a careful study of *C. duodecimcostatus*, *C.* (*Conotrochus*) *typus*, and *C. multiserialis* showed. The septal margins of Steriphonotrochus are regularly crenate (see Pl. IX, fig. 5c).

From the manner of treating the septal margins in the preceding case of *Caryophyllia dalli* and the succeeding one of *Parasmilia ludoviciana*, it may seem inconsistent to base a genus merely on the character of the septal margins; but in the present instance the conditions are different. There is no indifferent variation from entire margin to crenate margin, but the septa of all cycles are regularly uniformly crenate where preserved intact. No other kind of margin is represented. After examining a considerable number of species of Ceratotrochus, and searching carefully in the literature, I have been unable to discover any species that has not simple entire margins. For these reasons it seems to me that the peculiarity of the septal margins in Steriphonotrochus is a good basis for generic separation.

STERIPHONOTROCHUS PULCHER sp. nov.

Pl. IX, figs. 5 to 5d.

Form subcornute, slightly curved, transverse outline elliptical. Attachment area not very large. Corallum wall not very thick, a very little epitheca doubtfully present. Costæ corresponding to all cycles of septa. They are (on upper part of corallum) 54 in number, are prominent, standing up like plates; some are 1.5 mm. high, alternating in size. When viewed in profile, the margins of the costæ are seen to be wavy and ornamented with granules. The sides are covered with granules. Near the area of attachment the costæ become much less prominent, and the number is reduced to 24, alternating in size. These 24 septa are continued to the margin of the scar of the attachment area.

Septa weak, 54 in number; there are four complete cycles and a few septa of the fifth. Twenty-seven septa reach the columella. The other 27 fuse by pairs to the sides of the included septum of the next lower cycle. The upper margins of the septa are broken off in the type, and it can not be stated whether they are very exsert. The inner margins are crenately dentate. The sides beset with mamillate granules. Columella vesicular. Calicular fossa deep, 6 mm. Greater diameter of calice, about 17 mm.; lesser diameter of calice, about 13 mm.; height, 28 mm.

Locality.—Red Bluff, Wayne County, Mississippi. (Schuchert and Burns, collectors.)

Geologic occurrence.—Red Bluff beds.

Type.—United States National Museum.

Genus PARASMILIA Milne-Edwards and Haime.

PARASMILIA LUDOVICIANA sp. nov.

Pl. IX, figs. 6 to 13.

1896. *Parasmilia* n. sp. Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

Form cornute, elongate, curved, cross section approximately circular or slightly compressed. Wall a pseudotheca. Costæ corresponding to all cycles of septa; moderately prominent, subequal in size. Septa very slightly exsert, rather thin, about 32 in number; 16 reach the columella. The arrangement is in six systems, three complete cycles, 8 septa of the fourth cycle.

On the outside and inside of the wall the trabeculæ forming the septa are respectively inclined outward and inward. Very little of the septa is extra mural.

The character of the septal margins is variable. Those of the first, second, and third cycles are usually entire, while those of the fourth cycle are frequently dentate. The margins of the larger septa are usually entire; of these occasionally a septum may have some dentations. Near the columella, teeth are quite frequent. The smallest septa are usually dentate, but occasionally one of these may have an entire margin. The teeth on the inner ends of the large septa sometimes are paliform. There are no true pali, however. A few dissepiments are present. Columella false, upper surface papillate. Calicular fossa deep.

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice, about	8	10	8	6.5
Lesser diameter of calice	7.5	....	....	....
Height of corallum	22.5	36	22	17.5

Locality.—Montgomery, Louisiana.

Geologic occurrence.—Jacksonian stage.

Types.—United States National Museum.

Family OCULINIDÆ Milne-Edwards and Haime.

Genus ASTROHELIA M.-Edw. and H.

Astrohelia neglecta sp. nov.

Pl. IX, figs. 14 to 15.

Colony ramose, branches subcylindrical, from 14 to 22 mm. in diameter. Cœnenchyma moderately thick, but not always very dense; surface minutely granulate and covered to a great extent by slightly flexuous costostriæ. Corallites arranged in rather definite spirals; often constricted at the calicular margin, lower part filling with secondary deposit. Calices rather deep, subelliptical, diameter from 5 to 7 mm., distant from one-half to the length of their diameters; margins rather prominent, openings inclined toward the ends of the branches. Septa thin, not exsert, sides granulate, upper portion of margins minutely dentate, lower portion thrown into minute sharp transverse undulations, 10 to 14 principal septa, between each pair of which are one or three septa of the higher cycles. Columella poorly developed.

Locality.—Red Bluff, Mississippi.

Geologic occurrence.—Red Bluff beds.

Types.—From collection of T. H. Aldrich in the United States National Museum; and United States National Museum.

Astrohelia burnsi sp. nov.

Pl. X, figs. 3 to 3b.

Form ramose, branches of the type material small, 8 mm. in diameter, cross section subcircular. Cœnenchyma solid; ratio of diameter of axial corallite to that branch $\frac{3.5}{8}$. Surface of cœnenchyma striate, striæ not very prominent. Calicular margin usually elevated from 1 to 2 mm. above the cœnenchyma. Corallites arranged in irregular spirals. Distance between corallites, from 2 to 3 mm.; may be as much as 4 mm. Diameter of calices, from 2.5 to 3.5 mm. Calice near terminus of a branch may reach 5 mm. in diameter. Costæ corresponding to all cycles of septa, low, flat, becoming irregular on the cœnenchymal surface, with a tendency to be nodular, densely granulate; granulations small. Calicular fossæ shallow, filling up from below with secondary deposit, connection with axial corallite being obliterated. Dissepiments present, but very few. Septa thin, weak; arrangement is decidedly irregular; a common scheme in calices 2.5 mm. in diameter is eight principal alternating with as many smaller ones. In the larger calices there may be twelve principal alternating with as many smaller ones, i. e., in three complete cycles. The calice in Pl. X, fig. 3b (4.5 mm. in diameter), shows such an arrangement. Margins of septa irregularly dentate; no pali, an occasional paliform lobe; sides granulate, the granules irregular in size and distribution. Columella very poorly developed, formed by the loose fusion of the inner terminations of the septa or processes from them. Some calices, such as the one figured, are practically devoid of even the false columella.

Locality.—Jackson, Mississippi.

Geologic occurrence.—Jacksonian stage.

Type.—From collection of T. H. Aldrich in the United States National Museum.

Genus OCULINA Lamarck.

The following notes on *Oculina diffusa* of the West Indies may be of interest in this connection. The wall is a true theca (Pl. II, fig. 5), i. e., there are separate centers of calcification in the wall, which is not formed by the fusion of the distal ends of the septa.[1] The septa are solid, and are composed of ascending trabeculæ, with a line of divergence about coinciding in position with the wall. The margins, due to projection of the trabecular axes, are minutely dentate. The pali are lobes near the inner ends of the septa. The columella is false, formed by the fusion of septal processes. Reproduction takes place by both lateral budding and by fission (septal budding, dividing the mother calice into two daughter calices of the same size).

OCULINA VICKSBURGENSIS (Conrad).

Pl. X, figs. 4 to 10.

1847. *Madrepora vicksburgensis* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 296.
1848. *Madrepora vicksburgensis* Conrad. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. I, p. 127.
1850. *Astrohelia lesueuri* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. XIII, p. 75.
1857. *Astrohelia lesueuri* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 112, Pl. D1, figs. 8 and 8a.
1861. *Astrohelia lesueuri* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 178.
1881. *Astrohelia lesueuri* Quenstedt. Röhren- und Sternkorallen, p. 971, pl. clxxx, fig. 51.

The following is a translation of the original description of *A. lesueuri:*

Corallum dendroid, forming branches from 2 to 3 centimeters in thickness, cylindrical, sometimes coalescent, with cœnenchyma highly developed, extremely compact, and whose surface, which is very finely granulated, presents in addition flexuous feeble striæ. Calices circular, subequal, distant once or twice their diameter or even more, with thin slightly prominent margins, with a cavity of only little depth. Columella weak, spongy, slightly developed, but a little more than in other species of the genus. Fourteen principal septa alternately unequal, extremely thin, slightly flexuous, subgranulate, scarcely exsert. An equal number of very small septa. Diameter of the calices 4 millimeters. Tertiary of the Walnut Hills, on the banks of the Mississippi (Lesueur). Collection of the Museum.

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[1] Ortmann, in Die Zeitschrift für wissenschaftliche Zoologie, Vol. L, 1890, p. 309, writing of Oculina diffusa, says: "Oculina hat mit den übrigen sog. Oculiniden (Amphihelia, Acrohelia, Lophohelia) absolut nichts zu thun, sondern gehört in die Verwandtschaft von Heliastraea. Von ersteren unterscheidet sie sich vor allen Dingen durch das Fehlen der echten Mauer." A comparison of Pl. II, fig. 5, of this work, with Ortmann's statement, should be made. The figure shows an undoubted so-called true theca.

This description, although excellent, does not take into consideration all of the characters of the species, nor some of its important variations.

The margins of the calices may be slightly elevated or very greatly elevated. In some instances they may project as much as 2.5 mm., or in extreme cases even 4 mm. The elevated portion of the corallites is subcylindrical. Costæ are well developed in the region of the calicular margin, but are low and rounded. The depth of the calice is variable; it is shallow in low corallites, and deep in elevated corallites. The septa are usually thin, but may be moderately strong. The margins are regularly and minutely dentate. Near the inner termination of each of the principal septa, just before it joins the columella, there is a distinct, moderately wide granulate palus, or a strong paliform tooth. From the constant presence of these lobes, I place the species in the genus Oculina. In *Astrohelia palmata* (Goldfuss) from the Chesapeake Miocene, small lobes of quite similar character frequently occur on the principal septa. Dissepiments are present, but are not abundant. The size of the calices is necessarily variable; the usual size is, as Milne-Edwards and Haime state, 4 mm. It varies from about 2.5 mm. to 5 mm.

Localities.—Vicksburg and Byrams Ferry, Mississippi.

Geologic occurrence.—Vicksburg and Red Bluff beds.

Specimens.—United States National Museum (a magnificent suite); Wagner Free Institute of Science; collection of T. H. Aldrich; Academy of Natural Sciences of Philadelphia; Boston Society of Natural History; Museum of Comparative Zoology, Cambridge, Massachusetts; Muséum d'Histoire Naturelle of Paris.

The Milne-Edwards and Haime types of *A. lesueuri* are in Paris. Conrad's types may be in Philadelphia, but I am not positive.

Dr. William H. Dall possesses a series of four plates, engraved by Lesueur, representing the fossils found at Vicksburg (Walnut Hills), Mississippi. Pl. I, fig. 14, represents a coral, most probably *Oculina vicksburgensis* (Conrad).

The following notes give a few details of the finer structure: The structure of this species and of *Oculina diffusa*, as nearly as could be made out, is identical. The specimens are not sufficiently well preserved to permit the character of the wall to be made out with certainty, but it seems to be the so-called true theca.

The dense cœnenchyma which is laid down on the stock is of special interest This is deposited in layers parallel to the surface of the stock, and is striate perpendicularly thereto. This cœnenchyma is composed of minute calcareous bars which break into small blocks. As yet I have been unable to find calcification centers or nuclei from which the bars radiate. In some places a faintly radiate arrangement could be distinguished. I could not even make out the calcification centers in the septa where we know they exist, so there may have been the usual radiate structure in the cœnenchyma also. The interseptal loculi are filled, as Hinde has represented to be the case in Septastræa.

OCULINA MISSISSIPPIENSIS (Conrad).

Pl. XI, all figs.

1847. *Madrepora mississippiensis* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 296.

1848. *Madrepora mississippiensis* Conrad. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. I, p. 127, pl. xiii, fig. 22.

Lesueur *Planches inédites*, No. 5, fig. 15 and perhaps also figs. 12 and 13 (fide Milne-Edwards and Haime).

1850. *Oculina americana* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. XIII, p. 70.

1857. *Oculina americana* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 108.

1861. *Oculina americana* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 176.

1866. *Dendrophyllia mississippiensis* Conrad. Check List, p. 26.

The following is a translation of Milne-Edwards and Haime's original description of *Oculina americana:*

Branches cylindrical, calices circular, considerably crowded together, disposed according to rather regular spirals, terminating in distinct tubular mamelons opening upward. The terminal calice is in general larger than the others. Costal striæ not very pronounced, very fine, flexuous, slightly unequal. Fossa of the calice not deep. Columella and pali moderately developed. Septa in three complete cycles; in addition in one of the halves of two systems, one observes constantly septa of a fourth cycle, and the tertiaries comprehended between these attain a development almost equal to that of the secondaries, and coalesce near the internal margin of the secondaries. These septa are crowded together and are slightly exsert.

We have observed only isolated branches about 2 centimeters in size; the individuals are 6 or 7 millimeters at their base, only three at the calice.

Fossil from the middle tertiary of the Walnut Hills, on the banks of the Mississippi:

Coll. Mus. (Lesueur).[1]

[1] Milne-Edwards and Haime, Annales sci. nat., 3d ser., Vol. XIII, 1857, p. 70.

Milne-Edwards and Haime considered this species and their *Astrohelia lesueuri* as Miocene, but the Tertiary of Walnut Hills is well known to belong to the Vicksburgian Oligocene of Conrad, Dall, etc.[1]

Notes on Conrad's type, in the collection of the Academy of Natural Sciences of Philadelphia.—Conrad has described a young branch that does not show the characters of the adult specimens well. The calices are prominent and the corallites are more inclined to the axis of the colony than is usual.

	Mm.
Greater diameter of corallite at base	5
Greater diameter of corallite at calice	4
Lesser diameter of corallite at base	4
Lesser diameter of corallite at calice	3.75
Height of corallite (measured on side)	2.5
One corallite has a height of	4.2

The specimen is so much worn as not to permit the surface ornamentation to be made out well, but it is evidently of the type characterizing the typical *Oculina americana* of Milne-Edwards and Haime. This species presents an enormous amount of variation. The figures (Pl. XI) show it graphically. From an inspection of the illustrations one would be inclined to think there are no tangible specific characters, but there are several good ones. The septa are very thin, and neither pali nor paliform teeth are well developed. Because of the latter fact I have doubted whether the species should be referred to Oculina. The other specific distinction lies in the character of the cœnenchymal surface. This is usually thrown into humps or folds, especially around the bases of the projecting portion of the corallites; and it is covered by wavy, often disconnected, striæ. The striæ are almost concentric around the basis of the free part of the corallites. The cœnenchymal surface in *Oculina vicksburgensis* is more regular, the striæ are more continuous, and usually follow a general longitudinal course quite closely. These features are indicated by the figures.

[1] See Conrad, Am. Jour. Sci., 2d ser., Vol. II, 1846, p. 210.

OCULINA SINGLEYI sp. nov.

Pl. X, figs. 1 to 2a; Pl. XII, figs. 1 to 3a.

Colony ramose, branches attaining almost 2 cm. in diameter, irregular in form, but usually subcylindrical. Cœnenchyma thick and very dense; surface granulate and ornamented in addition thereto by fine flexuous striæ. Calices deep, circular, size varying greatly; the young calices on young branches or the young calices on old branches are much smaller than the old calices; diameters, from 1.75 to 4 mm.; usual size, from 2.5 to 3 mm.; distribution on the corallum irregular, on young branches they may be slightly crowded, on old branches they may be very distant, but the distance from one calice to that standing nearest to it rarely or never exceeds twice its diameter; margins usually prominent. On the outside of the projecting part of the corallites are prominent granulate costæ alternating in size. They project slightly above the calicular margin and connect with the corresponding septa. Septa rather weak, in many instances very frail, or they may be rather stout, sides granulate; margins minutely dentate; three complete cycles; six systems. In the largest-sized calices there are frequently a variable number of members of the fourth cycle. Pali small and fragile or fairly large, irregular in shape before all cycles of septa except the last. Columella moderately developed, spongy.

Localities.—Smithville, Bastrop Country, Texas; Moseleys Ferry, Brazos River, Burleson County, Texas; Wheelock, Robertson County, Texas; Alabama Bluff, Trinity River, Houston County, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—From collection of J. A. Singley deposited in the United States National Museum. Specimens represented in Pl. X, figs. 1 to 2a, from collection of Wagner Free Institute of Science.

This species resembles *Oculina mississippiensis* of Conrad rather closely, but it may be separated from the latter species chiefly by its deeper calices and the prominent costæ on the outside of the elevated portion of the corallites. These characters are well expressed in Pl. XII, figs. 2a and 2b.

OCULINA ALABAMENSIS sp. nov.

Pl. XII, figs. 4 to 7.

In the collections of T. H. Aldrich and of the United States National Museum are seven pieces of branches of a new Oculina, from Greggs Landing, Alabama. The branches are small, the longest between 20 and 25 mm. in length, and are very irregular in shape. The greater diameter of the thickest piece is 9 mm.; one of the smaller pieces has a diameter of about 4.5 mm. The corallites usually project somewhat above the cœnenchymal surface, but are not greatly elevated; about 1.5 mm. is the maximum height of the projecting portion. On the outside of the free part of each corallite are distinct costæ corresponding to all septa. The costæ of the last cycle may be decidedly less prominent than those of the first and second cycles, which are nearly (if not precisely) equal. In profile they are usually flattish, and are densely granulate. The cœnenchymal surface very often shows no costæ or striæ, but is densely granulate; other specimens, especially worn ones (see Pl. XII, fig. 7), show distinct costæ. The calices are moderately deep, show no definite arrangement. The distance between them is from 0.5 to 2 mm.; their diameters range from 1.5 to 2.5 mm.; a very little more than 2 mm. may be considered the average. The septa are in three complete cycles. The margins of those of the first and second cycles are somewhat exsert. The first and second cycles reach the columella, and have on the inner edges, just before reaching the columella, small, thin, weak pali. Their sides are minutely and densely granulated. Columella spongy, not greatly developed.

Locality.—Greggs Landing, Alabama.

Geologic occurrence.—Greggs Landing substage of the Chickasawan.

Types.—From collection of T. H. Aldrich in the United States National Museum; and United States National Museum.

This species is easily recognized by the small size of its calices and its fragile character.

Oculina harrisi sp. nov.

Pl. XII, figs. 9 and 9a.

This species is based on one specimen, the end of a branch, but it is very well preserved.

The length of the branch is 85 mm.; diameter of its lower end, 15 mm., of its upper end, 11 mm. The branch tapers but little and has a blunt termination. The cœnenchyma is very solid; its surface is marked by rather fine, low, granulated striæ. The calices are distributed in rather regular spirals; the usual distance between two, measured on a spiral, is 4 mm., but in one exceptional case the distance is 10 mm. The margins are thin, project abruptly about 2 mm. above the cœnenchyma; some are lower, and one is 3.5 mm. high. Externally the corallite walls are marked by rather broad, low costæ, alternating in size and corresponding to all cycles of the septa. The average diameter of the calices is 5 mm.; the smaller ones are 4.5 mm., and one large one has a diameter of 6.25 mm. There is practically no difference in the diameter of the corallite at the cœnenchymal surface and at the calicular margin. Calices deep, wide open. Septa thin, weak; a common arrangement is 14 principal and 14 small septa, i. e., three complete cycles in six systems, and four of the fourth cycle intercalated in the two half systems on each side of the uppermost primary. Two septa of the third cycle usually reach the columella in the two half systems on each side of the uppermost primary. These two tertiaries and the secondaries may be more prominent than the primaries. The margins are finely and regularly dentate. The pali are merely arched lobes near the inner terminations of the larger septa. They are usually distinct, but sometimes are confused with septal dentations; in some cases they are very broad. They are thin, and have granulated sides. Columella very poorly developed, formed by the lax fusion of the inner septal terminations. Dissepiments, if present, very rare. The calices fill up from below and obliterate the connection with the axial corallite.

Locality.—Red Bluff, Mississippi.

Geologic occurrence.—Red Bluff beds.

Type.—United States National Museum.

The species is characterized especially by (1) the blunt termination of the branches, which taper very slightly toward the apex; (2) the diameters of the corallites at their bases and circular margins being practically the same; (3) the thinness of the margins of the calices, the thin septa and pali, and the lax columella.

OCULINA ALDRICHI sp. nov.

Pl. XII, figs. 8 and 8a.

The species is described from a small but excellently preserved piece of a branch.

The branch is small; does not taper rapidly toward the end. Cœnenchyma solid, surface finely striate longitudinally, granulations not apparent. Corallites in rather definite spirals, inclined toward the termination of the branch, usually rise very little above the cœnenchyma, occasionally as much as 2 mm., scarcely constricted at the calicular margin. Distance between calices on a spiral about 3 mm.; sometimes a little more or a little less. Externally on the corallite wall there are low subequal costæ corresponding to all cycles of septa. Wall at calicular margin rather stout; diameter of calices, 4 to 5 mm.; calices not very deep. Septa rather thin; usual arrangement, 14 principal and as many smaller ones, i. e., three complete cycles of six systems, and two members of the fourth cycle in each of the half systems on the sides of the uppermost primary. The tertiaries in the half systems on each side of that primary usually reach the columella. Members of the fifth cycle are sometimes present in the quarter systems next the uppermost primary. Margins finely dentate, sides finely granulated. A very few dissepiments present. Pali erect, rather slender lobes near the inner terminations of the septa; they may be double. Columella poorly developed, formed by the fusion of the inner terminations of the septa or of septal processes. The basal portions of the corallites fill up by internal secondary deposit.

Locality.—Byrams Ferry, Mississippi.

Geologic occurrence.—Red Bluff beds.

Type.—From collection of T. H. Aldrich in United States National Museum.

OCULINA (?) SMITHI sp. nov.

Pl. XII, figs. 10 to 11.

Form dendroid or branches coalescing to form small flabelliform masses. Cœnenchyma very solid. Corallites projecting slightly or not at all. On small branches arrangement in rather regular spirals; when the branches fuse, the arrangement very irregular. Diameter of corallites 2 mm.; distance between them usually about 3 mm. Calicular fossa usually appears very deep, because the septa and columella are broken away. In the best-preserved specimens it is moderately deep. Septa in three complete cycles of six systems. Pali (?). Columella fairly well developed, spongy.

Locality.—Prairie Creek, Alabama.

Geologic occurrence.—Midway beds.

Types.—United States National Museum.

This species is based on very poor material, and is described more for the purpose of making the treatment of the fauna of the Midway beds as complete as possible than for any other reason. There are five specimens in the United States National Museum, evidently belonging to the same species of Oculinoid coral. The species is referred doubtfully to Oculina, because the probability seems greatest that it belongs there, but the interior of the calices has been destroyed to so great a degree that the presence of pali can not be determined. The three characters, (1) the coalescing of the branches into flabelliform masses, (2) the dense cœnenchyma, (3) the small size of the calices, when taken together, readily distinguish the species from any other coral of the same group found in our Eocene deposits. Pl. XII, fig. 11, represents a small branch with prominent calices; the highest projects 2.25 mm. Fig. 10 (Pl. XII) shows the habit of growth and the appearance of an eroded mass; the calices rather surely never projected much. Fig. 10a (Pl. XII) is of a calice with the columella broken down; it shows the arrangement of the septa.

Genus AMPHIHELIA Milne-Edwards and Haime.

AMPHIHELIA NATCHITOCHENSIS sp. nov.

Pl. XII, figs. 12 to 18.

1896. *Amphihelia* n. sp. Vaughan. Bull. U. S. Geol. Survey No. 142, p. 49.

The specimens are poorly preserved, but the method of growth, arrangement of calices, and manner of budding is the same as in the genus to which it is referred.

Although we have not obtained perfect masses, the form of the colony is evidently dendroid. Branches small, the largest that we have being 11 mm. in diameter and the smallest 1.75 mm. in diameter. The cross section of a branch is subquadrangular, the angles rounded. The greater diameter of a branch is at right angles to the plane containing the calices. Costæ not prominent and confined to a small area just below the outer edges of the calices. Cœnenchymal surface almost devoid of ornamentation; a few irregular, flexuous striæ. Distance between calices usually about 5 mm. Calices of two kinds, (1) not prominent, and (2) very prominent, the margin of the most elevated standing 3.5 mm. above cœnenchyma. Those calices produced by the alternate budding are usually not prominent, while those produced by budding from these are frequently very elongate. The calices are nearly circular, and range in diameter from 1.3 to 2 mm.; very deep—one has a depth of 3 mm.

Septa in six systems, three cycles; those of the first and some members of the second cycle have slightly exsert margins. The sides of the septa are granulate, and their margins show minute dentations. Columella distinct, deep down in the calices, spongy, and rather poorly developed.

Localities.—Natchitoches, Louisiana; San Augustine, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—United States National Museum.

This is another species that closely resembles a species from the Lower Oligocene of Jekaterinoslaw. The species with which it has apparent affinities is described by Sokolow as *Diplohelia* sp.[1] About the only difference found between the forms, after an examination of Dr. Sokolow's types, was that the calices of the Russian species are closer together than in the species from Natchitoches, Louisiana, a difference so slight that the two may perhaps be placed in the same species.

Genus CŒLOHELIA gen. nov.

Budding dichotomous, alternate, occasionally double. Corallum evidently dendroid. Cœnenchyma compact. Calices rather prominent, disposed in two opposite rows. Costæ exist only just below the margins of the calices and are insignificant. The remainder of the outer surface of the corallum shows no ornamentation; if it possesses any, there are only minute granulations. The septa are scarcely exsert at all; in three cycles of six systems; thicker at the wall. The margins show minute transverse

[1] Die unteroligocäne Fauna der Glaukonitsande bei der Eisenbahnbrücke von Jekaterinoslaw: Mém. du Comité Géologique (Russia), 1894, pp. 99-100, fig. 12 (in text), pl. ii, figs. 1a-1f.

undulations, and also some small dentations. One crown of pali before the second cycle of septa. Calicular fossæ very deep. No columella. Internal cavity of corallites not filling up. No dissepiments were seen.

After repeated attempts to place this coral in one of the recognized Oculinid genera, I have decided that it is necessary to make a new generic designation for it. The genera of Oculinidæ, with dichotomous budding, and calices arranged in two opposite rows, are Neohelia[1] Moseley, Lophohelia[2] M.-Edw. and H., Amphihelia[2] M.-Edw. and H., Enallohelia[2] d'Orb., Euhelia[2] M.-Edw. and H., Acrohelia[2] M.-Edw. and H., Cyathohelia[2] M.-Edw. and H., Bathelia[1] Moseley, and Tiarodendron[3] Quenstedt.

Tiarodendron has large calices and large prominent costæ, so it can be dropped from consideration at once. The following genera have no pali, so they can not be further considered: Neohelia, Lophohelia, Diplohelia, and Acrohelia.[4] I do not know whether Enallohelia and Euhelia possess them. The former has a styliform columella and the latter turbinate corallites with a rudimentary columella. Only Cyathohelia and Bathelia remain. The former has septa with prominent (exsert) margins, and both have well-developed columellæ. From this résumé of the points of difference between Cœlohelia and the other Oculinids possessing the same mode of growth, it will be evident that this is a very distinct genus. According to Duncan's classification of the Oculinidæ, it belongs in the alliance Oculinoidea, and seems to stand nearest Bathelia. The last-mentioned genus has deep, widely-open calices, with four cycles of septa and a single crown of pali. The columella is large and composed of numerous trabeculæ. The difference between Cœlohelia and Bathelia[5] is thus narrowed down to the latter possessing a well-developed columella, while the former does not.

In the following specific description some of the characters stated in the generic description are repeated.

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[1] Moseley, Deep sea corals: Challenger Reports, pp. 176 and 177.

[2] Duncan, Revision Genera Madreporaria: Journ. Linn. Soc., London, Vol. XVIII, 1884, pp. 37–44.

[3] Quenstedt, Röhren- und Sternkorallen, p. 739–741, pl. clxxii, figs. 1–10.

[4] Milne-Edwards and Haime, Hist. Nat. des Corall., Vol. II, p. 120.

[5] Duncan, op. cit., p. 44.

Cœlohelia wagneriana sp. nov.

Pl. XII, figs. 19 to 19b.

There is a single specimen of this species in the collection of the Wagner Institute. Its size and general appearance are shown by Pl. XII, figs. 19 and 19a. The calices are primarily arranged in two rows, opposite each other, one on each side of the branch. The budding may sometimes be double, but the general bilateral symmetry of the branch is not lost. The calices are elliptical, the longer axis being parallel to a plane passing vertically between the two rows of corallites. Measurements of two calices are as follows:

	1	2
	Mm.	*Mm.*
Greater diameter of calice	3	3.5
Lesser diameter of calice	2.3	2.5

The amount of elevation of the calicular margins and the distance between the calices are shown by the figures. Costæ are present only just below the calicular margin and are very insignificant. The outer surface of the corallum has suffered some erosion, so its ornamentation can not be stated positively. Apparently it is smooth; if it was ornamented, the ornamentation almost certainly consisted only of minute granulations. The septa are so slightly exsert that they can be described as not exsert. Three complete cycles of six systems. Very much thicker at the wall than interiorly. The margins fall quickly to the bottom of the calices; they are transversely slightly undulate, and exhibit minute dentations. There are three sizes of septa; on the inner margin of each of the six of the middle size, deep down in the calice, is a delicate erect palus. There are no pali before the third cycle of septa and apparently also none before the first cycle. The septal margins are very nicely preserved, so there is no reason to doubt that the above is the correct distribution of the pali. The sides of the septa are covered by many very small, tall granulations, which seem to have flattish or roundish terminations. The bottoms of the calices do not fill up with secondary deposit. I could find absolutely no vestige of a columella; therefore a corallite cavity communicates directly with the one below it, and, to be sure, the calices are very deep. The principal septa could not be seen to meet even in the bottom of the calice.

Locality.—Peach Tree Landing, Alabama River, Alabama.

Horizon.—Greggs Landing, Chickasawan stage.

Type.—Wagner Free Institute of Science.

Family STYLOPHORIDÆ Zittel (subfam. M.-Edw. and H.).

Genus MADRACIS Milne-Edwards and Haime.

MADRACIS GANEI sp. nov.

Pl. XIII, figs. 1 to 7.

1896. *Stylophora* n. sp. Vaughan. Bull. U. S. Geol. Survey No. 142, p. 49.

Colony branching; branches approximately circular in cross section; diameter of branches from 5 to 14 mm. Surface between calices rough, granular; no costæ. Calices shallow, subcircular, or elliptical, small; diameter about 2 mm.; usually about 2 mm. apart, margins very slightly elevated. Septa usually ten, which reach the columella; a variable number of smaller septa; thicker at the corallite wall, slightly exsert; sides minutely and irregularly granulate. Dissepiments abundant. Columella stout, styliform, below the projecting point very thick. The axes of the colonies are spongy, but between the central spongy axis of a colony and the bottoms of the calices the corallites are almost entirely filled with dense, solid, internal calcareous deposit.

Locality.—Natchitoches, Louisiana.

Geologic occurrence.—Lower Claiborne.

Types.—United States National Museum.

Named in honor of Dr. H. S. Gane.

The following gives some of the minute details of this species, and, for purposes of comparison, some notes on the recent West Indian *Madracis decactis* (Lyman) and *Madracis mirabilis* (Duchassaing and Michelotti):

This species agrees in every essential character with *Madracis mirabilis* of Duch. and Mich. and with *Madracis decactis* of Lyman—all of which agree with the original characterization of the genus.

In the cross section of a corallite of *M. ganei* a styliform columella can be seen between the thick and inner ends of the septa and the calcareous deposits that surround them. The columella probably has been broken out of those calices that seem to contain none, or rather which seem to possess only a false one. Quite often a single dissepiment is seen in the cross section of one interseptal loculus. The wall appears to belong to that type known as a true theca. The septal margins are finely dentate. As the septa are short, only a few dentations are seen. In this species the presence of more than ten septa is rare. But occasionally there are rudimentary septa of a higher cycle in a few interseptal loculi, as Gregory found to be the case in *M. decactis*[1] (Lyman). The general features are the same as in *M. ganei*. Frequently between the outer septal ends there is a slight bulging inward corresponding to the intervening true thecal calcification centers. These slight projections should probably be considered very rudimentary septa.

The resemblance of *M. mirabilis* (D. and M.) to *M. ganei* is remarkably close considering that they are so widely separated in geologic time. The two species are, however, specifically quite distinct; they only belong close together in the same genus. The calices of *mirabilis* are only about 1.5 mm. in diameter, while the smaller calices of *ganei* usually measure 2 mm. There are other differences also. Quite frequently rudimentary smaller septa exist in *mirabilis* between the larger septa. The inner part of the septal margins is dentate, but the part that is exsert has an entire margin; with a hand lens no dentations could be detected.

Fowler[2] has published some very interesting notes on *Madracis asperula*. Although it is a digression to introduce them here, it may be permissible. The more salient points are: The tentacles are both ectocœlic and entocœlic; the septa occur between pairs of normal mesenteries; the directive mesenteries are well developed, but do not (as is the case in Pocillopora and Seriatopora) always coincide with the axial and abaxial plane of the branch; there are peripheral lamellæ of the mesenteries in areas immediately surrounding the polyps. Von Heider has published an interesting paper, "*Madracis pharensis* Heller," in which notes are made on most, if not all, of the then known species of the genus.[3]

MADRACIS JOHNSONI sp. nov.

Pl. XIII, figs. 8 to 11.

Form ramose; large, thick, compressed branches; surface granulate; no costæ. Sometimes longitudinal, elevated, more or less granular lines. Calices with a more or less spiral arrangement; sometimes decidedly spiral,

[1] Quart. Jour. Geol. Soc. London, Vol. LI, Aug., 1895, p. 258, fig. 1.

[2] Quart. Jour. Microsc. Sci. (N. S.), Vol. XXVIII, No. 111, Feb., 1888, pp. 414-416.

[3] Korallenstudien, Arbeiten aus d. Zoölog. Institut zu Graz: Zeitsch. für wiss. Zoölogie, Vol. LI, 1891, pp. 316-322, pl. xxiv.

sometimes only obscurely so. Margins not at all elevated. Calices elliptical; longer diameter about 3 mm., shorter 2.3 mm. Septa not exsert, usually 9 or 10, all of which reach the columella; there are usually about the same number of smaller septa. They are moderately thick; thicker at the wall and where they join the columella. Margins granular; cavity filling up below. Columella short styliform, considerable calcareous thickening around it. Dissepiments present, thin.

Localities.—San Augustine, Texas; Alum Bluff, Colorado River, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—Wagner Free Institute of Science.

I have referred this species to Madracis with considerable hesitancy, because the collumella is so often nonstyliform, but it frequently is styliform. This species and *Madracis ganei* undoubtedly belong to same genus. The distinguishing features between the two are: *M. johnsoni* has compressed and larger branches, and larger calices, which are much more crowded and are arranged more regularly.

MADRACIS GREGORIOI sp. nov.

Pl. XIII, figs. 12 and 12a.

Colony small, branching. Corallites crowded together, variable in shape, joined directly by their walls, very little or no cœnenchyma. Walls not thick; upper surface rough. The immediate line of fusion of the walls of neighboring corallites is indicated by a small distinct ridge. The margin of each calice is marked by a small zigzag ridge. Between the ridge around the margin of a calice and the ridge marking the line of fusion between the walls of two corallites there is a slight groove. Calices shallow. The principal septa are ten in number; occasional rudiments of intermediate ones are seen; their faces granulate. At first they are weak, but become secondarily thickened. Columella small, styliform, thickening in old calices by deposit around it.

Diagonal diameter of calice 2.5 mm. (this is probably an average size); wall about 1.6 mm. in thickness.

Localities.—Hatchetigbee Bluff, Tuscahoma Landing, and Greggs Landing, Alabama.

Geologic occurrence.—Chickasawan stage.

Types.—From collection of T. H. Aldrich in the United States National Museum.

This is merely a species of Madracis with more crowded and more irregularly shaped calices than in the two other species.

Genus STYLOPHORA Schweigger.

STYLOPHORA MINUTISSIMA sp. nov.

Pl. XIII, figs. 13 to 15.

In the United States National Museum are several small branches of this species, weathered out of a cherty limestone. The best-preserved and the most easily studied branch measured 15.5 mm. in length and 2.5 mm. in diameter. The cross section of the branch is circular. The calices are shallow, and are arranged in regular ascending spirals. Their distance apart is about 1 mm. They are elliptical in shape, the greater diameter 0.7 mm., the smaller 0.5 mm. The margins not at all prominent, only a slight bulging upward of the surface in the calicular region. The cœnenchymal surface has suffered corrosion, but certainly is granulate, and may have in places possessed some longitudinal striations. Six stout septa reach the columella; no indications of a second cycle. The six septa in places seem so thickened that they almost close the lower part of the calicular cavity. Four pits, each between a pair of septa in the segment of the calice toward the distal end of the branch; two on each side of a vertical plane through the longer axis of the calice are deeper than the two pits at the other end of the calice (cf. Pl. XIII, fig. 14). The columella is stout. It was not possible to determine whether or not dissepiments exist.

Locality.—Russell Springs, Flint River, Georgia.

Geologic horizon.—Vicksburgian stage, Ocala group.

Type.—United States National Museum.

This species has an extremely close resemblance to *Stylophora affinis* Duncan,[1] from the Nivajé shale of San Domingo. The resemblance is especially close to the var. *minor*. The points of difference are: The calices of *St. affinis* are circular, while in *St. minutissima* they are elliptical; between the corallites of *St. affinis* there is on the cœnenchyma a distinct raised ridge, while no such ridge exists in *St. minutissima*.

[1] Duncan, Quart. Jour. Geol. Soc. London, Vol. XIX, 1863, pp. 436–437, pl. xvi, fig. 4.

STYLOPHORA PONDEROSA sp. nov.

Pl. XIII, fig. 16; Pl. XIV, figs. 1 to 1b.

Corallum, subplane or rounded masses, the largest of an irregular form, 40 cm. across and 10 cm. thick. Calices shallow, small, crowded; diameter, 1 mm.; distance apart, 0.5 mm. The cœnenchymal surface is preserved in its original condition on none of the numerous specimens in the United States National Museum; therefore its character must be deduced from the sections parallel to the long axes of the corallites. As shown by Pl. XIII, fig. 16, the cœnenchyma is laminate. Pl. XIV, fig. 1b, represents a portion of the weathered surface of a specimen seen in longitudinal section; Pl. XIII, fig. 16, is a magnified, thin, longitudinal section. In the former figure the laminæ are seen to be joined to each other by vertical elevations, while the latter figure shows light-colored laminæ, with tall spines of the same material. The higher lamina may rest on the spines (or echinulations) of the lower, or the spines may not quite reach from the lower to the next higher lamina. The spaces intervening between the laminæ and spines are filled by darker material.

It is extremely difficult to determine exactly how much of the original structure has been completely obliterated. In the instances where the spines do not reach from the lower to the next superimposed lamina, we may have a secondary condition, brought about by chemical changes in the corallum. In some places in the thin section the white calcite can be seen passing gradually into the darker, more amorphous material.

The following probably represents the original character of the cœnenchyma: Cœnenchyma, laminate, surface covered by tall erect spines (echinulations); each succeeding lamina in general rests on the summits of the echinulations of the immediately preceding lamina.

Septa, six well developed, reaching the columella; quite often rudiments of a second cycle can be distinguished, but only the first cycle is well developed; they are thicker at the wall. The usual appearance of the specimens is to have no septa at all, they having been destroyed in the process of fossilization. Dissepiments are present, but their details could not be made out. The corallite cavities usually are filled with solid calcite or are rotted out and hollow. The columella is moderately stout and styliform.

Locality.—Salt Mountain, 6 miles south of Jackson, Alabama.

Geologic horizon.—Lower Oligocene, from the Coral limestone overlying the Vicksburg beds.

Types.—United States National Museum.

This species is absolutely peculiar for the North American Tertiary deposits; nothing even resembling it is known from either the continent or the West Indian region.

Family ASTRANGIDÆ Verrill.

Genus ASTRANGIA Milne-Edwards and Haime.

The three following species have given me great trouble, and I am not thoroughly satisfied with the treatment of them, but with the material at hand it is the best possible.

Astrangia expansa sp. nov.

Pl. XIV, figs. 3 to 5.

1896. *Astrangia* n. sp. Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

This species is based on four specimens, one from Jackson, Mississippi, from the collection of T. H. Aldrich; and three from Montgomery, Louisiana, in the collection of the United States National Museum. Apparently the best method of presenting the specific characters is to begin by describing the simplest specimen, and to compare the others with it. This specimen, of which the following is a description, is represented by Pl. XIV, figs. 3 to 3b; it is from the collection of Mr. Aldrich.

Colony incrusting, the specimen is attached to a valve of *Barbatia cuculloides* (Conrad). The base is much expanded, producing a thin coating of considerable extent on the shell. The new corallites arise from basal expansions of the old, sometimes at the base of the old, sometimes at a considerable distance away, but are not at all crowded. The figure shows their arrangement with reference to one another. The surface of the expanded base possesses striations, radiating around the corallites. Corallites slightly elevated—2 mm. Their outer surface corroded, preventing the costal characters from being studied. The central corallite of the colony nearly circular in outline, with a diameter of 3 mm. The other corallites more or less elliptical. External surfaces of the corallites obscurely costate. The walls not very thick. Septa in three complete cycles with a considerable number of septa of the fourth; about half of the septa reach the columella. The septal faces granulate. Endotheca present, though not abundant. Columella large in proportion to the diameter of the corallite: very vesicular.

The other specimens considered are from Montgomery, Louisiana.

The specimen represented in Pl. XIV, fig. 4, resembles the one already described in the size and general arrangement of the calices, but the corallites are more crowded. The expanded base possesses strong costæ, which are beaded along the summits and are regularly alternately larger and smaller in size. The costæ on the outer surface of the corallite wall are similar in character. The costæ are not acute, but are somewhat rounded. This specimen is attached to a shell of *Pseudolira vetusta* (Conrad).

The features of importance in the next specimen are: One large calice has a longer diameter of 5 mm., and a shorter diameter of 4 mm., but another calice has a diameter of 3 mm. The corallites are crowded.

The last specimen (Pl. XIV, fig. 5) is almost certainly an abnormality. The basal expansion spreads over some Serpula tubes and an undetermined piece of coral which in cross section has a decidedly Astrangioid appearance. The corallites of the incrusting colony frequently have the appearance of having budded off from the basal object of support. But a section cut longitudinally through two corallites of the colony, and transversely through the object of fixation, showed no connection at all between the corallites and the latter. Except for the irregularities due to the very uneven surface of the mass to which the colony is attached, the surface of the expanded base presents the same characters as those already given. The corallites are usually rather distant, several millimeters apart. The distance between them is frequently determined by a Serpula tube, a corallite being on each side of it. The diameter of the calices usually varies from 2.5 to 4 mm., and they do not stand very high above the basal expansion. One corallite, however, is peculiar; its calice has a diameter of 5.25 mm., and projects 7 mm. above the basal expansion. This large corallite shows no characters, except abnormal size, that would suggest its being different from the other corallites of the various specimens of the species studied. The character of its costal markings, the costal arrangement, the number of septa, and the columella in all of the noncorroded corallites are the same. The basal expansion at the base of this corallite seems plastered over its costæ: therefore I am not sure that it may not be connected with the piece of coral which the colony incrusts. A few words should be added about this latter piece of coral. Its length is 22 mm.; the whole is occupied by one zooid. The greater diameter at the larger end is 9 mm., the lesser 6.5 mm. The piece was cut across about 14 mm. from the larger end. Here the greater diameter is 6.5 mm., and the lesser 5.5 mm. There are 48 septa on the section, half of which reach the columella. The columella is large and vesicular. It can not be proved, but I strongly suspect that every part of the coral portion of this specimen belongs to the same species. Possibly excepting the axial piece, which is the object of attachment, I am sure all of the other is of one species, if not absolutely of the same colony.

After reading the above, one will see that enough material for a thorough understanding of this species has not yet been collected. From the data above given it certainly should be easily identified when found in the future.

Localities, etc.—Already stated in the description.

Horizon.—Jacksonian stage.

Astrangia ludoviciana sp. nov.

Pl. XIV, figs. 6 to 7.

Colony incrusting, reproduction by budding from basal expansion or by lateral gemmation. The distribution of the corallites in the colony is shown by the figures. The surface of the basal expansion finely granulate, with or without fine costal striation. The outer surface of the corallites, just below the calicular margins, marked by small but distinct costæ, usually alternating in size. The costæ on the specimen represented in Pl. XIV, fig. 7a, extend to the basal expansion and are subequal in size. The height of the corallites varies from 0.5 mm. to 1.5 mm.; they may be subcylindrical in shape or slightly constricted at the calice. The diameter of the calices varies from 1.5 to 2.5 mm. The septa have slightly exsert, minutely dentate margins; the paliform dentations are indistinct or absent. The number of the septa varies from 20 to 28, one-half being larger, and usually all of the larger septa reach the columella. The septal faces granulate. No dissepiments were seen. Calicular fossa usually rather deep. Columella very lax, and often broken away altogether.

The species is based on two specimens, each of which is attached to a valve of *Barbatia cuculloides* (Conrad).

Locality.—Montgomery, Louisiana.

Horizon.—Jacksonian stage.

Types.—Pl. XIV, fig. 7, in the United States National Museum; Pl. XIV, figs. 6, 6a, in the collection of the Wagner Free Institute of Science. As the latter is the more satisfactory specimen, if one specimen should be designated as the type, it should be that one.

The material on which this species is based is not altogether satisfactory, as the amount and limits of variation can not be determined. However, it presents so many points of difference from the preceding *Astrangia expansa* that it does not seem possible for them to grade into each other. There are five points of difference: The calices of *A. ludoviciana* are much smaller, the septa are fewer, the columella is smaller and weaker, the surface of the basal expansion has less pronounced striations or none at all, and the costæ on the outer surface of the corallite are not so well developed.

Astrangia harrisi sp. nov.

Pl. XIV, figs. 8 to 10a.

1894. Harris, Tertiary geology of southern Arkansas: Annual Report Geological Survey of Arkansas, 1892, Vol. II, p. 172. (The undetermined coral from three-quarters of a mile above Vinces Bluff, Saline River—partial type of the species.)

Colony more or less incrusting, reproduction both from basal expansion and by lateral gemmation. The corallites are crowded, prominent, and often appear tufted. When budding takes place from the basal expansion, it is at the base of the older corallite. The height of the corallites depends on age; they quite often reach 6.5 mm. The costæ correspond to all cycles of septa; they are low, nearly always broad, and rounded in profile, with many small granulations scattered over them. The calices are elliptical. The size varies much according to age. The following measurements of adult or nearly adult calices will give an idea of their size:

	1	2	3	4	5	6
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	10	7.5	7.3	6.7	10.3	8.5
Lesser diameter of calice	7.5	6.3	5.5	6	6.5	7

The young calices may have diameters of 2.5 by 3 mm. The septal arrangement seems to be on a basis of four complete cycles. In some calices there are three complete cycles with about half the members of the fourth cycle present; in other calices there are four complete cycles and a few members of the fifth cycle. The septa are alternately larger and smaller, but not all the larger reach the columella. In some instances every alternate septum is continued to the columella, but in other instances it is the fourth septum that is thus prolonged. The members of the highest cycles fuse to the sides of those of the next lower cycles. The septal faces are granulate; the margins are dentate. The dentations are rather large, and are not very sharp, sometimes having more the appearance of crenations. Synapticulæ are present, usually are situated nearer the columella than the wall. Dissepiments present, but scanty. Calicular fossa rather deep. Columella well developed, very vesicular.

Locality.—Three-quarters of a mile above Vinces Bluff, Saline River, Cleveland County, Arkansas.

Horizon.—Jacksonian stage.

Types.—In the United States National Museum are two colonies and several separate corallites collected by Prof. G. D. Harris; in the Wagner Free Institute of Science is the specimen represented by Pl. XIV, figs. 10, 10a.

This species is so different from the two preceding species that critical remarks are unnecessary. It probably should be placed in the subgenus Phyllangia (genus of Milne-Edwards and Haime).

ASTRANGIA WILCOXENSIS sp. nov.

Pl. XIV, figs. 11 and 11a.

1894. *Cæspitose astræan* Vaughan. Rept. geol. Coast. Plain Ala.: Ala. Geol. Survey, 1894, p. 248.

A poorly preserved specimen of an Astrangioid coral, whose method of growth is in small tufts, is in the collection of Mr. T. H. Aldrich. Reproduction appears to be by budding around the base of a central corallite. The corallites are rather tall, 6 mm.; externally marked by distinct, subacute, granulated costæ, corresponding to all cycles of septa, and alternately large and small. Corallite wall strong. Calices elliptical. There are four complete cycles of septa in six systems, and a few members of a fifth cycle.

Those of the first and second cycle and some of the third cycle fuse in the columella space to form a false columella. Septal faces granulate. Character of the septal margins unknown. Greater diameter of calice,[1] 10 mm.; lesser diameter, 6 mm.

Locality.—Eastern Wilcox County, Alabama.

Geologic occurrence.—Midway beds, "Turritella rock."

The external features are well preserved in the specimen above described, so there should be no difficulty in recognizing the species when found again, but sufficient detail for absolute certainty in the generic determination can not be made out. The species is referred to Astrangia because some species of the genus have a similar habit of growth. *Astrangia lineata* (Conrad) from the Miocene of Petersburg, Virginia, is a good instance. This is undoubtedly an Astrangia, and among the specimens of it in the United States National Museum instances of exactly the same method of growth as that presented by *A. wilcoxensis* can be found. This species also may belong to the subgenus Phyllangia M.-Edw. and H.

A. wilcoxensis differs from *A. harrisi* in the character of the costæ. These differences are brought out in the specific descriptions and in the figures.

Genus CLADOCORA Ehrenberg.

Cladocora recrescens Lonsdale.

Pl. XV, figs. 1 to 3.

1845. *Cladocora* (?) *recrescens* Lonsdale. Quart. Jour. Geol. Soc. London, Vol. I, p. 517, fig.

1857. *Cladocora* (?) *recrescens* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 123.

The following is the original description of Lonsdale:

Branched; branches variously disposed, nearly cylindrical, outer wall thin, not thickened externally when old, porous, strongly but irregularly ribbed, and marked by lines indicative of renewals of growth; lamellæ numerous, unequal, sides foraminated and hispid; interstitial lamellæ or diaphragms distinct, center a complicated reticulation; branches produced from germs developed without the area, or on the sides of preexisting stems.

Localities.—Jacksonboro, Georgia; Eutaw, South Carolina.

I saw in the collection of the Geological Society of London specimens from Lonsdale's collection labeled "Eutaw, South Carolina." There are

[1] Figured on Pl. XIV, fig. 11a.

specimens of other corals labeled "Jacksonboro, Georgia," whose matrix is lithologically the same as that of the *Cladocora recrescens*. In the United States National Museum is a specimen of the species, and its matrix is the same as that of the Lonsdale specimens. The locality is given "Eocene, Rotten limestone, Georgia." It is quite probable that Lonsdale's specimens and the one in the National Museum came from Jacksonboro, Georgia.

The following notes are based on the specimen in the United States National Museum. The specimen is simply a cast; therefore the details can not be described in full.

Neither the walls nor the septa are perforate, as Lonsdale stated originally. He was misled by the appearances of the cast. The colony is more or less dendroid, or bush-shaped, reproduction by lateral gemmation. The diameter of the branches is 10 to 14 mm. Externally the costæ are distinct, well developed, but only moderately prominent (cf. Pl. XV, fig. 3), alternately larger and smaller. They are subacute, with broad bases, and are granulate. At different levels around the corallite are projecting girdles; these also are shown in Pl. XV, fig. 3. The number of septa could not be made out in detail and with absolute certainty, but by counting the costæ it seems that there were four complete cycles. The septal face granulate; dissepiments evidently were very well developed, curving from the outside inward and downward. The columella is well developed, moderately large and vesicular.

This species is very different from any other of our Eocene corals, and sufficient data are furnished by the cast for its identification.

Horizon.—This is not known with absolute certainty, but most probably it is Jacksonian, or lowest Oligocene.

Genera not placed in families.

Genus DICHOCŒNIA Milne-Edwards and Haime.

DICHOCŒNIA ALABAMENSIS sp. nov.

Pl. XV, figs. 4 to 4c.

Corallum massive, subplane above. Calices elliptical or subcircular, not very deep. Joined directly by their thick, solid walls; no exotheca. The distances between the calices is usually from 3 to 4 mm., but it may be only 1 mm., or as much as 5 mm. The elliptical calices are about 6 mm. long by 3 mm. wide. One of the subcircular calices has a diameter of 3 mm. Costæ are present, but their details could not be made out. Multiplication is by fission or by septal budding. There are usually about three cycles of septa, the first and second cycles being of the same size. They are strong, and their sides are beset with small granules. Endothecal dissepiments exist. Usually they are rather thin, curve upward and out, and are about 1.5 mm. apart. The calices when viewed from above show a lamellar columella, but in sections it appears as either lamellar or trabecular, or there may be only a calcareous deposit around the inner ends of the septa. In the sections the lamellar columella does not appear to be a separate structure, but only a prolongation of one of the principal septa, as one of the corallites in the magnified cross section (Pl. XV, fig. 4b) shows. Sections of other corallites show the same feature very clearly.

Locality.—Prairie Creek, Alabama.

Geologic occurrence.—Midway beds.

Type.—United States National Museum.

Remarks on Dichocœnia alabamensis and D. stokesi M.-Edw. and H.—As no specimens of *Dichocœnia porcata* (Lamarck), the type species of the genus,[1] were available for comparative study, comparison with *D. stokesi* M.-Edw. and H. was instituted. Excellent material of this species is in the United States National Museum and in my own private collection, through a contribution from Mr. R. T. Hill. The general aspect of the corallum, type of wall (a pseudotheca), and character of columella in *D. alabamensis*, correspond exactly to those of *D. stokesi*. The septal margins in the type of the former species are broken away; therefore to ascertain whether the two were really generically identical a miscroscopic examination of the septa of two species was made.

The septal structure of *D. stokesi* will be described, and then *D. alabamensis* will be compared with it. The septa in the former species are exsert, and are composed of ascending trabeculæ, with a line of divergence coinciding with the vertical axis of the septal arch. The trabeculæ pass upward and inward on the inside of the line of divergence, and upward and outward on the outside of the same line. The courses of the trabeculæ are indicated on the septal faces by elevated striæ or by fine rows of small granules. The septal margins are not entire, but are finely dentate. The dentations are small, but are distinct, and usually quite sharp on the exsert portion. The margin of the inner free portion may have pointed dentations, or fine crenations. Microscopically the pali exhibit no special difference from the septa, except they seem to possess a line of divergence independent of that of the

[1] Milne-Edwards and Haime, Mon. Brit. Foss. Corals, Palæontogr. Soc., p. xxx.

septa. This is an inference drawn from the distribution of the striæ on some of the more clearly exposed pali.

A thin section parallel to the flat surface of a septum shows very distinctly the trabeculæ with the line of divergence. The width of the trabeculæ varies from 0.05 to 0.128 mm. They are narrower at the line of divergence, and become wider as they pass away from it. New trabeculæ are formed by an apparent bifurcation of those having their origin at the line of divergence. Calcification centers are arranged along the trabecular axes at points from 0.04 to 0.06 mm. apart. The fibro-crystals pass upward and outward from the calcification centers, i. e., with reference to the trabecular axes. In the transverse sections of the septa the calcification centers show the same variation in distance apart that the trabeculæ showed in width. A large number were measured, with the following result: 0.024, 0.028, 0.04, 0.048, 0.06, and 0.128 mm. As would be expected, the calcification centers are more crowded in the median portion of the larger septa than they are in the costal or that portion near their inner termination. The fibro-crystals pass outward from the median septal plane, toward the interior of corallite, and at a rather small angle except at the inner ends of the septa. A longitudinal tangential section of the septa showed calcification centers ranged one above another, with fibro-crystals passing upward and outward from the median septal plane.

Only the cross section of *D. alabamensis* will be compared with the preceding. There is practically no difference in the microscopic characters of the two. Measurements of the distance between calcification centers gave the following: 0.04, 0.048, 0.053, 0.08, and 0.144 mm. The section parallel to the flat septal surface is not satisfactory, and as there is only one specimen in our collection, I shall not have another section cut. The larger septa have thickenings on their inner ends. These in cross sections are elongate elliptical and probably represent pali.

A few notes on the wall of this species may be added. Typically the wall is a pseudotheca, but quite often calcification centers are present between the distal ends of the septa. There can scarcely be any doubt that these centers represent the beginnings of young septa.

The description of the septal structure given above should be compared with that of Galaxea given by Miss Ogilvie.[1]

[1] Microscopic and Systematic Study of Madreporarian Types of Corals, pp. 106–121; Korallen der Stramberger Schichten: Palæontographica, Supplement II, Sect. VII, 1897, pp. 80–83.

Genus FAVIA Oken.

Favia merriami sp. nov.

Pl. XV, figs. 5 to 5c.

Corallum subplane or rounded above, massive. The species is based on three broken specimens, nearly of a size. Pl. XV, fig. 5, represents the best and smallest specimen, natural size. The condition of preservation of the material is, as is unfortunately too often the case with the fossil species, not satisfactory. The calices are elliptical. The following gives measurements of several:

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	6.5	6.5	5.5	5.5
Lesser diameter of calice	4.5	2.5	4.5	4.5

Some calices are almost circular, with a diameter of 4.5 mm. The calices are from 2 to 3 mm. apart. The walls between the corallites are thick (2 to 3 mm.), and usually compact; are evidently formed of fused costæ; correspondingly, sometimes the costæ can in the sections be traced some distance across the area between the corallites. On the upper surface of the corallum costæ correspond to all septa and extend from one calice to the next. They are low, sometimes flattened above or slightly acute, minutely granulated, straight or somewhat flexuous. Septa, in calice No. 1 of the above table, about 33 in number. The number for the fully grown calices seems to vary between 30 and 36; younger calices may have only 24. The various cycles are not distinctly indicated. There is usually a fairly regular alternation in size of the septa, the larger ones reaching the columella. They are thick, thicker at the wall, and have paliform thickenings on their inner ends. Faces granulate. Dissepiments very well developed, thin, 1.5 to 2.5 mm. apart in the longitudinal section of the corallites. The character of the septal margins is not shown by the material at hand. The calicular fossæ are extremely shallow, or are almost superficial. The columella is false, large, well developed.

Locality.—Southern California.

Horizon.—Cretaceous?

Types.—United States National Museum.

The specimens upon which the species is based were sent to me for description by Dr. J. C. Merriam, of the University of California, and it is with pleasure that the species is named for him.

The generic determination of this species is in one respect doubtful, i. e., the septal margins could not be studied, because of the worn condition of the surface of the specimens. The material is not well enough preserved to permit the microscopic details to be ascertained. In the cross section of some septa there are faint indications of rather large trabeculæ, similar to the trabeculæ of *Favia fragum* (Esper) (= *ananas* auct. non Linn.) of the West Indies. What evidence is afforded by the sections of the septa supports the opinion that the septal margins are dentate. All of the other characters are typical for Favia; therefore there is very little reason for doubting the generic reference.

Genus HAIMESIASTRÆA gen. nov.

Haimesiastræa conferta sp. nov., type species. Pl. XV, figs. 6 to 9; Pl. XVI, all figures.

Principal macroscopic characters.—Colony massive, or ramous. Corallites in the central portion of the colony united directly by their walls, by their costæ, or by exotheca. Calicular margins very slightly elevated. Septa in three cycles, six systems; twelve reach the columella space; margins entire, surfaces smooth. Endothecal dissepiment abundant. Corallite cavities not filling up. Columella false, formed by the fusion of the internal margins of the first two cycles of the septa. Budding between the corallites. In the central portion of the colony, where the corallites are more or less crowded, there is no cœnenchyma, but as the corallites pass outward they diverge, and a deposit of cœnenchyma begins. In young branches the cœnenchyma is often slightly vesicular, containing some exotheca, but in the outer portions of old branches it is almost or entirely solid. On the weathered end of a branch it shows a concentric structure. Its outer surface is granulate, and in addition thereto is marked by costæ corresponding to all cycles of septa.

MICROSCOPIC STRUCTURE.

The specimens are not so good as is desirable for a very accurate study of the microscopic features, chemical changes in many having obliterated the minute details.

The septa.—As already stated, the septal edges are entire and the faces are smooth. The only ornamentation of the septal faces are undulations that pass upward and then outward from the columella space, forming curves parallel to the septal margins (see Pl. XVI, fig. 4). These little waves are narrower near the columella, becoming wider near the corallite wall, sometimes bifurcating. The transverse measurement near the columella is slightly less than 0.11 mm.; near the wall about 0.22 mm. Besides these minute undulations there are frequently strong transverse flutings, especially near the inner termini of the septa; to these the dissepiments are usually attached.

A section parallel to the flat surface of a septum possesses a double structure (see Pl. XVI, figs. 5, 5a). First there are curves parallel to the septal margin, along which are dark points; these curves are 0.05 to 0.10 mm. apart, the dark points about 0.02 mm. apart. Second, there are fine lines normal to the curves first described, and passing between the dark points. By comparing these data with the preceding, it will be seen that on the same side of a septum the distance from the top of one undulation to that of the next is about twice the distance between the series of dark points (calcification centers). As the undulations on the septa alternate in position, the distance between neighboring septa and between the series of calcification centers coincides.

The septa in a cross section of a corallite shows a median line recognizable from the surrounding calcareous deposit. This median line varies in appearance according to the condition of preservation of the material; sometimes it is lighter in color, sometimes darker, than the more external portions of the septum. In a considerable number of sections series of small calcification centers were distinguishable. These were from approximately 0.02 to 0.037 mm. apart, the distance corresponding to the dark points in the curves previously described. The fibers passing outward from the median septal plane are, in the outer portion of the septum, in a general way perpendicular, or almost so, to that plane. Near the inner ends of the septa the fibers diverge inward from the median septal plane. In a somewhat oblique section calcification centers were cut across, and measured approximately 0.064 mm. to 0.09 mm. The calcareous fibers diverge upward and outward.

As the state of preservation of the material is not good, the above data were obtained only after a long study of the sections, and are not given with the degree of precision desirable. The following seems the only possible interpretation of the septal structure.

The septa are composed of extremely narrow ascending trabeculæ, which are only 0.02 mm. or slightly more across. The trabeculæ are crossed by transverse undulations, and very often a considerable number of dark points in the trabeculæ indicate the position of the undulations. These dark points apparently are calcification centers. A line of divergence was not observed; all of the trabeculæ within the wall pass upward and inward. No section of the extra-mural portion of the septa that could be studied was obtained; so there may be, and probably is, a line of trabecular divergence.

The wall.—The walls of the corallites of the central part of the colony are thin. When the middle lines of the septa are dark, a small, dark, circular line joining the septa together, is seen in the wall; when the median septal line is light, a light line is seen in the wall. I was unable to recognize distinct calcification centers with certainty in the wall, but it seems that the wall originally belongs to the true thecal type. In corallites, when the wall has been secondarily thickened from the outside, the same circular line can be distinguished near the corallite cavity, but outside of this the fibro-crystals converge inward to the costal axis, presenting the appearance of a pseudothecal wall. (Pl. XVI, fig 3.)

REMARKS.

The systematic position of this coral is very puzzling. It certainly has nothing to do with what were considered the representative genera of the Astreidæ (Mussa, Orbicella, etc.). It shows more features in common with the Oculinidæ, but we do not understand the Oculinid structural characters sufficiently well for the relations with that family to be discussed intelligently; therefore at present it is given no family association.

HAIMESIASTRÆA CONFERTA sp. nov.

Pl. XV, figs. 6 to 9; Pl. XVI, all figures.

Colony rather massive, ramous. Corallites crowded together, rather shallow, subhexagonal in outline; calices circular, 1.5 mm. in diameter; the margins project very slightly above the rather dense cœnenchyma. The cœnenchymal walls between the calices frequently 1 mm. thick on the older portions of the colony. Costæ distinct, corresponding to all cycles of the septa, granulate. The costæ of one calice meet those of the adjoining calices. The line of the junction usually indicated by a delicate ridge. The whole outer surface of the cœnenchyma is minutely granulate. The axial portions of the branches are spongy. In the axial portion the corallites are joined to one another directly by their walls or costæ, or are separated by exotheca. As the colony grows older, the corallites bend outward, so that ultimately their axes are nearly at right angles to the external surface. Septa in three cycles; those of the first and second cycles reach the columella; margins entire; surfaces smooth; inner ends of those of the first and second cycles somewhat thickened. From the sides of the septa wing-like processes are developed, which extend across the interseptal loculi and fuse, thus forming the endotheca. The dissepiments are often inclined; are very abundant. No pali. Columella well developed, false, formed by the fusion of the internal margins of the septa of the first and second cycles. Its upper surface is not seen from above in perfect calices, and it is not revealed until a section of the corallite is made.

Localities.—Woods Bluff, Greggs Landing, and Prairie Creek, Alabama.

Geologic occurrence.—Chickasawan stage. Types from Bells Landing beds. Specimens referred to this species occur in the Woods Bluff and the Midway beds.

Types.—United States National Museum.

HAIMESIASTRÆA PETROSA (Gabb).

Pl. XVII, figs. 1 to 6.

1864. *Astrocœnia? petrosa* Gabb. Paleontology of California, Vol. I, p. 208, pl. xxxi, figs. 274, 274a.

1893. *Astrocœnia? petrosa* Boyle. Bibl. Invert. Foss., p. 54.

1896. *Astrocœnia petrosa* Stanton. The faunal relations of the Eocene and Upper Cretaceous of the Pacific Coast: Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. I, p. 1029.

This species is described here because it is of doubtful Eocene or Cretaceous age. I wrote to Dr. J. C. Merriam, of the University of California, for information concerning the original locality of the species, and he replied: "I am not at all certain about the original occurrence of this species, but rather think it comes from some road ballast, brought from no one knows where, by the railroad company." Gabb states (loc. cit.): "All of the specimens were obtained from a single mass of limestone, a mile west of Martinez."

Dr. Merriam very kindly sent me a portion of the original type material of Gabb, and on it the following description is based.

The corallum is either massive or branching. The corallites are circular or slightly elliptical, 1.5 to 2 mm. in diameter. In the axial portion of a branch they are joined directly by their walls, which are not very thick, or by costæ. On the surface of this branch, which is about 12 mm. in diameter, the corallites are separated by stout, thick walls, from slightly less to slightly more than a millimeter thick. Costæ correspond to all septa. The outer surface of the corallum has been eroded; therefore the details of its ornamentation are obliterated. There are three cycles of septa, six systems; the members of the first cycle and usually some or all of the second cycle reach the columella space. The margins are not preserved, but from other characters the inference that they are entire can be drawn. There are no granulations on the septal faces, but, when looked at from above, wing-like expansions can be seen extending outward from the sides of the septa. The inner portions of the septa are transversely undulated. The septa are decidedly thicker at the wall, and the larger ones are thickened on their inner ends. Endothecal dissepiments are abundant and well developed; corallite cavity not filling up with secondary deposit. The columella is not "projecting beyond the edges of the septa," as Gabb states. He was misled by the weathered condition of most of the calices. In a well-preserved calice no columella can be seen from above, the margins of the larger septa meeting in the axial space. The columella is false, but is usually quite solid and firm, so that in weathered calices it stands out prominently. The calicular fossæ are shallow, almost superficial.

This material is in excellent condition for the study of the microscopic features; therefore the following notes are made:

The septa.—In the cross section of a corallite, the median dark line of a septum exhibits a row or chain of calcification centers. They are elongate elliptical and are connected with each other in a moniliform manner. The measurement across three very distinct centers was 0.09 mm., or the distance from one to the next adjacent center is 0.045 mm., but in places they may be more crowded. The measurement at right angles to the above, across a center, is 0.009 mm. The fibro-crystals diverge from the median septal plane toward the center of the corallite at an angle of about 45°. This section is so well preserved that in places one can distinguish the minute growth curves crossing the fibro-crystal. On one side of this septum is a protuberance, in which is a large distinct calcification center. The longitudinal section, perpendicular to septal plane, shows zigzag series of calcification centers, the zigzag arrangement corresponding to the undulations of the septum. One of these rows of centers is 0.27 mm. long and contains apparently four calcification centers. The next series measures about 0.18 mm. and contains three centers. The dissepiments are usually attached at the elbows of the zigzags. The fibro-crystals diverge upward away from the septal plane. In the longitudinal tangential section of another septum the middle point of one calcification center measures 0.09 mm. from the middle point of the center nearest it.

Neither of the two thin sections that I had made has cut a septum parallel to its flat surface; therefore the structure in the septal plane must be inferred from the two other sections. The structure is the same as in *Haimesiastræa conferta*, except the calcification centers composing the trabeculæ are larger than in that species (cf. ante, p. 144).

The wall.—The wall is a pseudotheca formed by the fusion of the thickened distal ends of the septa. A portion of a section across one corallite shows a problematic line concentric with the calice between a few septa. In this place there may be a few calcification centers between the distal ends of the septa. Excepting this instance the wall is clearly a pseudotheca.

The columella.—This is formed by the fusion of the inner ends of six or more septa. The inner ends of the septa are thickened and usually fuse solidly, making a firm, strong columella.

This species is most astonishingly similar to *Haimesiastræa conferta*. The surface of Gabb's type material being eroded, such a critical comparison as is desired can not be made. The three following distinctions can be pointed out: First, the septa of *H. petrosa* are more thickened at the wall than in *H. conferta;* second, the wall of the former is a pseudotheca, whereas that of the latter species appears to be originally a true theca; third, the calcification centers composing the septal trabeculæ of *H. petrosa* are larger than in *H. conferta*. Because of the difference in the character of the wall, some authorities would probably be inclined to place the two species in different genera. In my opinion the two forms belong in the same genus.

The two species are necessarily differentiated by microscopic characters, which I believe are good. When more abundant and more perfect material of Gabb's species is found, we may be able to discover gross characters, upon which the differentiation may be based.

Family ASTROCŒNIDÆ nom. nov.

Genus ASTROCŒNIA Milne-Edwards and Haime.

ASTROCŒNIA PUMPELLYI sp. nov.

Pl. XVII, figs. 7 and 7a.

Form of colony either palmate, lobate, or incrusting.

Corallites hexagonal, joined directly by their walls. Wall very narrow, with an acute upper edge, sometimes transversely zigzag. Calices very shallow; diameter of calices, 1.5 to 2 mm. Columella styliform. Septa usually 12; six reach the columella; occasionally there may be a few more than 12, but this is rarely the case. There are some dissepiments. In one corallite three or four were seen in the space of 1.5 mm.

Locality.—Russells Spring, on Flint River, Decatur County, Georgia. (R. Pumpelly, collector.)

Geologic occurrence.—Vicksburgian stage, Ocala group.

This species has a decided resemblance to *Astrocœnia ornata* of Duncan[1] from the chert formation of the Antiguan so-called Miocene. I am not certain that the Antiguan species of Duncan is the same species as *Astrocœnia ornata* (Michelotti). Specimens of Antiguan corals have been submitted to me by Mr. Robert T. Hill and Dr. J. W. Spencer; therefore I can make a direct comparison between the two species of Astrocœnia. Looked at superficially the two corals seem the same. *Astrocœnia pumpellyi* has delicate thin walls and practically always six principal and six small septa; *Astrocœnia ornata* Duncan has stout walls and nearly always eight large and eight small septa; six large and six small septa seem to occur only in young calices.

As *Astrocœnia pumpellyi* possesses dissepiments, it would, according to Tomes, not belong to Astrocœnia,[2] but as he states that he did not study the type species of the genus *Astrocœnia orbignyana* M.-Edw. and H., his rectification of the genus can not be accepted. The observations of Tomes do not coincide with those of Frech and others, who note the presence of dissepiments in species of Astrocœnia.[3]

[1] Quart. Jour. Geol. Soc. London, Vol. XIX, 1863, pp. 425–426.

[2] Ibid., Vol. XLIX, Nov., 1893, pp. 569 et seq.

[3] Felix, Beiträge zur Kenntniss der Astrocœninæ: Zeitschr. Deutsch. geol. Gesell., Vol. L, Pt. II, 1898, pp. 247–256; one plate.

Genus PLATYCŒNIA gen. nov.

Colony flat, incrusting; corallites rather small, usually circular, joined directly by their solid walls or by an echinulate cœnenchyma, across which costæ may sometimes be traced by the arrangement of the echinulations. Calicular margins very slightly or not all elevated. The outer surface of the free portion of a corallite marked by minute, crowded, acute costæ; in some instances a costa is simply a row of small spines. Frequently there are costæ between the septa as well as corresponding to them. The septa are few in number, are solid, formed of trabeculæ directed horizontally inward. The septal margins dentate. The smallest septa are represented by rows of spines placed one above another. Very few granulations on the septal faces. Calicular fossæ, rather deep; columella a rather tall pointed style. Endotheca present. Reproduction by budding between the corallites or directly from the base of the peripheral corallites.

This genus belongs, systematically, near Astrocœnia.[1] It is distinguished from Astrocœnia by the corallites usually not being directly united by their walls.

A few remarks should be made on the relationship existing between this genus and *Astrocœnia pulchella* M.-Edw. and H.[2] Mr. R. F. Tomes[3] has pointed out that this is probably not an Astrocœnia. The corallites are not directly united by their walls. As this character is one by which Platycœnia is separated from Astrocœnia, it might be thought *Astrocœnia pulchella* belongs to the genus here proposed. The septa of that species are described as having "their upper edge entire and convex." This character removes *Astrocœnia pulchella* from both Astrocœnia and Platycœnia. It almost certainly belongs to a new genus.

PLATYCŒNIA JACKSONENSIS sp. nov.

Pl. XVII, figs. 9 to 9c.

Colony small, 21 mm. in diameter, flat, incrusting. Calices deep, 1.5 to 2 mm. in diameter, circular or irregular in outline; united directly by their solid walls or separated by a little echinulate cœnenchyma. Calices which

[1] Cf. Felix, Beiträge zur Kenntniss der Astrocœninæ: Zeitsch. Deutsch. geol. Gesell., Vol. L, Pt. II, 1898, pp. 247 et seq.

[2] Mon. Brit. Foss. Corals, Palæontogr. Soc., p. 33, pl. v, figs. 3, 3a–3c.

[3] Quart. Jour. Geol. Soc. London, Vol. XLIX, Nov., 1893, pp. 569, 570.

are not approximate have a raised acute edge, and the corallites whose walls are free are ornamented externally by crowded, minute, granulated, acute costæ. Septa not exsert, margins regularly and sharply dentate, the trabeculæ directed horizontally, or almost horizontally, inward. Some septa are represented by horizontal spines placed one above another. None of the septa examined showed any perforations. Septal arrangement: six systems, two cycles, the first of which reaches the columella; frequently members of the third cycle are present, then two or even three septa of the second cycle may be fused to the columella. In this case the appearance is eight systems of two cycles, or the arrangement apparently is irregular. Endothecal dissepiments are present. They are thick, not numerous. A little exotheca sometimes present. Columella tall, styliform, rather slender.

Locality.—Jackson, Mississippi.

Geologic occurrence.—Jacksonian stage.

Type.—United States National Museum.

Genus STEPHANOCŒNIA Milne-Edwards and Haime.

Stephanocœnia fairbanksi sp. nov.

Pl. XVII, figs. 10 to 11a.

(Figs. 10 and 10a, Stephanocœnia fairbanksi var. columnaris var. nov.)

Form of corallum explanate or columnar. The specimens possessing the explanate method of growth may be considered the typical form; those with the columnar method of growth, *St. fairbanksi* var. *columnaris* var. nov. The sizes and general appearance of the two forms are shown in Pl. XVII, figs. 10 and 11. The corallites are polygonal in form, usually hexagonal, are joined directly by their walls or by very short costæ. The greater diameter of the corallites is very constantly 3.5 mm. Some corallites may be smaller and some slightly larger, but 3.5 mm. is the usual diameter. The walls between two corallites on an unweathered surface or in a section are stout and usually solid; they are almost a millimeter thick. They are clearly pseudothecal. In places the corallites may be joined by very short costæ; then open vertical spaces may exist between the costæ. None of the specimens show the upper edge of the wall in its original condition; therefore its ornamentation can not be described. The septa are in three complete cycles; the members of the first and second cycle fuse to the columella; those of the third cycle fuse to the sides of those of the second (?). (There is no way of differentiating the first from the second cycle.) They are thicker at the wall; their faces granulate. The character of the septal margins could not be studied. In the best-preserved calices there appear to be pali before both the first and second cycles of septa. In the thin section both of these cycles of septa show thickenings on and near their inner ends corresponding in position to the apparent lobes on the septa. The calices are not preserved intact, but that 12 pali existed seems quite clear. Endotheca very well developed. Some has the appearance of being synapticular, but recrystallization has gone so far that the microscopic detail is nearly always destroyed. The columella presents two quite different appearances, depending upon the condition of the material. In the best-preserved calices it has a knob-like upper surface, but in the worn specimens it has a spongy appearance, as Felix describes for *Stephanocœnia formosa*.[1] The structure of the columella seems to be as follows: There is a central (axial) styliform or more or less compressed essential piece. The thickened inner ends of the septa fuse among themselves and to this essential part of the columella in a more or less compact manner. The result is a spongy-looking columella in a weathered corallum. This can not be positively asserted, because, as already stated, the material is not satisfactory for microscopic investigation. The calicular fossæ are shallow.

Locality.—Southern California.

Horizon.—Doubtfully Cretaceous.

Types.—Of var. *columnaris*, Pl. XVII, fig. 10, returned to Dr. J. C. Merriam, University of California; of Pl. XVII, fig. 11, presented to the United States National Museum by Dr. Merriam.

The species is based on three specimens, all of which were sent to me by Dr. Merriam; two of the specimens he very kindly presented to the National Museum, and at his request the species is named for Dr. H. W. Fairbanks.

Stephanocœnia fairbanksi appears to be quite closely related to *St. formosissima* (Sowerby) of the "Craie tuffeau of Uchaux, Gosau, Corbières," etc.; but as I have no material of the latter species, a comparison of the two species will not be attempted.

The type species of the genus is *Stephanocœnia intersepta* (Esper),[2] recent and fossil in the West Indian region. Some notes on this species will be appropriate in this connection, and will fill a gap in Felix's

[1] Zeitschr. Deutsch. geol. Gesell., Vol. L, 1898, p. 253.

[2] Milne-Edwards and Haime, Mon. Brit. Foss. Corals, Palæontogr. Soc., p. xxx.

Beiträge zur Kenntniss der Astrocœninæ.[1] Fortunately, my sections of the species are excellent. The septa are composed of ascending trabeculæ; near the wall is a line of divergence. External to this line the trabeculæ pass upward and have a slight inclination outward. The trabeculæ on the inner side of the line of divergence pass upward and incline inward. The trabeculæ are fine, measuring from 0.027 to 0.04 mm. across. A study of the lines of growth across the trabeculæ would indicate an entire or very obscurely dentate septal margin. The growth segments of the septa are well defined; the distance across one, measured along the line of divergence, is about 0.32 mm. on an average. The wall of this species is very interesting. The distal ends of the septa do not thicken sufficiently to form a pseudotheca. In places dark centers or a dark band can be seen in the theca between the septal ends, i. e., the wall belongs in the euthecal class. In some instances the wall is clearly formed by peripherally placed dissepiments. The corallites are quite often joined by their costæ. In such instances the wall of one corallite is usually formed by dissepiments. The columella has in both the hand specimen and thin section the same appearance as in *Stephanocœnia fairbanksi*. There is usually distinguishable a central erect piece, around which the principal septa fuse by their inner margins. In some instances the columella appears to be formed merely by the fusion of the septal margins. In one calice the axis of the columella is vacant, the septal margins having fused around it. The pali in cross section show as thickenings on the inner septal ends. The inner ends of the tertiary septa are free. The above description should be compared with Felix's description of *Stephanocœnia formosa* (Goldf.)[2] I should also like to call attention to a statement by Miss Ogilvie, that "it is doubtful if they [Astrocœnia and Stephanocœnia] are represented in recent seas."[3] She evidently did not know that the type species of Stephanocœnia is the recent *St intersepta* (Esper). So if there is any doubt, it is that the genus is found fossil earlier than late Tertiary. I have never been able to study specimens of *Astrocœnia pectinata* Pourtalès[4] from the Florida coast, but from the figures there is absolutely no reason to doubt the correctness of Pourtalès's generic reference. The type species of Astrocœnia is *A. orbignyana* M.-Edw. and H.[5]

[1] Zeitsch. Deutsch. geol. Gesell., Vol. L.
[2] Op. sup. cit., pp. 252–254, pl. xi, fig. 1.
[3] Op. cit., p. 307.
[4] Florida Reef Corals: Mem. Mus. Comp. Zoöl., Vol. VII, No. 1, 1880, pl. ii, figs. 5–7.
[5] Cf. Mon. Brit. Foss. Corals, Palæontogr. Soc., p. xxx.

Family FUNGIDÆ Milne-Edwards and Haime.

Genus SIDERASTREA de Blainville.

1801. *Astrea* (pars) Lamarck. Syst. d. anim. sans vertèbres, p. 371 (non Astræa Bolten Mus. Boltenianum, p. 79, 1798).
1815. *Astræa* Oken. Lehrb. der Naturg., Vol. 1, p. 75.
1830. *Siderastrea* de Blainville. Dict. d. Sci. nat., Vol. LX, p. 335.
1846. *Siderina* Dana. Zoophytes Wilkes Expl. Exp., p. 218.
1848. *Siderastræa* Milne-Edwards and Haime. Comp. rendus Acad. sci., Vol. XXVII, p. 495.
1857. *Astræa* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. II, p. 505.
1861. *Astræa* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 235.
1886. *Siderastræa* Quelch. Reef corals: Challenger Reports, p. 113.
1890. *Siderastræa* Verrill. In Dana's Corals and Coral Islands, 3d ed., p. 424.
1895. *Astræa* Gregory. Quart. Jour. Geol. Soc. Lond., Vol. LI, p. 278.

More references might be inserted in this synonymy, but it seems that a sufficiently large number have been given.

The synonym of this genus has been very much debated; therefore the question will be discussed here somewhat thoroughly. The name Astræa was first used in a binomial way by Bolten in 1798 for mollusks, now referred to Astralium and Xenophora.[1]

Astræa had previously been used for a coral (by Browne in 1756[2]). Gmelin used it in the thirteenth edition of the Linnæi Systema Naturæ, 1790, page 3767, but merely in a quotation from Browne. The name reappears in the 1789 edition of Browne's work. In none of these cases was Astræa used in a binomial manner. The first binomial author to publish the name Astræa as a generic term was Bolten, and the name must date from him. I have not looked up the synonymy of Astræa in mollusca, but it seems to be antedated by several other names for the same thing, and therefore is not used in molluscan nomenclature. "Once a synonym, always a synonym;" therefore the name can not be used for a genus of corals.

The following is the history of the name among corals: Lamarck, in 1801, proposed the genus Astrea, separating it "into two sections, one having for its type *Madrepora rotulosa* of Ellis and Solander, and the other *Madrepora galaxea* of the same authors; subsequently the name Astræa was

[1] I have been able to examine a copy of the Museum Boltenianum through the courtesy of Dr. William H. Dall.

[2] Civil and Natural History of Jamaica, p. 392.

reserved by Oken for this latter section, without doubt because the species called by Ellis *Madrepora galaxea* was the *Madrepora astroites* of Linnæus."[1] In 1830 de Blainville[2] renamed the Astrea Lamarck (pars) (=Astræa Oken) Siderastrea. Quelch, in his report on the Challenger Expedition reef corals, considers that Oken had no right to take *Madrepora galaxea* Ell. and Sol. as the type of Astrea, but that *Astrea rotulosa* should be the type, and he places Favia, proposed by Oken for the latter species, in the synonymy of Astrea, and uses Siderastrea for the *Madrepora galaxea* group of species.[3] Gregory, the last to consider the subject, supports the conclusion of Milne-Edwards and Haime, but notes the use of Astræa previous to the time of Lamarck.

The name Astrea, for reasons already given, must be abandoned. Oken had a perfect right to subdivide the Lamarckian genus; therefore his name Favia must stand for the *Madrepora rotulosa* group of species. The *Madrepora galaxea* is thus left without a generic designation. The first name proposed after Oken was Siderastrea, by de Blainville, and this must stand. Siderina of Dana falls into the synonymy of Siderastrea.

This name Astrea has been a source of so much trouble to students of zoophytes that it is truly fortunate that strict laws of nomenclature compel us to abandon it.

It is not necessary to enter into a discussion of the structural features of the genus, as the work of Miss Ogilvie[4] is sufficient.

SIDERASTREA HEXAGONALIS sp. nov.

Pl. XVIII, figs. 1 to 4.

1894. *Siderastræa hexagonalis* Vaughan nom. nud. Rept. geol. Coast. Pl. Ala.: Ala. Geol. Survey, 1894, p. 248.

Corallum massive, depressed, with flat base. Greatest distance across type specimen, 57 mm.; thickness, 23 mm. Greatest diameter of calices, 6 to 7.5 mm. Corallites hexagonal, separated by a thin wall of synapticular composition. The wall is usually slightly raised. The septa of adjoining calices may meet each other end to end, or they may alternate in position. Septa do not show a very definite cyclical arrangement; in one calice 68

[1] Milne-Edwards and Haime, Hist. Nat. des Corall., loc. cit.

[2] Dict. d. Sci. nat., Vol. LX, p. 335.

[3] Ogilvie in her Micros. and Syst. Stud. Mad. Types of Corals, 1896, p. 159, makes some remarks on Astræa, but she shows an absolute ignorance of the history of the name; so her notes need no discussion.

[4] Ibid., pp. 178–183.

were counted. The septal grouping rather definite; the members of the third cycle curve toward those of the second, those of the fourth toward those of the third, and those of the fifth curve toward those of the fourth. There are four complete cycles and a considerable number of the members of the fifth. The margin of the outer half of each septum lies in an almost horizontal plane; the inner half of the margin falls in a curve to the bottom of the calicular fossa. The result of these characters of the septal margins is to cause a wide almost flat area between the calicular fossæ. The margins have a beaded appearance on the perfect septa. The septal faces are granulated. Synapticulæ are well developed and numerous; there are several (two or three) rather definite rows near the wall, and often other synapticulæ without definite arrangement. There may be some dissepiments, but of that I can not be sure; nearly all of the endotheca is certainly synapticular. The calicular fossæ are shallow circular depressions in the middle of the calices. Columella poorly developed, false, with a papillate upper termination.

Locality.—Prairie Creek, Alabama.

Geologic occurrence.—Midway beds.

Type.—United States National Museum.

This species is represented in the United States National Museum by only one specimen, which, fortunately, is well preserved. As all the detail necessary for generic and specific determination could be made out without a thin section, none was cut.

Genus STEPHANOMORPHA gen. nov.

As the succeeding description of the species on which this genus is based is somewhat detailed, only those characters usually considered of generic importance will be pointed out here.

Corallum in small rounded masses; corallites subhexagonal; calices usually circular, with slightly elevated rims. Between the calices a distinct, rather wide, somewhat depressed costate area. The costæ pass directly from one calice to the next, alternate with each other, or meet at an angle. Synapticulæ in definite vertical series at periphery of corallite cavity, and where the costæ of neighboring corallites meet; they are more or less irregularly distributed in the other parts of the intercostal spaces and between the septa. Septa not numerous, three cycles in type species, solid, composed of trabeculæ passing upward and inward. In addition to synapticulæ, apparently some dissepiments present. Pali in one crown, before septa of the first and second cycles. Columella well developed, apparently composed of a central erect styliform or compressed piece, around which the inner margins of the septa of the first and second cycles fuse more or less compactly. Reproduction by budding from the angles between calices.

This genus appears to be most closely related to Pseudastræa Reuss[1] and to Mesomorpha Pratz. The latter genus will be considered in describing a species of it. The resemblance, excepting both have compact septa, is not great. The difference between Stephanomorpha and Pseudastræa is not so evident. Reuss did not describe the septal structure; therefore we must leave that out of consideration. The pali and columella in the two genera if not the same are very similar. From Reuss's figure it does not seem that the calices are so distinctly marked off from the intervening costate area in his genus. Reuss says there is no endotheca (excepting synapticulæ) in his genus, but that feature is scarcely of generic importance. The corallum of Pseudastræa is much larger and more massive than in Stephanomorpha.

STEPHANOMORPHA MONTICULIFORMIS sp. nov.

Pl. XVIII, figs. 5 to 7.

1894. *Stephanocœnia monticuliformis* Vaughan nom. nud. Rept. geol. Coast. Pl. Ala.: Ala. Geol. Survey, 1894, p. 248.

Corallum in small rounded masses. The two diameters of the specimen figured in Pl. XVIII, fig. 5, are in a horizontal plane, greater, 30 mm., lesser, 26 mm.; height, 23 mm. None of the nine specimens studied indicate a much larger size. The calices are circular and are definitely circumscribed. Their margins are slightly elevated above the intervening costate area. Diameter, from 2.5 to 3.5 mm.; distance apart, from somewhat less than 1 to 1.5 mm This intervening area is depressed somewhat below the level of the calicular margins and costate. The costæ correspond to all septa. They may be directly continuous from one calice to the next, may alternate with one another, or may meet at an angle. There is sometimes a small raised line indicating where the costæ of adjacent calices come together.

[1] Die fossilen Foraminiferen, Anthozoen und Bryozoen von Oberburg in Steiermark: Denkschr. K. Akad. Wiss., Wien, Math.-naturw. Cl., Vol. XXIII, 1864, pp. 24, 25, pl. viii, fig. 1.

The costæ are thick, low, equal, and have granulate edges. Looked at superficially from above, each calice seems peripherally bounded by a wall; and there appears to be a second wall where the costæ from one calice meet those of the next adjacent calice. But this is only an appearance. Synapticulæ occur between both septa and costæ. These are arranged in a definite circle around each corallite cavity, and give the appearance of a definite wall when viewed from above. There is another definite series of synapticulæ at the costal junction of adjacent corallites. These features were shown by breaking some of the specimens longitudinally to the vertical axis of the corallites. Besides these definitely arranged synapticulæ, there are many others between the costæ without apparent order. The septa are arranged definitely in three cycles. The six of the first cycle are slightly the largest and fuse by their inner ends to the columella. The members of the second cycle also reach the columella. Those of the third cycle fuse by their inner edges to the sides of the second. All of the septa are decidedly thicker at the periphery of the calice, and have their edges slightly elevated. None of the septa have the margins preserved, but they are without doubt dentate. The septa are composed of trabeculæ directed upward and inward. Occasionally minute pits indicated the trabecular courses, but no instance of a septum being undoubtedly originally perforate could be found. The septa, typically, are solid, imperforate. Synapticulæ exist between the septa, but are not so abundant as they are between the costæ. Besides the synapticulæ, there appear to be some small thin dissepiments. Pali are present on the inner ends of the septa of the second cycle; and in the best-preserved calice studied they seemed to be on the inner ends of those of the first cycle also. The following, apparently, is the correct characterization: Pali well developed, moderately wide, with a curved upper edge, in a single crown, on the inner ends of the first and second cycles of septa. The precise nature of the columella can not be made out with absolute certainty, because of chemical changes which the specimens have undergone. The inner margins of the septa of the first and second cycles fuse more or less compactly, making a well-developed columella. There appears to be in most calices a central, erect, more or less styliform or compressed piece that is independent of the septa; and apparently the columella in the worn specimens is composed of the two elements—one essential, the other merely a reenforcement of the first by septal fusion around it. Calicular fossæ shallow. Reproduction takes place by budding from the costate area between the angles of the calices.

Localities.—Prairie Creek, Alabama (United States National Museum); eastern Wilcox County, Alabama (collection of T. H. Aldrich).

Horizon.—Midway beds; "Turritella Rock," according to the label of Mr. Aldrich's specimens.

Types.—United States National Museum; specimens in the collection of Mr. T. H. Aldrich.

From a superficial study of this coral I at first made the mistake of referring it to Stephanocœnia. By comparing the preceding description with that given for *Stephanocœnia fairbanski* the general superficial resemblance will be quite apparent, in spite of the two corals being essentially very different.

Genus MESOMORPHA Pratz.

MESOMORPHA DUNCANI sp. nov.

Pl. XVIII, figs. 8 to 10.

1894. *Thamnastræa duncani* Vaughan nom. nud. Rept. geol. Coast. Pl. Ala.: Ala. Geol. Survey, 1894, p. 248.

Corallum in rounded, rather low, more or less cap-shaped masses, base almost flat. Two specimens in the National Museum that show the form and size of the colony possess the following dimensions:

	1	2
	Mm.	*Mm.*
Diameter	34 to 35.5	56
Height	23	29

Septo-costæ flexuous, confluent from one calice to the next; distance between calicinal centers 4 to 5 mm.; no walls between calices. The cyclical arrangement of the septa not very definite; the number of septa varies from 29 to 48. There are three complete cycles, with a greater or less number of those of the fourth, the latter sometimes being complete. The septa are crowded and have a decided tendency to form groups of from three to five each. They are composed of ascending completely fused trabeculæ, which stand vertical or are slightly inclined inward. No perforations could be discovered in several thin cross sections, nor in many longitudinal sections, nor on the flat faces of the septa. Synapticulæ very abundant; in an interseptal loculus extending from one calicinal center to the next there are from six to nine. Those synapticulæ whose origin could be made out are false, but I can not deny that true synapticulæ also may sometimes be present. There appear to be occasional dissepiments, but of this I can not be positive. The calices are not preserved in their original condition; therefore the original character of the columella could not be made out with absolute certainty. In many cases it appears to be a stout pillar or style, but this appearance might be produced by chemical changes, soldering the inner ends of the septa together after the death of the coral. In other instances it seems false. The thin sections show the fusion of the inner ends of the septa in the columella space. The following characterization seems correct: Columella well developed but false, formed of the innermost septal trabeculæ, which may fuse so completely that in cross section, below its upper surface, it may appear solid. Upper surface papillate. The calices are superficial. Reproduction by budding between the calicinal centers.

Locality.—Prairie Creek, Alabama.

Horizon.—Midway beds.

Types.—Three specimens in the United States National Museum.

This species resembles very closely *Thamnastræa balli* Duncan from the Ranikot (Lower Eocene) series of the Sind. It has more septa than the Sind form, and its calices are larger.

The species just described is undoubtedly Mesomorpha. A species, *Mesomorpha catadupensis*, recently described by myself from Catadupa, Jamaica,[1] might not be Mesomorpha, as the septa just below the upper edge may sometimes be perforate.

In the paper on Jamaican corals, just alluded to, some remarks are made on the insufficiency of the characterization of Thamnastræa. Those remarks, with some additions, will be repeated here.

There is no way of distinguishing from the literature the difference between Mesomorpha and Thamnastræa, because no thorough study of the type of the latter genus, *Th. dendroidea* (Lamouroux), has been made. Pratz, in his memoir Ueber den Aufbau des Septalapparates einiger

[1] Bull. Mus. Comp. Zoöl. Harvard Coll., Vol. XXXIV, 1899, p. 246, pl. xli, figs. 1–3.

charakteristischer Gattungen,[1] does not even mention the type species. So although Pratz has added some interesting observations on the septal structure of some corals, he has not informed us what Thamnastræa really is. He has not given the name of the species on which he based his figures and studies; therefore we do not know that he studied Thamnastræa at all.

According to Pratz's figure of Mesomorpha,[2] the species under consideration must belong to that genus, but it is impossible to decide whether it is a Thamnastræa. The following is Pratz's definition of Mesomorpha:[3]

> Polypar massiv knollig, höckrig oder ästig. Zuweilen incrustirend. Kelche niedrig, nicht durch scharfe Grate umschrieben, sondern durch Septocostalradien untereinander verbunden. Eine Mauer fehlt oder ist höchtens rudimentär und von den Septacostalradien versteckt. Septa compact, an den Seitenflächen mit Körnchen versehen. Die benachbarten Septalflächen sind durch starke, echte Synaptikeln mit einander verbunden. Letztere verleihen dem zwischen den Kelchcentren befindlichen Sclerenchym bei unregelmässigem Verlaufe des Septocostalradien zuweilen ein cœnenchym-artiges Aussehen. Der Septalrand ist regelmässig gekörnelt und deutet auf einen trabeculären Aufbau hin. Säulchen papillär, häufig mit mehreren Sternleisten verschmolzen.

There could be only one cause for questioning my generic reference; this is, *M. duncani* has false synapticulæ, but in my opinion, as already expressed, whether synapticulæ are true or false is of no systematic value.

Koby in discussing Thamnastræa[4] does not mention *Thamnastræa dendroidea*, although the species occurs in the Jurassic of Switzerland. He says (p. 557): "Je prends pour type des véritables Thamnastrées la *Thamnastræa arachnoides*, dont je vais donner une description du polypier." As the type of the genus has already been designated, Koby can not change it. Until some one furnishes us a detailed study of *Th. dendroidea* we are working absolutely in the dark on the relations of the whole set of the so-called Thamnastræoid genera.

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[1] Ueber die verwandtschaftlichen Beziehungen einiger Korallen Gattungen: Palæontographica, Vol. XXIX, 1882, pp. 92–98.

[2] Eocäne Korallen aus der libyschen Wüste und Aegypten: Palæontographica, Vol. XXX, 1883, Pal. Theil, pp. 226–227, pl. xxv, figs. 45, 45a.

[3] Eoc. Korall. aus der lib. Wüste, u. s. w.: Loc. cit.

[4] Monogr. d. polypiers jurass. d. la Suisse: Mém. Soc. pal. Suisse, Vol. XVI, 1889, pp. 556–560.

Family EUPSAMMIDÆ Duncan (subfamily Milne-Edwards and Haime).

Genus BALANOPHYLLIA Searles Wood.

Discussion of the genus Osteodes.—In Vol. VII, page 263, of the Proceedings of the Academy of Natural Sciences of Philadelphia, Conrad proposes the above name for a genus to include such forms as *Balanophyllia irrorata*[1] and *B. caulifera*.[2] The forms included in this genus are now distributed into two genera[3], both of which antedate Conrad's name. Balanophyllia was proposed by Searles Wood in 1844[4] (type species *B. calyculus* S. Wood) and Eupsammia by Milne-Edwards and Haime in 1848[5] (type species *E. trochiformis* (Pallas). Furthermore, Conrad published no figures, except for *E. caulifera*,[6] and did not describe his genus with sufficient accuracy. Therefore it is discarded. The discussion is introduced here because this is the first species noted which was referred to that genus.

The generic difference between Balanophyllia and Eupsammia is so slight, and as some species, for example, *Balanophyllia haleana*, have individuals which can with propriety be referred to either genus, I have sometimes thought it best to place Eupsammia in the synonymy of Balanophyllia. The reasons why I have not done so are: First, in later Tertiary and recent times the two genera are distinct; second, when we obtain sufficient material of various fossils, every species, every genus, etc., must intergrade with some other species or genus; therefore it seems to me better not to merge species or genera into one when they grade into one another in a lower horizon, but are distinct in an upper one. There may be difference of opinion on this point. I will state that Eupsammia and Balanophyllia do pass one into the other, and if that destroys the validity of a genus, the former becomes a synonym of the latter, and the family name Eupsammidæ must be changed.

Here seems the most appropriate place to introduce some observations

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[1] Proc. Acad. Nat. Sci. Phila., Vol. VII, 1855, p. 263.

[2] *Turbinolia caulifera* Conrad, Proc. Acad. Nat. Sci. Phila., Vol. III, 1847, p. 296; Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. I, 1848, p. 127, pl. xiii, figs. 33 and 34.

[3] Cf. *Osteodes elaborata* (Conrad). Check List, 1866, p. 2. Referred to genus Eupsammia in the present paper, vide inf. p., 180.

[4] Searles Wood, Ann. and Mag. Nat. Hist., Vol. XIII, 1844, p. 11.

[5] Annales sci. nat., Vol. X, 1848, p. 77. Duncan erroneously cites 1860 as the date of this genus.

[6] Conrad's septal diagram of *Turbinolia caulifera* is not accurate and is of no value in determining the characters of his proposed genus.

made on the minute structure of two species of Balanophyllia, viz, *B. irrorata* (Conrad) and *B. elongata* sp. nov. For purposes of comparison attention is called to Miss Ogilvie's work on the structure of *Eupsammia trochiformis*.[1]

BALANOPHYLLIA IRRORATA (Conrad).

The wall.—Distally the septa are joined by synapticulæ. True theca was seen in one part of the section, i. e., a calcification line was seen between the ends of two septa, but this might be a rudimentary septum. In another place a very rudimentary septum was inserted between two older; the ends were fused so as to form a pseudotheca.

The septa are not directly continuous to the outside, as in the so-called Astræids, Fungids, Turbinolids, etc. For a portion of the length a septum is continuous, straight or slightly curved. As it approaches the exterior it becomes perforate, and a spongy mass of synapticulæ and disconnected portions of septa prevail. The main axis of the septal plane does not coincide with the central vertical axis of a costa, but corresponds to one side of it. A short disconnected rudimentary septum corresponds to the other side of the costa. In places the apex of a costa seems formed by a keystone piece set in between the ends of a large and rudimentary septum. In other places the small septa may each have a corresponding fine costa, making a set of compound costæ. Very often it is extremely difficult, because of perforations and synapticulæ, to trace the course of a septum, the whole being resolved into a spongy mass. But in general the costæ correspond in position to the septal (speaking of the developed septa) planes projected through the wall. I do not know of any exception to this.

The septal trabeculæ, as judged by the granulations on the surface of the septa, pass upward and inward. The course of a trabecula may continue uninterruptedly across several growth segments, new trabeculæ being introduced between the old, or, as Miss Ogilvie has noted, the new trabecular courses may alternate in position with the old trabeculæ. Both conditions occur, i. e., the trabeculæ are not always continuous across all growth segments. In the spongy zone quite near the periphery of the corallum is a line of divergence, outside of which the trabeculæ pass upward and outward.

[1] Microscopic and Systematic Study of Madreporarian Types of Corals, pp. 193–201.

Along the sides of the middle line of the septa the micro-fibers diverge inward and converge outward along the middle of the septum. Both true and false synapticulæ are present. The lower part of the corallum is filled by the continuous thickening of the skeletal elements in that portion of the corallum. The columella is a spongy mass composed of calcification centers that fuse by processes among themselves and also sometimes to the septa; but which appear entirely independent of septal trabeculæ. There seems absolutely no order in the arrangement of the larger granules in the septal sides.

BALANOPHYLLIA ELONGATA sp. nov. (vide infra).

The character of the wall, relations to costæ, septal structure and character of columella are practically the same as in *B. irrorata.* Quite often calcification centers, apparently independent of the septa and arranged irregularly around these distal ends, are seen. By a rapid thickening of all the distal elements, a solid wall is formed. By a thickening of the septa, etc., the whole basal part of the columella becomes almost solid.

Miss Ogilvie, in her work already alluded to, has given so detailed a description of *Eupsammia trochiformis* that it is not necessary to add other notes here.

BALANOPHYLLIA DESMOPHYLLUM Milne-Edwards and Haime.

Pl. XVIII, figs. 11 to 13a.

1848. *Balanophyllia desmophyllum* Milne-Edwards and Haime. Mon. des Eupsammides: Annales sci. nat., 3d ser., Vol. X, p. 86.

1850. *Balanophyllia desmophyllum* Milne-Edwards and Haime. Mon. Brit. Foss. Corals, Palæontogr. Soc., pp. 35–36, pl. vi, figs. 1 and 1a–1c.

1857. *Balanophyllia desmophyllum* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 102.

1881. *Balanophyllia desmophyllum* Quenstedt. Röhren- und Sternkorallen, p. 1042.

Form subflabelliform, attached by a short pedicel, transverse outline elongate elliptical. Calice rather deep. Septa thin, in five cycles. The members of the first and second cycles with prominent upper margins. The margins of the third also exsert, but not to so great a degree as in the first and second cycles. The members of the fourth cycle have the least prominent margins. Those of the fifth cycle meet and unite in front of the fourth and then fuse to the sides of the third. They are very perforate. Their surfaces granulate. There are no dissepiments. Costæ rather fine, crowded together. Those corresponding to the first, second, and third cycles coarser than those corresponding to the fourth and fifth cycles. Those costæ corresponding to the fourth and fifth cycles, fine, acute, present a serrate appearance when seen from the side, composed of a single row of granules; those corresponding to the first, second, and third cycles of septa consist in their lower portion of a single row of granules, but in their upper portion of a double row. Branching by trifurcation. In old specimens the costæ of the upper portion are wider and more granulated. Occasionally a septum of the fourth cycle will be fused distally to one of the second cycle, and a single costa will correspond to the two septa. The perforations in the intercostal furrows are very close together. There may be an extremely thin pellicle of epitheca just above the place of attachment. Epitheca rudimentary or absent. Wall rather dense, vesiculated. Columella very well developed, spongy, vesiculated.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	14	13	23
Lesser diameter of calice	8.5	8.3	16.5
Height of corallum	18.5	17.5	28.5

Localities.—Greggs Landing and Woods Bluff, Alabama; Newton, Mississippi; Wautubbee Hills, Mississippi; 9½ miles south of Hickory, Mississippi; Indian Mound, 2½ miles east of Newton, Mississippi; 1 mile south of Hickory, Mississippi; 2 miles southeast of Hickory, Newton County, Mississippi; 8 miles west of Enterprise, Clarke County, Mississippi; 8 miles southeast of Hickory, Newton County, Mississippi; Wheelock, Robertson County, Texas; Smithville, Texas; 1 mile southeast of Mason Springs, Maryland.

Geologic occurrence.—Bells Landing, Woods Bluff, and Lower Claiborne beds.

Figured specimens.—United States National Museum; and from collection of T. H. Aldrich, also in United States National Museum.

The subflabellate form of this species easily separated it from the other Eocene species of Balanophyllia in the United States.

I have very carefully compared our American material with the descriptions and figures of *B. desmophyllum* given by Milne-Edwards and Haime, and when in London, in January, 1898, I had the opportunity to examine the types of the species. I have been unable to find any character by which the American specimens can be separated from those from Bracklesham beds, England. Milne-Edwards and Haime give an account of the affinities of *B. desmophyllum* for the other European species of the genus in their Monograph of the British Fossil Corals. Their work can be consulted for these notes.

BALANOPHYLLIA DESMOPHYLLUM var. MICROCOSTATA var. nov.

Pl. XIX, figs. 1 to 3c.

Corallum horn shaped: base pointed, slender; cross section elliptical. Attached in its early stages, becomes free later. The corallum may be curved in the plane of either the longer or shorter transverse axis of the calice, or in a plane not containing either of these axes. Septa in five cycles, their surfaces granulate. The costæ delicate, composed of a rather regular, usually single, series of granules. In some specimens, on the basal portion of the corallum these costæ are coarse, but they soon branch and become fine and much crowded together. The intercostal furrows very perforate. Wall moderately thick, somewhat vesiculate. Some epitheca on the lower portion of the corallum.

	1	2	3	4 *a*
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	11	10	15	17
Lesser diameter of calice	9.2	8.75	10.5	13.5
Height of corallum	20.1	16	20.5	34

a Figured specimen.

Locality.—Nanafalia Bluff, Alabama.

Geologic occurrence.—Nanafalia horizon.

Types.—United States National Museum.

This variety grades directly into the typical forms of *B. desmophyllum*, and is quite close to some varieties of *B. irrorata* (Conrad). It does not grade into the latter, but the two are very close together, and it may be confidently expected that subsequently they will be found to pass into each other, and that *B. irrorata* is a descendant of *B. desmophyllum* through the variety *microcostata*. This variety is close to *Balanophyllia gravesi* M.-Edw. and H. of the Calcaire Grossier.

Balanophyllia irrorata (Conrad).

Pl. XIX, figs. 4 to 11a.

Pl. XIX, fig. 4, drawn from one of Conrad's original type specimens; figs. 5 to 5b, drawings of a typical specimen from Jackson, Mississippi; fig. 6, side view of a septum; fig. 7, of Gabb and Horn's type of "*Trochosmilia*" *mortoni*; fig. 8, another specimen of var. *mortoni*; figs. 9 and 10, variety *dichotoma* Gabb and Horn; figs. 11 and 11a, variety *coniformis* var. nov.

1855. *Osteodes irroratus* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1860. *Trochosmilia mortoni* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, p. 389, pl. lxix, figs. 4–6.
1860. *Cylicosmilia caulifera* Gabb and Horn (non *Turbinolia* (=*Balanophyllia*) *caulifera* Conrad). Jour. Acad. Nat. Sci. Phila., Vol. IV, p. 389, pl. lxix, figs. 7–9=
1860. *Cylicosmilia dichotoma* Gabb and Horn. Loc. cit.
1866. *Osteodes irroratus* Conrad. Check List, p. 21.
1890. *Osteodes irroratus* de Gregorio. Mon. de la Fauna éocenique de l'Ala., p. 256.
1896. *Balanophyllia irrorata* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 51.

This species may be divided into four fairly distinct varieties by which it will be described, and their relations to one another will be shown.

Balanophyllia irrorata (Conrad) typical.

Pl. XIX, figs. 4 to 6.

Corallum elongate, subconical, may be curved in the plane of the longer or shorter transverse axis of the calice, sometimes straight. Cross section elliptical, attached in the young stages, but subsequently becomes free. In old specimens the scar is covered by a deposit of calcareous matter. The epitheca is very thin, covering the lower portion of the corallum. Costæ are rather coarse, acute, usually present a carinated appearance, composed of many small nodules in a single row; branch by trifurcation. When the carinæ are worn down a little, the porous character of the costæ is revealed. The wall is perforate, thick, and spongy. Septa in five cycles, their surfaces covered with many pointed granules. Near the wall these granules meet, forming synapticulæ, and thus increase the thickness of the wall. Columella spongy.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Longer transverse axis of calice	18	17	17
Shorter transverse axis of calice	13.8	13.5	13.5
Height of corallum	39	30	23

Localities.—Montgomery, Louisiana; Jackson, Mississippi; and Claiborne, Alabama.

Geologic occurrence.—Jacksonian stage, and Upper Claiborne (?).

BALANOPHYLLIA IRRORATA var. MORTONI (Gabb and Horn).

Pl. XIX, fig. 7, drawn from one of Gabb and Horn's types; Pl. XIX, figs. 8 to 8b, from a specimen with more pointed base, from Wagner Institute collection.

1860. *Trochosmilia mortoni* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., Vol. IV, p. 389, pl. lxix, figs. 4–6.

The following description is based upon the original types:

Corallum of a short subconical form, cross section elliptical, slightly curved. The curvature may be in the plane of the lesser or greater transverse axis of the calice. Attached by a broad base when young, but becoming free, and the scar may be ultimately almost obliterated. Costæ well developed, but not so prominent as in *B. irrorata*; branch by trifurcation. Intercostal furrows perforated. A slight development of epitheca. Wall strong, not very thick, slightly vesiculated. Septa in five cycles; those of the fifth cycle uniting in front of those of the fourth. Columella weak.

	1	2 [a]
	Mm.	*Mm.*
Greater diameter of calice, about	18	17
Lesser diameter of calice, about	14	14.5
Height of corallum	18.5	22

[a] Adult specimen, Pl. XIX, fig. 7.

Localities.—Caldwell County, Texas; Moseleys Ferry, Brazos River, Burleson County, Texas; Black Shoals, or Colliers Ferry, Brazos River, Texas; Lexington, Lee County, Texas.

Geologic occurrence.—Lower Claiborne.

Original types.—Philadelphia Academy of Natural Sciences.

In Pl. XIX, fig. 7, there is a young coral attached to an old corallum. This shows very nicely the method of attachment of the young. In the adult none of the expanded base persists, and the scar is healed over by a subsequent calcareous deposit. The costæ resemble those of *B. irrorata*, but they are not so coarse and are more acute. In the form of the corallum the variety is variable; it is either rather elongate or rather short; the corallum is shorter than in *B. irrorata* typical.

BALANOPHYLLIA IRRORATA var. DICHOTOMA (Gabb and Horn).

Pl. XIX, figs. 9 and 10.

1860. *Cylicosmilia caulifera* Gabb and Horn (non *Turbinolia* (= *Balanophyllia*) *caulifera*, Conrad). Jour. Acad. Nat. Sci. Phila., Vol. IV, p. 389, pl. lxix, figs. 7–9. As Gabb and Horn suspected that this might not be Conrad's species, they proposed the alternate name *C. dichotoma*.

Shape subconical, slightly compressed, attached in young stages but free in adult stage. Costæ well developed, strong, usually composed of a single series of granules, slightly carinated, branch by trifurcation. Wall strong, shows few vesicles. In both of the type specimens there is a rather abrupt increase in size of the corallum a short distance above the base, giving the corallum a slightly shouldered appearance. Septa in five cycles; in the upper portion of the corallum they are thin and delicate; in the lower portion thick and strong. Their surfaces granulated. Columella vesicular.

	1	2
	Mm.	*Mm.*
Greater diameter of calice, about	11.5	9
Lesser diameter of calice, about	10	7.75
Height of corallum (from base to upper edge of wall)	14	11.5
Height of corallum (to end of projecting columella)	17	....

Localities.—Caldwell County, Texas; Alabama Bluff, Trinity River, Houston County, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—Gabb's original specimens in Philadelphia Academy of Natural Sciences. Of the two original specimens of this species, the one that is figured here appears abruptly truncated; the other specimen, which is much smaller, comes to an obtuse but rounded end.

Since the above was written, Mr. C. W. Johnson, of the Wagner Institute of Science, has collected five good specimens (and one other specimen, probably a young individual) of this variety, at Alabama Bluff, Trinity River, Houston County, Texas. The specimens show a basal scar of attachment. The largest specimens are free and have a rounded base, as in *Eupsammia elaborata*. The basal scar on three specimens is quite large; on one it is 2 mm. across. These scars probably would not be entirely obliterated.

The following are the measurements of these specimens:

	1	2	3	4	5 *a*
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	10	9	10.5	9.5	12
Lesser diameter of calice	8	8	9	8	10
Height of corallum	13	14	15	15.5	18.5

a Pl. XIX, fig. 10.

One of these specimens, No. 4 of above table, has the calice very well preserved. It is shallow, and has the columella projecting upward in its bottom.

At first I considered this coral a good species and placed it in the genus Eupsammia, but a careful comparison of a large number of specimens of the var. *mortoni* showed perfect intergradation.

BALANOPHYLLIA IRRORATA var. CONIFORMIS var. nov.

Pl. XIX, figs. 11 and 11a.

The specimen represented by Pl. XIX, fig. 8, indicated a transition from the type of var. *mortoni* to var. *coniformis*. The figure of the latter variety is drawn looking at the end of the greater transverse axis. It is near the ends of this axis that every fourth costa is so much more accented than the intervening costæ. The costæ of this variety present no characters especially different from typical var. *mortoni*, except that some of those corresponding to the first, second, and third cycles of septa are more prominent than those corresponding to the fourth and fifth cycles. The real difference between the two varieties is merely the form. The corallum of var. *coniformis* is almost straight, slightly compressed conical, with a small area of attachment surmounted by a very short pedicel. The circumference of the calice is proportionately to the height of the corallum much greater than in var. *dichotoma*.

The excellent collection made by Mr. C. W. Johnson in Texas, for the Wagner Institute of Science, shows that this variety passes directly into the var. *mortoni*.

Locality.—Smithville, Texas.

Horizon.—Lower Claiborne.

Type.—Collection of Wagner Free Institute of Science, Philadelphia.

These two species, *B. desmophyllum* and *B. irrorata*, with their varieties, form an apparently connected genetic series.

B. desmophyllum var. *microcostata* is the oldest of the series, and occurs in the Nanafalia bed at the base of the Chickasawan. It is succeeded by the typical *B. desmophyllum* in the next higher horizon, the Greggs Landing beds. This form ranges through the middle and upper Chickasawan, and well up in the Claibornian. In the Lower Claiborne, as an offshoot from this species, var. *mortoni* of *B. irrorata* appears. Var. *coniformis* of *B. irrorata* is derived from var. *mortoni*. As another further descendant of var. *mortoni* we have the typical *B. irrorata*, as it is found in the Jackson beds of Mississippi and Alabama. The variety *dichotoma* of *B. irrorata* is also derived from var. *mortoni*.

Balanophyllia inauris sp. nov.

Pl. XIX, figs. 12 to 14.

The following is a doubtful synonymy:

1834. *Turbinolia inauris* Morton. Synop. Org. Rem. Cret. Group., p. 81, pl. xv, fig. 11.
1861. *Turbinolia inauris* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 100.
1893. *Turbinolia inauris* Boyle. North Amer. Mes. Invert. Bull. U. S. Geol. Survey No. 102, p. 291.

Morton never described "*Turbinolia inauris*" and published only a miserable figure that gives merely the form of the corallum, and the figure is drawn upside down. The specimens, supposedly the types of the species, were sent to me from the Philadelphia Academy of Sciences, through the courtesy of Prof. H. A. Pilsbry. Unfortunately, the figured specimen of Morton is not in the lot. It seems reasonable to assume that Morton's type came from the same locality as these specimens, but even when this assumption is granted it can not be decided what species he meant. There are four different species among the supposed types, viz: *Flabellum mortoni* sp. nov., *Trochosmilia conoides* Gabb and Horn, an Endopachys, probably *E. maclurii* (Lea), and a Balanophyllia that I here name *B. inauris*. Bölsche, in Credner's Die Kreide von New Jersey,[1] describes what he calls *Trochosmilia ? inauris* (Morton), but he gives no figure, and in the state of confusion of the species one can not tell from his description what species he had.

It seems to me best to discard Morton's species altogether. I apply *inauris* to a Balanophyllia occurring among his so-called types, but this

[1] Zeitsch. Deutsch. geol. Gesell., Vol. XXII, 1870, p. 215.

name as applied to the Balanophyllia is not an identification of Morton's "*Turbinolia inauris.*"

The following description is based on seven specimens in the United States National Museum, and five specimens and two sections in the collection of the Academy of Natural Sciences of Philadelphia:

The corallum possesses two forms; they are either cornute, curved in the plane of the longer transverse axis of the calice, or are straight; occasionally a specimen may be slightly curved in the plane of the shorter transverse axis. The first-described form of corallum is that figured by Morton. The area of attachment is small. The following gives the measurements of a series:

	1 *a*	2	3	4	5
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Greater diameter of calice	20	19	17+	17	15
Lesser diameter of calice	15	14.5	14.5	13.5	12.25
Height of corallum	35	21	27.5	....	18

a Specimen 1 is represented by Pl. XIX, fig. 12. It and specimen 2 are in the United States National Museum. Specimen 3 is represented by Pl. XIX, fig. 13. It and specimens 3, 4, and 5 are in the Academy of Natural Sciences of Philadelphia.

The costæ are fine, low, granulate, usually not acute; subequal in size, or every fourth one slightly larger than the intervening three. The corallum wall, to be sure, is perforate. Apparently, girdling bands or shreds of epitheca are sometimes present. Septa in five complete cycles, with typical Balanophyllid arrangement (see Pl. XIX, fig. 14); the members of the fifth cycle standing next those of the first and second cycles are longer than the other members of the fifth cycle. The upper margins of the first and second cycles considerably elevated; those of the third less so. Calice rather deep. Columella, lax, spongy, not greatly developed.

Locality.—(Of specimens in the United States National Museum) upper part of second bed of Green Sand or lower part of third bed, Williams, near Squankum, New Jersey (Meek and Hayden). The specimens from the Academy of Natural Sciences of Philadelphia bear on the label only "N. J."

Horizon.—Shark River beds, probably about Middle Eocene (Clabornian).

Types.—United States National Museum; Philadelphia Academy of Natural Sciences.

This is a very well characterized species. It seems to have its closest resemblance with *Balanophyllia irrorata* (Conrad); but that is not great. The costæ are much finer in the former than in the latter, and constitute one good difference.

BALANOPHYLLIA PONDEROSA sp. nov.

Pl. XX, figs. 1 to 2.

A large, coarse species. Form elongate, cross section elliptical, curved in plane of longer axis of the calice. Area of attachment rather large. The size does not always increase uniformly from the base; therefore there are sometimes girdling constrictions, giving the specimens a moniliform appearance.

Corallum wall composed of two layers, an outer rather thin, solid one, and an inner, thick, vesicular. Viewed from the outside it looks solid; it does not show perforations. The costæ are low, broad, rounded, and granular. There are larger costæ, intervening between each pair of which are either three or seven smaller ones. There are five complete cycles of septa. The costæ corresponding to the first and second cycles are larger than those corresponding to the higher cycles. In one system there are two costæ corresponding to septa of a sixth cycle. The total number of costæ is 98. Thin pellicular epitheca present.

The number of septa have already been stated—five complete cycles and occasional members of a sixth cycle. Those of the fifth cycle fuse in front of the included fourth. The septa are very thin, and have spinose sides. Columella large vesicular. The calicular portion is so broken that as good measurements as were desired could not be obtained, but those obtained were as follows: Greater diameter of calice, 25 mm.; lesser diameter of calice, 20 mm.; height, 44 mm.

Locality.—Prairie Creek, Wilcox County, Alabama. (L. C. Johnson, collector.)

Geologic occurrence.—Midway beds.

Type.—United States National Museum.

This species may be easily distinguished by its large size, moderately large area of attachment, thin outer solid wall, thick inner vesicular wall, and low, wide, round, granular costæ. It seems nearer to *B. elongata* or *B. caulifera* than to the other species of the genus, but both of these species are much smaller and have very small areas of attachment.

Balanophyllia annularis sp. nov.

Pl. XX, figs. 3 to 5.

Shape of corallum subconical, rather short, usually slightly curved, transverse outline elliptical; attached by a small base. Costæ small, corresponding to all cycles of septa; beautifully granulate. Usually there is a single row of granules on the costæ corresponding to the third, fourth, and fifth cycles of septa, but occasionally it may be double. The costæ corresponding to the first and second cycles are much wider than those corresponding to the higher cycles, which are equal in size; the former are rather flattened above, while the latter are acute. The epitheca is usually well developed, extending rather far up the side of the corallum. Since it is thicker in some places than in others, it gives to the corallum an annulated appearance. The wall in its upper portion is rather thin but dense for a Balanophyllia, the corallum filling up internally by secondary thickening. Septal arrangement typical for the genus in five cycles; their sides granulate. Dissepiments absent. Columella vesiculate, weak. The following measurements are from an average specimen: Greater diameter of calice, 11.5 mm.; lesser diameter of calice, 10 mm.; height of corallum, 17 mm.

Locality.—Lower Peach Tree Landing, Alabama.

Geologic occurrence.—Bells Landing beds.

Types.—From collection of T. H. Aldrich in the United States National Museum. Specimens in collection of Wagner Free Institute of Science.

This species stands alone among our Eocene Balanophylliæ; no other one possesses such a dense, highly developed, annulated epitheca. It has a gross resemblance to some specimens of *B. irrorata* var. *coniformis*, but the two forms could scarcely be confused. Occasional specimens lack the epitheca. These resemble *Eupsammia elaborata* (Conrad), to be described later. *B. annularis*, in all the well-preserved specimens that I have seen, has a very small nipple-like pedicel, or a scar of attachment. The corallum is more compact than in *Eupsammia elaborata*.

Balanophyllia augustinensis sp. nov.

Pl. XX, figs. 6 to 10.

Form slender, elongate cornute, cross section elliptical, base pointed, attached by a very small pedicel. Costæ subequal in size, low, broad, granular. In lower part of corallum frequently composed of simply one row of granules, while in the upper portion there may be as many as three alongside one another. When there is more than a single row of granules, the granules are arranged irregularly. Shape and character of the costæ distinguish the species. Wall originally regularly perforate, but becomes secondarily compact below the calice. The presence of epitheca is doubtful; on the best-preserved specimens there is none.

The septa have the typical Balanophyllid arrangement. In the smaller coralla there are five complete cycles. Those of the fifth fuse in front of the fourth, and by a prolongation from place of fusion to the columella or to the sides of the third. They appear to be thin originally, but become secondarily thickened and completely fill the lower portion of the corallite cavity. The septal faces are beset with rather tall, pointed granulations. The granulations are frequently inclined. There is no system about the direction of the inclination; sometimes they point outward, sometimes inward. No dissepiments could be found. The columella is not very large; it has a papillate upper surface.

The following are the measurements of the types:

	1	2	3 *a*
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	9	8.5	15
Lesser diameter of calice	8.5	7.5	14
Height of corallum	25	15	34+

a Base broken off

Locality.—San Augustine, Texas.

Geologic occurrence.—Lower Claiborne.

Types.—Collection Wagner Free Institute of Science, Philadelphia.

BALANOPHYLLIA ELONGATA sp. nov.

Pl. XX, figs. 11 to 14.

Form of corallum elongate conical, slightly curved, the curvature not having special reference to the planes containing the longer or shorter transverse axis of the calice. Attached by a very small base. Costæ distinct, granular, flat, not very prominent, those corresponding to the first and second cycles of septa stronger than those corresponding to the third and fourth cycles. Epitheca thin; reaches high up the sides of the corallum, quite near to the calicular margin. Upper portion of the wall perforate. Within, a dense deposit entirely fills the lower portion of the corallum. Near the wall there is a considerable amount of vesicular endotheca. There are also inclined dissepiments, sloping from the outside downward. Septa in four cycles, not exsert. Their upper margins reach about to the same level as the upper limit of the wall. The septa of the first and second cycles reach the columella, those of the fourth cycle meet in front of the third, which do not always reach as far as the fusion of the former. From the point of fusion of the fourth cycle a plate extends to the columella. The upper margins of the septa are entire, their inner margins jagged, faces granulate; perforate near the wall. Columella large, well developed, spongy.

	1	2	3	4
	Mm.	*Mm.*	*Mm.*	*Mm.*
Greater transverse diameter of calice	11.5	12.3	10	8
Lesser transverse diameter of calice	8.7	10.1	8.5	7
Height of corallum	28.5	27	26	17

Localities.—Red Bluff and Carson Creek, Wayne County, Mississippi.

Geologic occurrence.—Vicksburgian stage, Red Bluff beds.

Types.—From collection of T. H. Aldrich in the United States National Museum.

This species has considerable resemblance to *B. caulifera* (Conrad), but is much more elongate and more slender, and I have been unable to find dissepiments in the latter species.

Balanophyllia caulifera (Conrad).

Pl. XX, figs. 15 to 18.

1847. *Turbinolia caulifera* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 296.
1848. *Turbinolia caulifera* Conrad. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. 1, p. 127, pl. xiii, figs. 33 and 34.
1855. *Osteodes caulifera* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1866. *Turbinolia caulifera* Conrad. Check List, p. 26.
1895. *Eupsammia caulifera* Vaughan. Am. Geol., Vol. XV, p. 223.
1896. *Balanophyllia caulifera* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 52.

The following is a description of the typical form of the species:

Corallum conical, usually straight, slightly compressed; cross section elliptical, attached by a short nipple-like pedicel in its early stages. Costæ rather wide, usually flattened or rounded in profile, may be acute, granulate, branching by trifurcation. Wall moderately thick, perforate, vesiculate. The epitheca may be rudimentary or fairly well developed. Sometimes these are simply encircling bands or shreds. Septa not so crowded as is usually the case in the other species of the genus here considered, in four complete cycles, and the fifth is appearing at the end of the longer transverse axis of the calice. Those of the fourth cycle fuse to the sides of the third. When there are members of the fifth cycle, those of the fifth fuse to the sides of the fourth; prolongations from their fusions meet in front of the septa of the third cycle or fuse to the sides of this cycle. The first and second cycles, and a prolongation from each septal group about the members of the third cycle reach the columella. No dissepiments could be found in the interseptal loculi. Columella vesiculate, fairly well developed.

	1	2	3
	Mm.	*Mm.*	*Mm.*
Longer transverse axis of calice	12.5	8.5	16
Shorter transverse axis of calice	10.5	7	14
Height of corallum	18	8.7	23

Localities.—Vicksburg and Red Bluff, Mississippi; near Rosefield, Catahoula Parish, Louisiana.

Geologic occurrence.—Vicksburgian stage.

Types.—In the collection of the Philadelphia Academy of Natural Sciences. Pl. XX, fig. 15, is drawn from one of the original specimens of Conrad. The other specimens figured are in the United States National Museum.

The most characteristic feature for typical *B. caulifera*, after its form, is its small nipple-like pedicel.

Balanophyllia caulifera var. multigranosa var. nov.

Pl. XX, figs. 19 to 20.

From the specimens figured, one would not suspect that this is only a variety of *B. caulifera*. It was some time before I could consent to believe it, but such it certainly is.

The variety about to be described occurs in the Red Bluff horizon, and is the immediate ancestor of typical *B. caulifera* as it is found in the

Vicksburg beds. During the time of the formation of the Red Bluff, the species had not assumed definite characters, but was almost protean. The specimens that are straight and with a basal nipple may be referred to *B. caulifera* s. s. The variety may be thus characterized:

Corallum more or less cornute, short or rather long, the curvature not having any invariable relation to the calicinal axes, but usually in the plane of the greater axis. The area of attachment extremely variable in size; sometimes the attachment is by a small pedicel, but in other instances by a considerably expanded base. The costæ may be a simple row of acute granulations, or they may be wide, rounded, or flattened in profile and densely and irregularly granulated. The septa and columella need no special description. No dissepiments could be found in the interseptal loculi.

	1	2
	Mm.	*Mm.*
Greater diameter of calice	15	13
Lesser diameter of calice	11.5	10.5
Height of corallum	23	21

Localities.—Red Bluff and Carson Creek, Mississippi.

Horizon.—Red Bluff beds.

Types.—From collection of T. H. Aldrich in the United States National Museum; a splendid suite in the United States National Museum.

BALANOPHYLLIA HALEANA (Milne-Edwards and Haime).

Pl. XX, figs. 21 to 23; Pl. XXI, figs. 1 to 2.

1848. *Eupsammia haleana* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. X, p. 80.

1860. *Eupsammia haleana* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 96.

1861. *Eupsammia haleana* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 243.

The following is a translation of the description in the Annales des Sciences Naturelles:

Species very near to the preceding (*E. bayliana*). Base umbilicate. Costæ very crowded, composed of very fine, very prominent, and regular grains, which, for the most part, are double in their lower part and trifurcate at a certain height. Columella considerably developed, spongy, but rather dense. Septa very much crowded, extremely thin, with faces covered with numerous small, pointed grains. Those of the last cycle fuse at about two-thirds the length of the neighboring septa. Height, 25 mm.; longer axis of the calice, 19; shorter, 16; the approximate proportion, 100:118. Fossil from Alabama. Collection of Alcide d'Orbigny. The general form of the single specimen we have seen differs very little from that of *E. trochiformis*, but the base is feebly curved in the plane of the shorter axis of the calice.

Pl. XX, figs. 21, 21a, are two views drawn from photographs of the type specimen and kindly furnished by Prof. Alphonse Milne-Edwards. When in Paris, in January, 1898, through the courtesy of M. Boule, of the Collection Paléontologique, I had the opportunity to examine this specimen and several others that Milne-Edwards and Haime had. The type specimen is the most abnormal specimen of the species that I have seen; it represents the extreme of elongation of the species. Pl. XX, fig. 22, represents a specimen intermediate in character between the type and the usual form. There is a second specimen in the Collection Paléontologique that presents the ordinary characters.

The species is transferred to the genus Balanophyllia because the specimens always show a distinct and often fairly large scar of attachment. Some specimens may become free, but others evidently are permanently attached during the life of the animal. Usually there is a thin pellicular epitheca over the lower portion of the corallum. These two characters are the essential ones by which Balanophyllia is differentiated from Eupsammia.

The following is a characterization of the usual form of the species:

Corallum compressed, conical, rather short; cross section broadly elliptical, usually curved in the plane of the shorter transverse axis of the calice, occasionally in the plane of the longer transverse axis.

All of the specimens examined show indications of attachment on the base. Costæ usually broad and flat, except at their origin, when they are composed of a single row of granules, in the wide portion composed of a double, sometimes treble, set of granules arranged transversely, perforated. Intercostal furrows very small, perforated. Base of the corallum usually covered by a thin pellicle of epitheca. Wall thick, vesiculated, perforated. Columella very vesicular. Septa thin, in five cycles, with usual Eupsammid grouping, their surfaces covered with granules.

	1	2	3	4	5
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Longer transverse axis of calice	15	16.5	13	19	13
Shorter transverse axis of calice	12	14	11	15	11
Height of corallum	20	20.5	20	18.5	23

Nos. 1, 4, and 5, figured. 1, 2, and 3 in the Philadelphia Academy collection; 4, Boston Society of Natural History collection: 5, United States National Museum.

Localities.—Knights Branch, Clarke County, Alabama; near Choctaw Corner and Thomasville, Alabama; 4 miles south of Mount Sterling, Alabama.

Geologic occurrence.—Woods Bluff (Bashi) horizon.

Type.—Collection Paléontologique, Paris.

Figured specimens of this paper.—Pl. XX, figs. 21, 21a, type; Pl. XX, figs. 22, 23, United States National Museum; Pl. XXI, fig. 1, Philadelphia Academy of Natural Sciences; Pl. XXI, fig. 2, Boston Society of Natural History.

Specimens.—In collection of British Museum of Natural History; Wagner Free Institute of Science; T. H. Aldrich.

This is one of our commonest and most clearly characterized Eocene species.

Genus EUPSAMMIA Milne-Edwards and Haime.

Eupsammia elaborata (Conrad).

Pl. XXI, figs. 3 to 7.

1846. *Turbinolia elaborata* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 22, pl. i, fig. 30.

1866. *Osteodes elaborata* Conrad. Check List, p. 2.

1890. *Osteodes elaborata* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 255.

1890. (?) *Placosmilia* (*Trochosmilia*) *connivens* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 255, pl. xliv, figs. 25–28.

1895. *Eupsammia elaborata* Vaughan. Johns Hopkins Univ. Circ., Vol. XV, No. 121, p. 6.

1896. *Eupsammia elaborata* Vaughan. Bull. U. S. Geol. Survey No. 141, p. 90.

The following brief description is based on the original type of Conrad. It bears the label, written by Conrad, "*Osteodes elaborata Con.*, Claiborne, Ala." This specimen is in the Academy of Natural Sciences of Philadelphia. Pl. XXI, fig. 3, is from a drawing of it.

Corallum compressed, conical, straight; cross section elliptical, no indication of attachment. Costæ rather fine, show perforations; branch by trifurcation. No epitheca. Wall perforate, spongy. Septa thin, in five cycles, anastomosing as usual in Eupsammia. Columella spongy. Greater diameter of calice, 12 mm.; lesser diameter of calice, 9 mm.; length of corallum, 13 mm.

Locality.—Claiborne, Alabama.[1]

The following description was based on material from Greggs Landing, Alabama, in the United States National Museum:

The corallum is subconical or subcuneiform, the cross section is elliptical. The base is rather obtuse, usually rounded; very frequently on the tip is a minute scar, showing that the corallum, in its early stages at least, is attached. The adults are evidently free, and the basal scar may be obliterated. The coralla are usually straight, but sometimes the apex of the base may be nearer to one end of the long transverse axis than to the other. There is no epitheca. The costæ correspond to all septa; they are equal, fine and crowded; they are acute, with beaded margins; nearly always have along the summit a single row of granules; very rarely the row may be double for a short distance. The septa are thin, weak, arranged in five complete cycles, six systems, with the typical Eupsammid scheme of anastomosing. The granulations on the septal faces are rather low. The columella is lax, spongy, fairly well developed.

	1*a*	2	3
	Mm.	*Mm.*	*Mm.*
Greater diameter of calice	13	14	12
Lesser diameter of calice	10	11.5	10
Height of corallum	17.5	18.5	14+

a Represented by Pl. XXI, fig. 5.

The specimens from Virginia are usually more slender than those from Alabama. Pl. XXI, fig. 4, represents one of these slender specimens.

Localities.—Greggs Landing, Alabama; Woods Bluff, Alabama; Potomac Creek, Virginia; Aquia Creek, Virginia; 1 mile southeast of Mason Springs, Maryland.

[1] Doubtful. It is quite probable that Conrad has assigned a wrong locality to the specimen.

Geologic occurrence.—Bells Landing and Woods Bluff beds.

Type.—Academy of Natural Sciences of Philadelphia.

Specimens.—United States National Museum; collection of T. H. Aldrich; and Wagner Free Institute of Science.

The following is M. de Gregorio's original description of *Placosmilia* (*Trochosmilia*) *connivens* de Gregorio (Pl. XXI, figs. 8 to 9a):

"Tr. conoidea, simplex, elegans, calice elliptico, paulo excavato; septis numerosis in 6 cyclos dispositis, laminaribus, tenuibis, valde angulosis spinulosisque, apud columellam vix incrussatis; columella carente vel cellulosa, ficta; costulis exterioribus confertis, minutis, granulosis."

Translation: "Tr. conoid, simple, elegant; calice elliptical, slightly excavated; septa numerous, disposed in 6 cycles, thin, delicate, with very sharp minute spines, thickening near the columella; columella absent or cellular, false; external costæ crowded together, minute, granular."

The description suits *Eupsammia elaborata* except for the number of cycles of septa, and the columella is never absent. *E. elaborata* has only five cycles of septa. M. de Gregorio's figures for the side view of his species, and the outlines of the calice, answer for *E. elaborata*, and only five cycles of septa are represented. In the arrangement of the septa, however, his drawings do not represent what is found in Conrad's species. The septal diagrams given by M. de Gregorio for other species of corals that I know well are not accurate, so it is not improbable that these likewise are not correct representations of what is found in the specimens. I believe that M. de Gregorio has redescribed *E. elaborata*.

The following notes are made on the more minute structure of the species. The structure of a cross section is practically the same as in *Balanophyllia irrorata*, except corresponding to each septum is a distinct, sharp, single costa. The distal spongy zone of the two genera is the same. The wall is made up of a network of false and true synapticulæ, and the costæ sometimes fuse laterally.

One instance was seen where apparently a new septum was being introduced. Here the costa was double: the large septum corresponding to one side and the rudimentary septum corresponding to the other. This is a reproduction of the condition previously described for Balanophyllia.

The sides of the septa are minutely striate, with a considerable number of granules along the courses of the striæ. The striæ may be directly continuous across several growth segments, or the new may be so introduced that the striæ (trabecular lines) of a succeeding growth segment may alternate in position with those of the preceding. Both conditions are common. In the spongy zone is a line of trabecular divergence; interior to it the trabeculæ pass upward and inward; exterior to it the trabeculæ appear horizontal.

The margins of the septa where perfect were entire. The whole structure of this species of Eupsammia is the same as in Balanophyllia, except in the comparatively insignificant detail already mentioned.

EUPSAMMIA CONRADI nom. nov.

Pl. XXI, figs. 10 to 10b.

1843. *Turbinolia pileolus* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. I, p. 327.
1846. *Turbinolia pileolus* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 22, pl. i, fig. 26.
1895. *Eupsammia ? pileolus* Vaughan. Johns Hopkins Univ. Circ., Vol. XV, p. 6.
1896. *Eupsammia ? pileolus* Vaughan. Bull. U. S. Geol. Survey No. 141, p. 90.
non *Turbinolia pileolus* Eichwald. Zool. Spec., Pt. I, 1829, p. 186, pl. iii, fig. 1.

Shape like a very short cylinder set on a hemisphere. The basal portion is very slightly conical, rounded. Very faint costæ. Wall thick vesiculate. Septa thick, in four cycles; those of the fourth cycle fuse to the sides of the third, near the wall. The first three cycles reach the columella. Sides granulate; columella vesiculate. Greater diameter, 13 mm.; lesser diameter, 11.3 mm.; height, 11 mm.

Locality.—Pamunkey River, Kent County, Virginia.

Type specimen.—Philadelphia Academy of Natural Sciences.

We know but little of this species; only one specimen seems to have been found, and that is very unsatisfactory. I have referred it to the genus Eupsammia, because of the strong resemblance of its septal arrangement to that of young forms of other species. There is a faint scar on the base, which may be due to attachment in its early stages. More information concerning this interesting little form will be welcomed.

Genus RHECTOPSAMMIA gen. nov.

The character of the wall, septa, etc., is typical of the family Eupsammidæ.

Corallum simple, firmly attached by a short pedicel; flaring out above the pedicel, with thin wings on the edges of the larger specimens. Wall very thin and very porous, naked, no epitheca. Broad costæ correspond to the septa of the first and second cycles; a single broad costæ usually corresponds to the combined septa of the third and fourth cycles; they are irregular in their development; all are minutely granulated. There are four cycles of septa in the type species. They are very perforate near the wall. The upper margins slightly exsert; the margins of the larger septa subentire, with some faint dentations, or occasional crenations; those of the smaller septa spiniform dentate. The septal faces striate, the striæ rather remote, with comparatively tall, round-pointed granulations distributed along them. The trabecular construction seems to be the same as in Eupsammia and Balanophyllia. Columella very lax and spongy. This genus presents such distinct characters that it can scarcely be compared with any other Eupsammid genus. It would group in Duncan's alliance Balanophyllioida, and probably has most resemblance to Endopachys, but differs in such important characters that a special résumé is not necessary.

RHECTOPSAMMIA CLAIBORNENSIS sp. nov.

Pl. XXI, figs. 11 to 13.

Corallum small, straight, firmly attached by a pedicel to some object; in the specimens before me the attachment is usually to a small gastropod shell. Above the pedicel the corallum flares out rather suddenly. There may be slight marginal wings. Cross section of calice elliptical. The wall is thin and very perforate. There is no epitheca. The costæ are poorly developed; corresponding to the first and second cycles of septa, they are moderately distinct. For the third and fourth cycles they can scarcely be distinguished, or a low broad costa may correspond to the two cycles combined in one half system. They are vesicular.

The septa consist of four complete cycles in six systems. Those of the fourth cycle meet in front of the third. The first and second (and prolongation from junction of the fourth) meet the columella. They are very thin, and their sides are covered with small spines. Columella spongy. The calicular fossa is deep.

	1	2
	Mm.	Mm.
Greater diameter of calice	6	5.7
Lesser diameter of calice	4.5	4.2
Height of corallum	6	6.5
Length of pedicel	2	2
Lesser diameter of pedicel, about	2.5	....
Greater diameter of pedicel, about	3	....

Localities.—Claiborne, Alabama (L. C. Johnson, collector); and Jackson, Alabama (C. W. Johnson, collector).

Geologic occurrence.—Clairbornian stage (horizon of Claiborne sands).

Types.—United States National Museum.

In the material from Claiborne in the National Museum, are several excellent young specimens. The following notes are based on them:

Pl. XXI, fig. 12, represents the youngest. It is attached to a specimen of *Dentalium blandum* de Gregorio. The basal plate is well preserved; it forms a thin coating on the shell, and around its outer edge bends upward. The original number of septa is twelve. Their inner ends do not meet in the center; the latter is an open space with a few papillæ resting on the basal plate. Their outer ends do not reach the upturned peripheral edge of the basal plate.

The next stage is represented by Pl. XXI, fig. 13. This is a view of the basal end of a specimen. The twelve primary septa are shown. In the figure their inner ends seem fused, but in reality a portion of the basal plate still adheres to the septa: by turning the specimen one can see beneath its sharp edge. The septa have been extended peripherally to the upturned edge of the basal plate; the soft parts of the coral have overflowed it, and have built a porous wall outside of it. This specimen is about 2 mm. high; the greater diameter of the calice is about 3.25 mm., and the lesser, 2.5 mm. An examination of the calice shows three complete cycles of septa (reckoning six septa in the first cycle). The members of the third cycle are longer than those of the second, and grow to meet the columella beyond the latter, or may fuse in front of them. One of the second cycle may sometimes fuse to the side of one of the third. The columella in this stage is well developed and possesses a soft, spongy texture.

Genus ENDOPACHYS Lonsdale.

ENDOPACHYS MACLURII (Lea).

Pl. XXI, figs. 14 to 16; Pl. XXII, figs. 1 and 6.

1833. *Turbinolia maclurii* Lea. Contrib. to Geol., p. 193, pl. vi, fig. 206.
1838. *Turbinolia maclurii* Michellotti. Spec. zoophyt. dil., p. 57.
1845. *Endopachys alatum* Lonsdale. Quart. Jour. Geol. Soc. London, Vol. I, p. 214, fig. a.
1848. *Endopachys alatum* Bronn. Index Pal., p. 461.
1848. *Turbinolia maclurii* Bronn. Index Pal., p. 1315.
1848. *Endopachys maclurii* Milne-Edwards and Haime. Annales sci. nat., 3d ser., Vol. X, p. 82, pl. i, figs. 1 and 1a.
1850. *Endopachys maclurii* d'Orbigny. Prodrome de Pal., étage 25, num. 1252.
1851. *Endopachys maclurii* Milne-Edwards and Haime. Polyp. foss des Terr. Pal., p. 134.
1855. *Endopachys expansum* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1855. *Endopachys alticostatum* Conrad Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.
1857. *Endopachys maclurii* Pictet. Traité de Pal., Vol. IV, p. 428, pl. cvi, fig. 10.
1857. *Endopachys maclurii* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 98.
1861. *Endopachys maclurii* de Fromentel. Introd. à l'Étude des Polyp. foss., p. 243.
1866. *Endopachys maclurii* Conrad. Check List, p. 2.
1866. *Endopachys alticostatum* Conrad. Check List, p. 2.
1866. *Endopachys expansum* Conrad. Check List, p. 2.
1886. *Endopachys maclurii* Aldrich. Prelim. Rept. Tert. Foss. Ala. and Miss., pp. 44 and 49.
1889. *Endopachys maclurii* Nicholson and Lydekker. Man. of Pal., Vol. I, p. 308, fig. 190.
1881. *Endopachys maclurii* Quenstedt. Röhren- und Sternkorallen, p. 1042, pl. clxxxiv, fig. 16.
1890. *Endopachys maclurii* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 258, pl. xlv, figs. 23–30.
1890. *Endopachys alticostatum* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 258.
1890. *Endopachys expansum* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 258.
1895. *Endopachys maclurii* Vaughan. Am. Geol., Vol. XV, p. 213.
1896. *Endopachys maclurii* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 49.

Shape cuneate, cross section subelliptical; the margins may be straight and subparallel to each other, with the base at right angles to them, the corners being rounded; or they may slope out from the base, and the base be uniformly rounded. Near the margins the corallum is nearly always compressed so as to form lateral wings. In adult or nearly adult specimens the base and margins, however, do not present a sharp edge, but are obtuse, gradually rounded; in the young, however, they are acute. On the faces are two strong elevated tubercles; between these there may be developed a third, but not so large, and there may be developed two other rather small tubercles, one on the outside of each large tubercle. Surface granulate; there are often striæ running upward from the basal portion. Wall thick, vesiculated, perforated. Septa in five cycles, those of the fifth fusing in front of those of the fourth; faces granulate. Columella very vesiculate, elongated in the longer transverse axis of the calice. The size of the species is indicated in the figures.

Localities.—Alabama, Mississippi, Louisiana, and Texas; 4 miles northeast of Quitman, Clarke County, Mississippi; 8 miles west of Enterprise, Clarke County, Mississippi; Wautubbee Hills, Mississippi; 12 miles northwest of Enterprise, Clarke County, Mississippi; 1 mile south of Hickory, Mississippi; 2 miles southeast of Hickory, Mississippi; Moodys Branch, Jackson, Mississippi; Claiborne, Alabama; Holstun's well, Louisiana; sec. 17, T. 18 N., R. 6 W., Bienville Parish, Louisiana; Pittman's mill, SW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of sec. 19, T. 19 N., R. 7 W., Claiborne Parish, Louisiana; St. Maurice, Louisiana; Montgomery, Louisiana (several specimens of var. *triangulare* Con.; one specimen has a small amount of pellicular epitheca on the base); Mount Lebanon, Louisiana; 1 mile below Shipps Ford, Bastrop County, Texas; Elm Creek, Lee County, Texas; Alabama Bluff, Trinity River, Houston County, Texas.

There is in the collection of the Academy of Natural Sciences of Philadelphia a specimen of Endopachys from New Jersey (Shark River beds). This is probably *E. maclurii*, but the specimen is too poor for positive identification.

Geologic occurrence.—From the Lower Claiborne to the Jacksonian stage, inclusive.

This is a protean species, and it is very difficult to characterize it so as to include all of the variations to which it is susceptible.

There is in my collection from Mount Lebanon, Louisiana (Pl. XXII, fig. 1), a specimen that differs from the usual forms of *E. maclurii*. Its margins are much compressed, form subtriangular, wall rather solid, but perforate, distinct costæ present. This is apparently only a varietal form of *E. maclurii*.

ENDOPACHYS MACLURII var. TENUE var. nov.

Pl. XXII, figs. 2 to 5.

This variety is characterized by being much compressed, with a great development of the marginal wings and a small development of the lateral tubercles. The base may be straight, curved, or subtriangular. The calicinal cavity is small compared to the size of the corallum, and there are not five complete cycles, but four complete cycles with members of the fifth present in the systems next the ends of the longer transverse axis.

I do not see how this can be regarded as more than a variety, but it usually has a quite distinct facies and is characteristic of one horizon.

Locality of types.—Elm Creek, Lee County, Texas; found in Louisiana and Texas.

Horizon.—Lower Claiborne.

Types.—Wagner Free Institute of Science, Philadelphia.

ENDOPACHYS MACLURII var. TRIANGULARE Conrad.

Pl. XXII, figs. 7 and 8, drawn from a specimen labeled by Conrad; and probably also fig. 9.

1855. *Endopachys triangulare* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 26.
1866. *Endopachys triangulare* Conrad. Check List, p. 2.
1890. *Endopachys triangulare* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 258.
1896. *Endopachys maclurii* var. *triangulare* Vaughan. Bull. U. S. Geol. Survey No. 142, p. 57.

This variety can be best characterized by a comparison with *E. maclurii.* The outline of the corallum when seen from the side is that of an isosceles triangle, with the apex truncated; the two tubercles on its face are not so prominent as is usually the case in *E. maclurii*, and it has more distinct costæ than the latter species. The septal arrangement is identical with that of *E. maclurii.* Greater diameter of the corallum, 26.5 mm.; greater diameter of the fossa, 19 mm.; lesser diameter of the fossa, 14 mm.; height of corallum, 16.5 mm.

Localities.—Vicksburg and Jackson, Mississippi; Montgomery, Louisiana.

Geologic occurrence.—Jacksonian and Vicksburgian stages.

Type.—Collection of the Academy of Natural Sciences, Philadelphia.

The large specimen represented by Pl. XXII, fig. 9, comes from Jackson, Mississippi, and is from the collection of Mr. T. H. Aldrich.

It seems to be cnly a large overgrown specimen of *Endopachys maclurii* var. *triangulare.*

The following are a few notes on the finer structure of *E. maclurii:*

The structure of the wall is in all particulars identical with that of *Eupsammia elaborata.* The margins of the larger septa are entire; those of higher (younger) cycles are dentate in their lower portions. The upper portions of the margins of these septa are entire or obscurely dentate. The septal faces are minutely striate, with granulations along the courses of the striæ. The septal trabeculæ are fine; have a line of divergence at the inner edge of the spongy perforate zone. Interior to the line of divergence the trabeculæ pass upward and inward and are usually directly continuous across all growth segments until they reach the septal margin. On the outside of the line of divergence the trabeculæ seem first to pass upward and outward for a short distance, and then to bend into a horizontal position. Each septal perforation is due to the discontinuity of one or two trabeculæ. In the outer perforate and spongy zone synapticulæ are very abundant. Pl. XXI, fig. 16, shows an enlarged view of the surface of a septum, the outer coating peeled off. The septal structure, etc.. of Endopachys is identical with that of Rhectopsammia.

Endopachys lonsdalei sp. nov.

Pl. XXII, figs. 10 and 10a.

Shape subcuneiform, ventricose, base gently rounded, margins not much compressed, subparallel to each other. Looked at with the edge toward one, the corallum slopes gradually from the calicular margin to the base. The lateral tubercles are not prominent. There are in the upper portion of the corallum distinct, fine, granular costæ corresponding to all the cycles of septa; those of the first and second cycles slightly larger. On the basal portion of the corallum these costæ disappear, and the surface is covered with granules. The wall is thick and vesiculate. The septal arrangement is the same as in *E. maclurii.* Columella vesiculate. Greater diameter of calice, 15.5 mm.; lesser diameter of calice, 12.5 mm.; height of corallum, 13.5 mm.

Localities.—Monroe County and Coffeeville, Alabama; Newton, Mississippi; 4½ miles east of Newton, Mississippi; Wautubbee Hills, Mississippi (apparently young of this species).

Geologic occurrence.—Lower Claiborne.

Type.—From collection of T. H. Aldrich in the United States National Museum.

ENDOPACHYS SHALERI sp. nov.

Pl. XXII, figs. 11 to 14.

Shape subcuneate, somewhat compressed, transverse section elliptical; base subconical, usually rounded, occasionally subacute. The surface is granulate, no costæ. The marginal wings are very rounded; lateral tubercles not very much elevated, elongated. Wall rather thin, very vesiculate. Septa in five cycles. Those of the fifth cycle fuse to the sides of the fourth rather near the corallum wall, the fourth fuse to the third about half way between the wall and columella. About 20 septa reach the columella. Sides granulate. Columella vesiculate. Greater transverse diameter of calice, about 12 mm.; lesser transverse diameter of calice, 6.5 mm.; height of corallum, 6 mm.

Locality.—Alabama?

Geologic occurrence.—Eocene?

Types.—In the Boston Society of Natural History.

I found this little undescribed species of Endopachys labeled "Eocene, Alabama?" in the collection of the Boston Society of Natural History. I have seen no other specimens of the species and can not identify its geologic horizon by the character of its matrix. I insert the description as that of a doubtfully Eocene form.

ENDOPACHYS MINUTUM sp. nov.

Pl. XXII, figs. 15 to 18.

This is a curious little species, and according to strict definition does not belong to the genus to which it is here referred, but it has a compressed shape like Endopachys. It shows no signs of attachment, and the tertiary septa of the fourth cycle fuse in front of those of the third cycle.

The shape is difficult to describe; the figures show it very well. The corallum is contracted at the calice. There are sometimes indistinct costæ, but the whole external surface is granulate. No tubercles on the faces of the corallum. Wall thin, perforate, but not very porous. The septa are arranged in four cycles; those of the fourth cycle unite in front of the third;

sides granulate. Columella vesiculate. Greater diameter of calice, 4 mm.; lesser diameter of calice, 3 mm.; height of corallum, 4 mm.

Localities.—Jackson, Mississippi; near Rosefield, Louisiana.

Geologic occurrence.—Moodys Branch beds, Jacksonian stage.

Types.—Collection of Wagner Free Institute of Science, Philadelphia.

Specimens.—In the collection of T. H. Aldrich.

This species presents a noteworthy difference from the other known representatives of Endopachys, by having no lateral tubercles, but as these are very variable in the amount of their development in *E. maclurii*, their absence does not seem of generic value. A thin cross section of *E. minutum* shows no structural difference from *E. maclurii.*

Genus DENDROPHYLLIA de Blainville.

Dendrophyllia striata sp. nov.

Pl. XXII, figs. 19 to 19b.

Branched or fascicular (the specimen is not sufficient for one to decide), compound, reproduction by lateral budding. In the specimen that I have there is one large corallite, with a circular cross section, and the other corallites, five in number, are grouped irregularly near the base. There are distinct costæ whose general direction is longitudinal; they are coarse near the basal portion of the colony, but higher they divide into finer costæ. The intercostal furrows are perforate. Wall rather dense, but contains small vesicles, and is perforate. Septa thin, weak, in four cycles The fourth cycle fuse at about half the distance from the wall to columella to the sides of the third. Sides granulate. Columella well developed, but very spongy. Greater diameter of largest corallite, 7.5 mm.; lesser diameter of largest corallite, 6.5 mm.; height of specimen, 17.5 mm.

Localities.—Near Mount Lebanon, Louisiana; Rayburn's well, sec. 29, T. 17 N., R. 5 W., Louisiana.

Geologic occurrence.—Lower Claiborne.

Type.—United States National Museum.

Dendrophyllia lisbonensis sp. nov.

Pl. XXII, figs. 20 to 20c.

This species belongs to the second group distinguished by Duncan, viz, those Dendrophylliæ with the calices forming vertical series. Calices arranged in rather regular vertical rows, and have a tendency to regular spirals. They are elevated about 1.75 to 2 mm.; circular or slightly elliptical in outline, their diameter varies from 2.7 to 3.2 mm.; axis of colony circular in section; diameter of axis 7.5 mm. The calices are rather distant, but occasionally two corallites may almost touch at their bases. The distance between the bases of corallites is usually slightly more than 1 mm.; the whole surface of the colony covered with very minutely granulated vermicular costæ. The costæ correspond to all cycles of septa. The intercostal furrows very punctate; the wall of the axial polyp thick, dense, but perforate; the septa in four cycles with the typical arrangement for Dendrophyllia. They are weak, and have granular surfaces. Columella spongy.

Localities.—Lisbon, Alabama; T. A. Rumley's, Monroe County, Alabama; Rayburn's well, sec. 29, T. 17 N., R. 5 W., Louisiana.

Geologic occurrence.—Lisbon beds.

Type.—From collection of T. H. Aldrich in the United States Natural Museum.

Since the above description was written I have received the collection made for the Wagner Free Institute of Science by Mr. C. W. Johnson, and have found in the United States National Museum another specimen from Claiborne, Alabama, Lisbon horizon.

The specimen from Claiborne does not present any great difference from the figured specimen (Pl. XXII, fig. 20). It is a portion of a branch 27.5 mm. long and 7 mm. in diameter. The calices are somewhat more distant than in the figured specimen, and do not rise perpendicularly from the intercorallite surface, but are somewhat inclined toward the distal end of the branch.

Specimens from San Augustine, Texas, collected by Johnson, at first sight look quite different from those above described, but the difference consists solely in the greater size of the calices. The largest calice on the larger specimen has a greater diameter of 5 mm. and a lesser of 4 mm. This specimen has a length of 37 mm.; diameter of larger end, 12.5 mm., of smaller end, 11 mm. It is somewhat elliptical in cross section. The largest calice in the other specimen has a greater diameter of 4.5 mm. and a lesser of 4 mm; while the smallest calice has a greater diameter of slightly less than 3 mm. This specimen is a piece of a branch 22 mm. long and 9 mm. in diameter. At the lower end is a small side branch about 6 mm. in diameter at its base.

The smallest calice, whose measurements have just been given, is situated on the side branch. It seems to me that the other specimens that I have seen are pieces of young branches or come from near the tips of branches; and therefore the specimens and their calices are small.

The character of the costæ, number and arrangement of septa, and character of the columella are the same in all specimens. It should be borne in mind that in the larger specimens the costæ are necessarily coarser. All the specimens of the species come from beds of Lower Claiborne age.

Family MADREPORIDÆ Milne-Edwards and Haime.

Genus DENDRACIS M.-Edw. and H.

DENDRACIS TUBULATA (Lonsdale).

Pl. XXII, figs. 23 and 24 (reproduced from Lonsdale).

1845. *Madrepora tubulata* (?) Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 520, figs. a, b.

1860. *Dendracis tubulata* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 170.

The following is Lonsdale's original description:

Branched; branches irregularly divergent, cylindrical, slender, composed chiefly of long, lamelliferous tubes, springing from the center and diverging slightly; intermediate structure foraminated; no continuous central tube; lamellæ twelve, six very narrow, and limited in vertical range; surface terminations of tubes small; irregularly distant; interspaces echinated.

The remains of *Madrepora tubulata* (?) consisted wholly of casts of the exterior and of the lamellæ tubes. The diameter of the branches in no case exceeded three lines, or that of the unmagnified figure (a). The tubes sprang successively from the axis and wholly composed it, the perfect exclusion of a central, continuous tube or star. As they gradually diverge, they separated, slightly increasing in diameter; and near the surface termination they suddenly bent outward, their relatively great length (3 lines) and small width producing the scattered distribution of the terminal stars. In Guettard's figures the branches have a greater diameter and the casts of the stars are closer. The lamellæ through a considerable portion of the tubes were apparently confined to the six broader, the casts of the six narrow commencing about one third from the upper extremity; both series had evidently consisted of solid plates, and not of interrupted ones, as in *Porites*. So far as could be ascertained, there was no distinct, central structure. The nature of the interspaces between the tubes was very imperfectly exhibited, the remains being limited to a few filiform processes, extending from the casts of the tubes to the exterior, but the original structure constituted a considerable portion of the branches near the surface, and the lamellæ tubes were completely embedded in it from the points of separation. The surface casts of the branches were closely and finely punctured, the indentations being surrounded frequently by a circle, and near the terminations of the tubes were, in some cases, casts of short ribs. The production of additional lamellæ tubes was apparently confined to the center.

Locality.—Jacksonboro, Georgia.

The figured specimen of Lonsdale is in the collection of the Geological Society of London. It lies in a matrix of white, chalky, argillaceous limestone, which contains also specimens of *Porites* (*Ocellaria*) *ramosa* and *Cladocora recrescens.* I have never found any specimens of the species, and am unable to add to our knowledge of it.

The specific name of this corals is invalid, but as the species is doubtful I have not proposed a new one for it.

Genus TURBINARIA Oken.

TURBINARIA (?) ALABAMENSIS sp. nov.

Pl. XXIII, figs. 1 to 3; Pl. XXIV.

Corallum massive, the masses may be more than 20 cm. across, and 7 cm. thick, upper surface apparently convex or concave. General appearance of the corallum is as if composed of superimposed laminæ. Calices shallow (?), crowded; diameter, 1.5 mm.; distance apart, quite constantly 1 mm. Cœnenchyma, of superimposed irregularly perforate laminæ. Wall, perforate. Septa, perforate, in three complete cycles; 12 septa reach the columella; the members of the third cycles usually fuse by pairs to the sides of an included septum (the first and second cycles can not be distinguished from each other, and therefore it can not be known whether the septa of the third fuse to the sides of the first or second). Sides granulate. Pali are probably present, but no detail could be made out. Columella very well developed, spongy.

Locality.—Salt Mountain, 6 miles south of Jackson, Alabama.

Geologic horizon.—"Coral limestone," above Vicksburg beds.

Types.—United States National Museum.

I have not been able to decide positively whether this is an Actinacis or a Turbinaria. It probably belongs to the latter genus.

Family PORITIDÆ Milne-Edwards and Haime.

Genus PORITES Link.

Porites ramosa (Lonsdale).

Pl. XXIII, figs. 4 to 6 (fig. 4 reproduced from Londale's figure).

1845. *Ocellaria ramosa* Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 510, figured. (Non *Porites ramosa* Catullo, 1856.)

1860. *Ocellaria ramosa* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 123.

Branched or lobed, fibers coarse, cylindrical or compressed, intimately reticulated; interfibral lacunæ equal in dimension to the fibers; canals numerous, vertical in center of specimen, horizontal toward the exterior, no definite arrangement; form more or less circular, no distinct wall; lower extremity blended with the fibrous structure, interior sometimes penetrated by converging simple fibers; exterior of specimen partially invested by a thin rugose layer.[1]

Lonsdale considered this coral related to the Cretaceous sponge Ventriculites, and wrote considerable about the similarity of the two fossils; his observations on this I think will not aid much in identifying the species, so I omit them.

Localities.—Jacksonboro, Georgia; Eutaw, South Carolina.

I found some specimens of this species in the collection of the Geological Society of London, but not the ones figured by Lonsdale. These specimens came from Jacksonboro, Georgia, and are lithologically the same as the one in the United States National Museum. I could not add any special detail from the London specimens. Very little can be added from the one in the United States National Museum. Two drawings from this specimen are shown in Pl. XXIII, figs. 5, 6. The whole skeletal structure, both cœnenchyma and septa, are very perforate. The corallites are 2 mm. in diameter, and are from 2 to 3 mm. apart. There seems to be 10 or 12 septa. This is about all that can be said concerning the characters of the species.

The matrix is a whitish, rather hard, chalky, argillaceous limestone, and contains, besides the *Porites ramosa*, specimens of *Cladocora recrescens*.

DOUBTFUL SPECIES.

We either have no clue to the proper systematic position of the following species, or, as in two instances, no descriptions of the species could be found, or they can not be identified for other reasons.

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[1] Lonsdale, loc. cit.

FLABELLUM STRIATUM Gabb and Horn.

1860. *Flabellum striatum* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, p. 399, pl. lxix, figs. 10, 11, 11a.

"Thick, wedge-shaped; angle of case acute; laminæ thin, edge finely crenate, slightly undulate; sides coarsely granulous; granules regularly arranged in striæ, toward the edge of the laminæ fine."

Locality.—Rotten limestone of Prairie Bluff, Alabama.

The figures given by Gabb are worthless and the description is entirely insufficient for specific identification. The types sent me from the Philadelphia Academy of Natural Sciences are only internal casts, and are not sufficient for specific characterization, so the species lapses.

PARACYATHUS (?) SERRULUS Conrad.

1866. *Paracyathus* (?) *serrulus* Conrad. Check List, p. 2.
1890. *Paracyathus* (?) *serrulus* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 256.

This species is referred to by Conrad in his Check List of the Invertebrate Fossils of the Eocene and Oligocene of North America, but I have been unable to find either any description or the original types. I searched in both Philadelphia and Washington for the latter. M. de Gregorio could not find any description of the species. Conrad referred the species to the Lower or Middle Eocene.

PLATYTROCHUS SPECIOSUS Gabb and Horn.

1860. *Platytrochus speciosus* Gabb and Horn. Jour. Acad. Nat. Sci. Phila., 2d ser., Vol. IV, p. 399, pl. lxix, figs. 15, 16, 17.

"Conical, laminæ exsert, denticulate and granulous; exterior coarsely striate from the continuations of the exsert lamellæ; striæ alternating in size, coarsely granulous, often denticulate on the edge; depth of cup exceeding half the length of the mass."

Dimensions.—Length, 0.5 inch; breadth of top, 0.57 inch.

Locality.—Hardeman County, Tennessee. (Professor Safford.) Gabb published this as a Cretaceous species, but G. D. Harris has shown that all of the fossils that Gabb received from Hardeman County, Tennessee, are Midwayan Eocene.[1]

[1] Bull. Amer. Paleontology, Vol. 1, No. 4, 1896, p. 8.

TURBINOLIA INAURIS Morton.

1834. *Turbinolia inauris* Morton. Synop. Org. Rem. Cret. Group, p. 81, pl. xv, fig. 11.

For discussion of this species see page 171.

TROCHOCYATHUS sp. de Gregorio.

1890. *Trochocyathus* sp. de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 256, pl. xliv, figs. 10–11.

"Tr. conoideus, curtis, dilatatus, septis erosis, lateribus, extus bifidis. C'est une espèce très douteuse, car je n'en possède qu'un exemplaire très usé."[1]

CARYOPHYLLIA SUBDICHOTOMA Lonsdale.

Pl. XXII, fig. 22 (reproduction from Lonsdale).

1845. *Caryophyllia subdichotoma* Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 519, fig.

1860. *Caryophyllia subdichotoma* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 123.

The following is Lonsdale's description:

Main stem cylindrical; branches numerous, short, slender, very divergent; outer wall thin, porous, surface finely ribbed and furrowed; lamellæ numerous, unequal, very irregular near the periphery; center union of lamellæ; branches produced by subdivision of preexisting structures.

The single specimen, a cast, was about an inch in height and 4 lines in diameter, and consisted of a cylindrical stem (partially removed in the figure) with portions of three branches. The main stem had been composed of numerous lamellæ partly united in the center without any distinct structure, and greatly subdivided or reticulated near the circumference. The original wall was apparently very thin except at the divergence of the branches, and its general porous structure was proved by transverse filiform processes, or their fractured extremities on the ridges representing external furrows. The cast of the outer surface exhibited also other signs of minute foramina and reticulations. The branches were essentially composed at their commencement of certain of the lamellæ of the parent stem, including in the principal example given in the figure some of those which composed the central portion of the latter. The branches, however, differed from those of true Caryophylliæ in being of limited dimensions, not effecting a bifurcation; also in diverging laterally and suddenly, and in permitting the main stem to be continued perpendicularly upward. In this respect there was an agreement with the Dendrophyllia of De Blainville; but in that genus the branches are not composed of previously existing lamellæ, being developed from germs. The amount of extension outward of the branches was not shown.

Locality.—Shell Bluff, Georgia.

This is all that we know concerning this species. It belongs to the Madreporaria perforata, and we can not be sure of anything more, though the coral is probably one of the Eupsammidæ.

STYLOPHORA (?) PERDUBIA de Gregorio.

Pl. XIV, figs. 2 and 2a.

1890. *Stylophora* (?) *perdubia* de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 257, pl. xliv, figs. 7–8.

Original description: "St. dendroidea, minuta; polypieritibus confertis, minutis, approximatis; calicibus rotundatis subpentagonalis."

Translation: "St. dendroid, minute; polypites crowded together, minute, near each other; calices round subpentagonal."

M. de Gregorio adds: "It is a very doubtful coral, on account of its having been worn. It appears to me that it has affinity with *St. conferta* Reuss of Castel Gomberto. The rock is the same as that of Cycloseris."

ASTROCŒNIA sp. de Gregorio.

Pl. XVII, fig. 8.

1890. *Astrocœnia* sp. de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 257, pl. xliv, fig. 9.

"Dubium exemplar satis erosum, conchæ adnatum."

"Doubtful specimen much eroded, attached to a shell." (De Gregorio.)

CYCLOSERIS sp. de Gregorio.

1890. *Cycloseris* sp. de Gregorio. Mon. de la Faune éocénique de l'Ala., p. 257, pl. xliv, figs. 20–22.

"Cycl. discoidea, nummulitiformis, elegantes radiata tuberculataque."

" * * * La couleur grisâtre montre qu'il ne provient pas de la même assise que la *Turbinolia faretra* Lea."

OSTEODES CYANTHUS Conrad.

1855. *Osteodes cyanthus* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 263.

Conrad cites near City Point, Virginia, as its locality. After a diligent search I have been unable to find any description of the species.

MADREPORA PUNCTULATA Conrad.

1847. *Madrepora punctulata* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. III, p. 298.

The original description is: "Cylindrical ramose, with prominent cells; whole surface ornamented with fine, equal, punctate, impressed lines. Diameter, one-third. Locality, St. Matthews Parish, Orangeburg, South Carolina. Vanuxem. A species highly ornamented by the punctate vermicular lines. It occurs much larger than the specimen described."

This is all that I have been able to find concerning this species.

DENDROPHYLLIA LÆVIS Lonsdale.

Pl. XXII, fig. 21.

1845. *Dendrophyllia lævis* Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 516, figured.

1860. *Dendrophyllia lævis* Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 123.

Branches with a persistent, central, lamelliform structure, and many lateral shoots scarcely projecting beyond the thickened surface of the stem; lamellæ numerous, unequal, about ten principal plates in the side shoots; cast of the outer surface generally smooth, sometimes finely ribbed in young branches or near the extremity of the shoots.

In the specimens of the coral which were examined, the whole of the original substance had been removed, and even casts of the central structure were partially wanting. The most illustrative portion is represented in the woodcut. Of the nature of the thickened matter in which the lateral shoots were originally embedded, no opinion could be formed, except that it was probably very solid or similar to that of Oculinæ, there being no vestiges of casts of capillary tubes or of a reticulated structure, though abundant proofs of the matter having been penetrated by burrowing animals. The signs of lamellæ in transverse sections of the central part were very faint, but sufficient to show that the broadest were twelve in number, and that the intermediate ones varied from one to four. The surface of this inner cast was slightly traversed by lines indicating the vertical range of the broadest lamellæ, and by traces of irregularly disposed striæ. Between the cast and the base of the side shoots was an extremely narrow space, proving that there was no structural interblending of lamellæ and main stem. The shoots at the inferior termination were obliquely conical, but they soon attained their full dimensions, so far as could be inferred from the specimens, the greatest diameter being about one tenth of an inch or two-thirds that of the central cast—a disproportion observable in recent Dendrophylliæ. Their range was limited also to less than a line. The general outer surface was apparently smooth, but uneven as in some Oculinæ; and the cast of it bore traces of parasitic Bryozoa, additional indication to that of the numerous burrowing animals that the polypes had perished some time previously to the specimen being inclosed in its matrix.

Localities, Wilmington, Shell Bluff.[1]

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[1] Lonsdale, loc. cit.

This species is known to me only through the above description and Lonsdale's accompanying figure, which is here reproduced. The figured specimen is in the collection of the Geological Society of London; in same matrix as the *Flabellum cuneiforme.* The species is based on undeterminable material, so the species must lapse.

DENDROPHYLLIA (?) sp. Lonsdale.

1854. *Dendrophyllia* (?) sp. Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 517.
1860. *Dendrophyllia* (?) Milne-Edwards and Haime. Hist. Nat. des Corall., Vol. III, p. 123.

Several worn casts, possibly fragments of a Dendrophyllia, claimed a notice, though their generic determination could not be ascertained. They were slightly conical or cylindrical, the lower termination not unfrequently preserved, presenting the same character as that of the lateral shoots of *Dendrophyllia lævis.* The specimens had nearly uniform diameter of half an inch at the upper extremity; and the greatest length was about an inch. The characters of the lamellæ, so far as they could be ascertained, agreed with those of Dendrophyllia, and in the reticulated structure of the very partially preserved exterior, as well as in the mode of union with the lamellæ, there are still further agreements. In these particulars a resemblance also with the Alabama coral *Endopachys alatum* existed, but in no instance was a trace of a pedicel detected, nor any indication of a surface which had once been attached.

Localities, Mulberry, Cooper River; Eutaw.[1]

Genus DENDROPHYLLIA.

Subgenus PETROPHYLLIA[2] Conrad.

1855. *Petrophyllia* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 266.

"Corallum not cellular, but in layers like the coats of an onion; branches anastomosing; central axial star having distant septa between the lamellæ."

DENDROPHYLLIA ? (PETROPHYLLIA) ARKANSASENSIS Conrad.

1855. *D. ? (Petrophyllia) arkansasensis* Conrad. Proc. Acad. Nat. Sci. Phila., Vol. VII, p. 266.

"Corallum minutely granulated, suboval, sides faintly marked with vermicular lines; calices round, not very prominent, unequally distributed, proximate or remote; lamellæ minutely serrate."

Locality.—White River, Arkansas (Professor Thomas).[3]

[1] Lonsdale, loc. cit.

[2] Felix, in the Zeitschr. Deutsch. geol. Gesell., Vol. XXXVII, 1885, pp. 397–400, proposes the generic name "Petrophyllia" for *Montlivaultia grumi* Catullo sp. of Reuss and d'Achiardi, from Monte Grumi, Montecchio Maggiore, etc., Italy. As the name Petrophyllia had been previously used by Conrad for a different genus of corals, "Petrophyllia" Felix must be replaced by another name.

[3] Conrad, loc. cit.

Conrad published no figure of this species, and I was unable to find the type either in Philadelphia or Washington. I have seen no specimen that could be referred to the species.

PORITES sp. Lonsdale.

1845. *Porites* Lonsdale. Quart. Jour. Geol. Soc. Lond., Vol. I, p. 522.

Only the casts of a few terminal stars of this coral were examined; and they did not permit a comparison with published tertiary species or the establishment of definite characters. The casts showed that the stars were slightly concave and in close contact with a perfect structural blending at the lines of junction, and that the number of interrupted lamellæ in the best defined cases did not exceed twelve.

Locality, Jacksonboro, Georgia.

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PLATES.

PLATE I.

PLATE I.

Structure of the Coral Skeleton.

Fig. 1. Diagrammatic representation of Mussa corallum and soft parts, to show the relations between hard and soft parts (after Ogilvie). The heavy black line represents the boundaries of the flesh ; o., oral body-wall ; a., aboral body-wall ; e., edge zone (Randplatte) ; s., septum ; c., costa; ps. th., pseudotheca ; i. s. l., interseptal loculus ; i. c. l., intercostal loculus ; ep., epitheca ; d., dissepiments, (fig. about natural size).

Fig. 2. Septum of *Manicina areolata* (L.). Section parallel to flat surface, × 5. l. d., line of divergence of the trabeculæ ; tr., trabeculæ ; l. f., line of fusion of trabeculæ ; ep., epitheca.

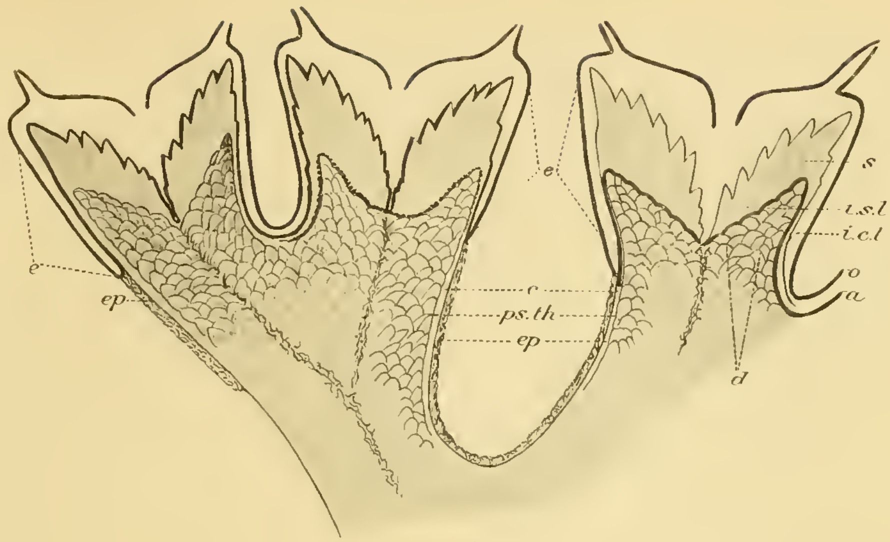
Fig. 3. Cross section of septa and wall of *Manicina areolata* (Linnæus), × 17. tr., trabeculæ; ps. th., pseudotheca ; d., dissepiment.

Fig. 4. Section parallel to flat surface of septum of *Antillia ponderosa* (Duncan), × 5. tr., trabeculæ.

Fig. 5. Section parallel to flat surface of septum of *Eusmilia knorri* Milne-Edwards and Haime, × 18.

Fig. 5a. Section parallel to flat surface of septum of *Eusmilia knorri* Milne-Edwards and Haime. Three trabeculæ magnified about 175 times.

Fig. I, copy by Miss Frances Wieser; other drawings by Dr. J. C. McConnell.



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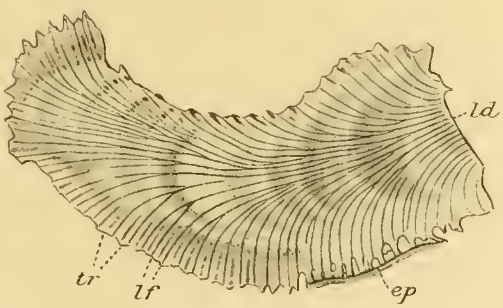

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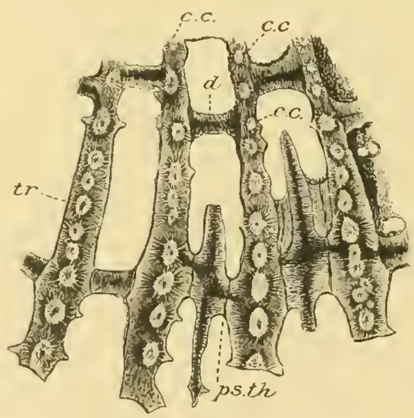

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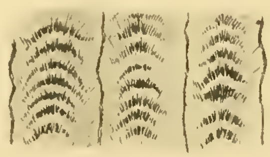

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5

STRUCTURE OF THE CORAL SKELETON

PLATE II.

PLATE II.

STRUCTURE OF THE CORAL SKELETON; GRAPHULARIA PERPLEXA.

FIG. 1. Cross section of two septa of Siderastrea sp. (after Ogilvie); syn., true synapticula; ps. syn., pseudosynapticula; co., synapticular coalescence of septa.

FIG. 2. Cross section of septa and wall of *Eusmilia knorri* Milne-Edwards and Haime, × 18, to show pseudotheca.

FIG. 3. Cross section of septa and wall of *Caryophyllia cornuformis*, to show psuedotheca, × 19.

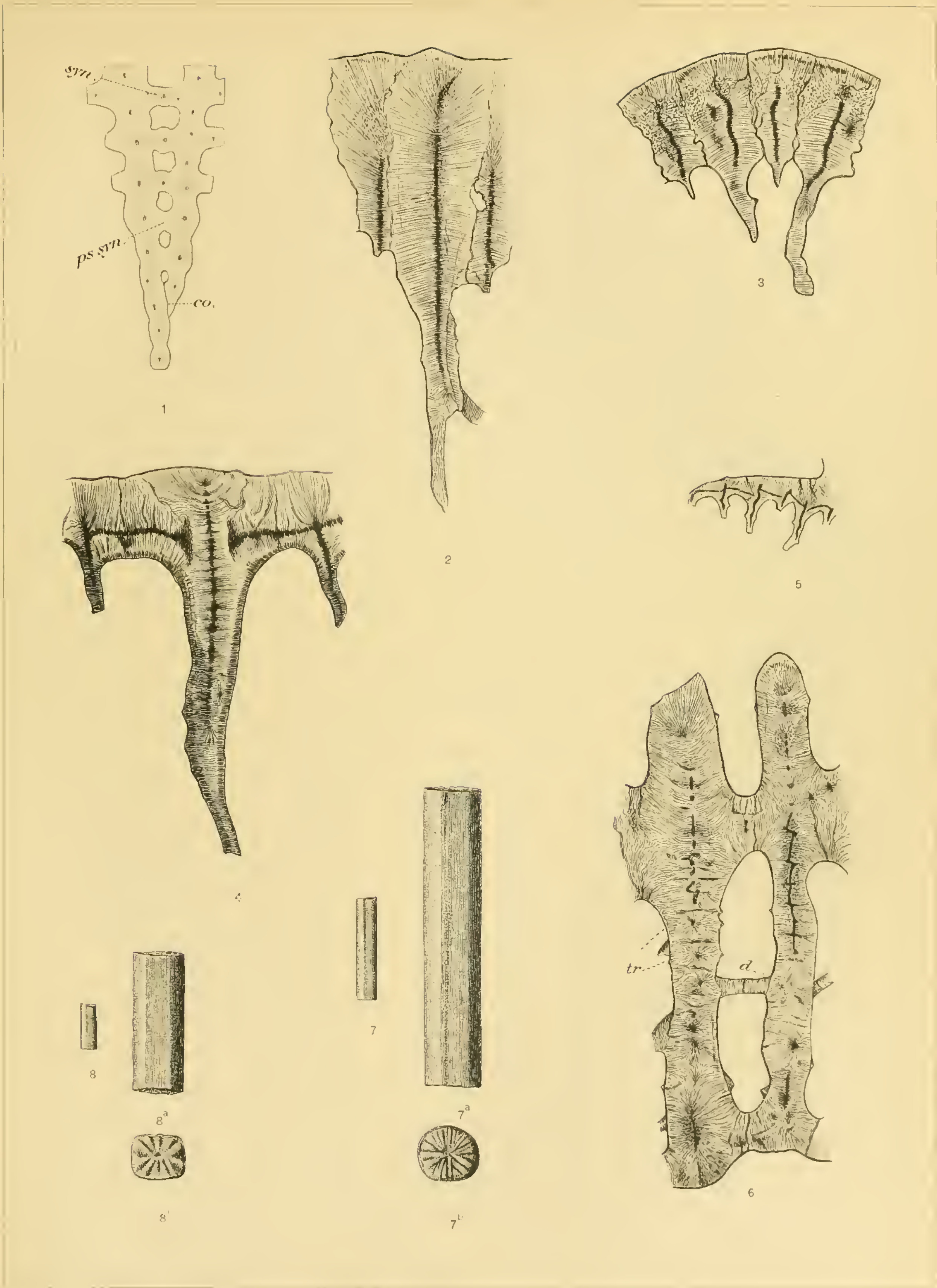
FIG. 4. Cross section of septa and wall of *Caryophyllia communis*, to show eutheca, × about 24.

FIG. 5. Cross section of septa and wall of *Oculina diffusa* Lamarck, to show eutheca, × 17.

FIG. 6. Cross section of two septa of *Thysanus excentricus* Duncan, × 18. Dissepiment shows line of fusion between the two parts.

FIGS. 7, 7a, 7b, 8, 8a, 8b, *Graphularia perplexa* (de Gregorio) (after de Gregorio). The smaller figures, 7 and 8, natural size. (See p. 56.)

Fig. 1, copy by Miss Frances Wieser; other drawings by Dr. J. C. McConnell.



STRUCTURE OF THE CORAL SKELETON
AND
GRAPHULARIA PERPLEXA

PLATE III.

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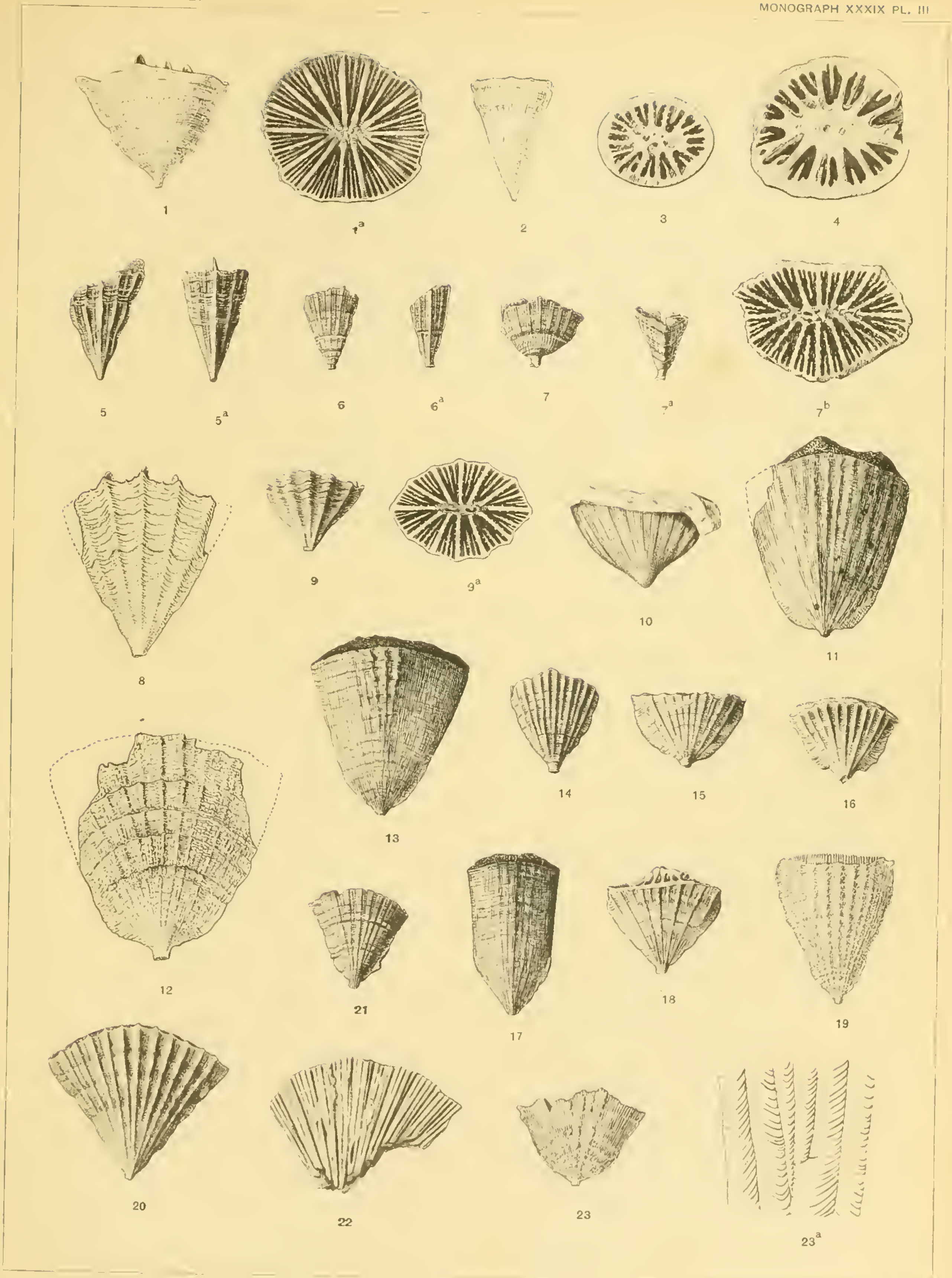
PLATE III.

Flabellum.

Figs. 1, 2, 8, 12, 19, 23, and 23a drawn by J. Henry Blake; figs. 11, 13, and 17 by Hunter Harris; others by Dr. J. C. McConnell.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FLABELLUM

PLATE IV.

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PLATE IV.

FLABELLUM, ALDRICHIA, PLATYTROCHUS.

Page.

FIGS. 1 to 3a. *Flabellum cuneiforme* var. *wailesi* Conrad 64

Figs. 1 and 2 normal, but large, specimens; figs. 3 and 3a, a small conical form, referable to this variety. All figures natural size.

FIGS. 4 and 4a. *Flabellum cuneiforme* var. *magnocostatum* var. nov 65

Two views of the same specimen, both natural size.

FIGS. 5 and 6. *Flabellum remondianum* Gabb 67

Fig. 5, view of flatter side of specimen; cross section of another specimen.

FIGS. 7 to 10. *Flabellum mortoni* sp. nov 66

Figs. 7, 8, and 9, views of three specimens, all natural size; fig. 8a, surface of specimen enlarged to show alternation of costæ and septa; fig. 10, cross section of a corallum, magnified slightly more than four times, to show septal arrangement.

FIGS. 11 to 12. *Flabellum californicum* sp. nov 69

All figures natural size.

FIGS. 13 to 14. *Flabellum rhomboideum* sp. nov 69

Fig. 13, upright view, $\times 1\frac{1}{2}$; fig. 13a, small portion of surface enlarged; fig. 13b, another view of the same specimen, $\times 1\frac{1}{2}$; fig. 13c, calicular view, $\times$ about 2; fig. 14, longitudinal section of a corallum, $\times 2$.

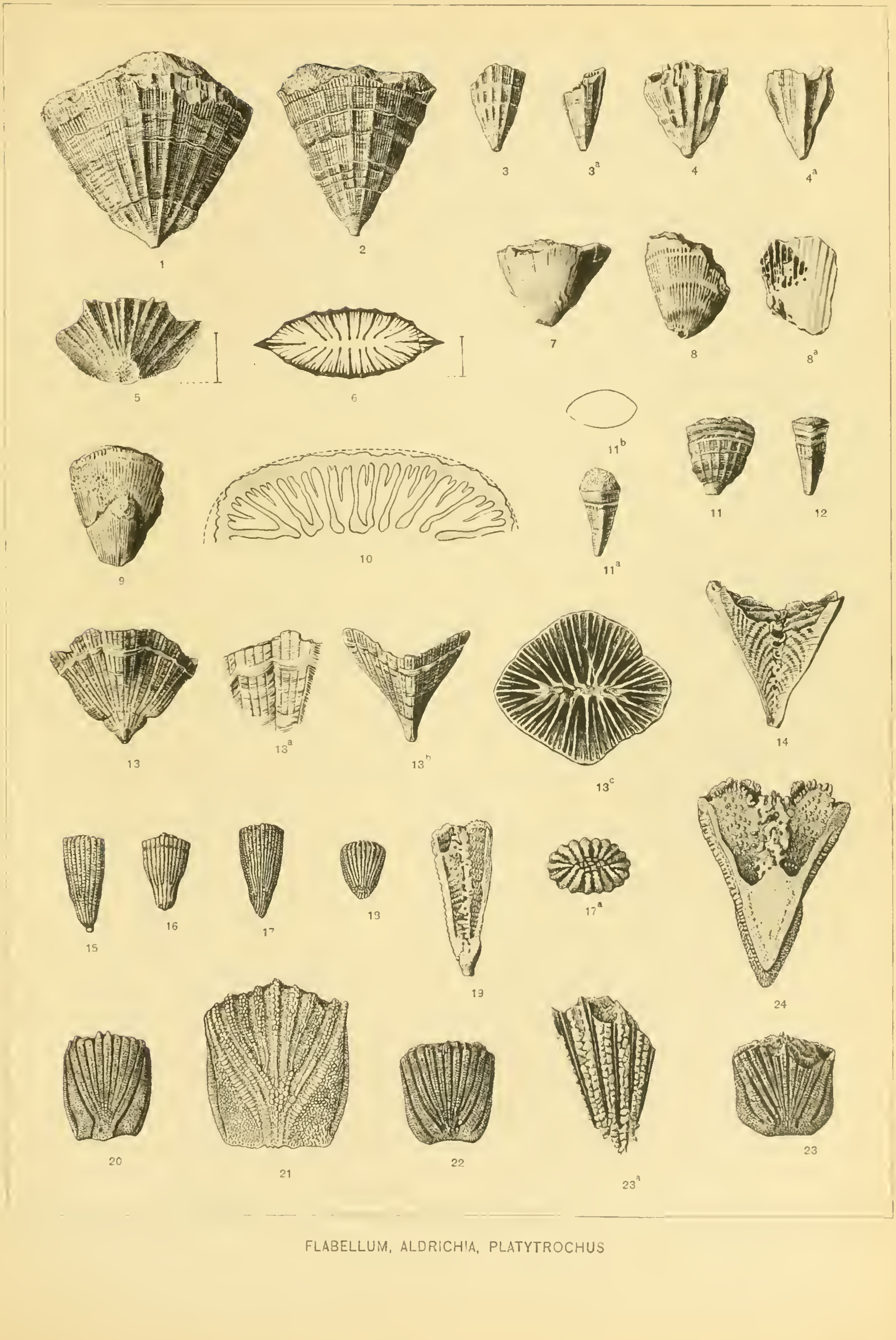
FIGS. 15 to 19. *Aldrichia elegans* gen. et. sp. nov 70

Figs. 15 and 18, upright views of two specimens, flatter side toward the observer, $\times 3$; figs. 16 and 17, upright views of two specimens, enlarged slightly more than four times; fig. 19, longitudinal section of a corallum, enlarged about ten times; fig. 17a, calicular view of specimen represented by fig. 17, $\times 8$.

FIGS. 20 to 24. *Platytrochus stokesi* (Lea) 74

Figs. 20 to 23, upright views of specimens, as seen looking at sides; figs. 20 and 22, $\times 3$; fig. 21, $\times 4\frac{1}{2}$; fig. 23, $\times 3\frac{1}{3}$; fig. 23a, costæ of specimen represented by fig. 23, $\times 8$; fig. 24, longitudinal section of a corallum, showing the structure of the columella, etc., $\times 6$.

Figs. 5 and 6 drawn by H. Chadwick Hunter; fig. 21 by J. Henry Blake; all others by Dr. J. C. McConnell.



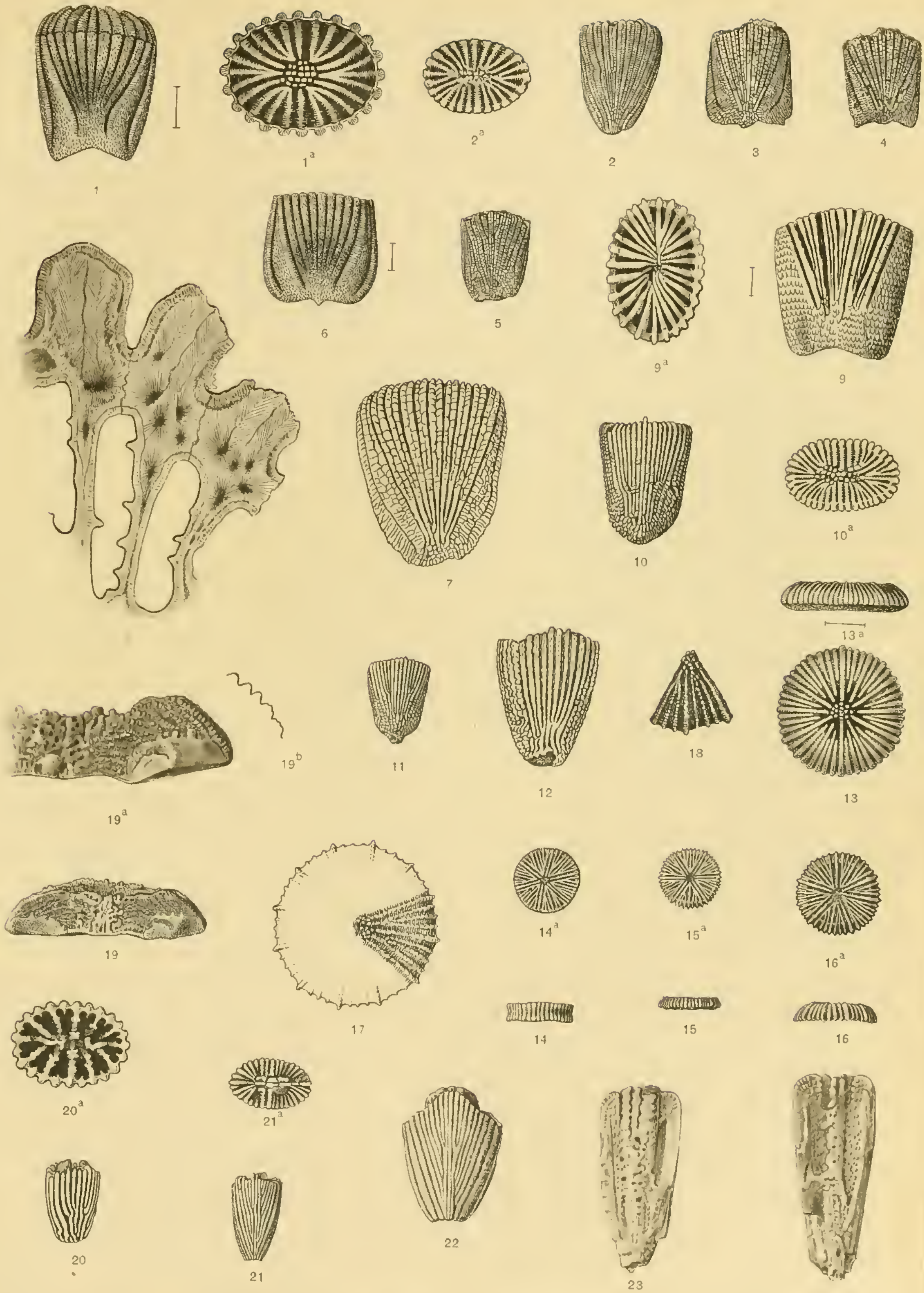
FLABELLUM, ALDRICHIA, PLATYTROCHUS

PLATE V.

PLATE V.

Platytrochus, Discotrochus, Sphenotrochus.

Figs. 7, 12, 17, 20, and 20a drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



PLATYTROCHUS. DISCOTROCHUS SPHENOTROCHUS

PLATE VI.

PLATE VI.

Sphenotrochus, Turbinolia, Trochocyathus.

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Figs. 1 to 3a. *Sphenotrochus claibornensis* sp. nov		85
	Figs. 1 and 3, × 3; fig. 2, × 3½; fig. 2a, calice of specimen represented by fig. 2, × 5.	
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	Fig. 5, longitudinal section of a corallum, × 5; fig. 6, upright view of a specimen, × 5; fig. 6a, costæ and intercostal spaces of the same specimen, more enlarged; fig. 6b, calicular view of the same specimen, enlarged almost 12 times; fig. 7, × 5; fig. 8, × 4; fig. 8a, calice of another specimen, × 6; fig. 9, a large robust variety from Texas, × 3½; fig. 10, longitudinal tangential section of a corallum, × 5; fig. 10a, a portion of a septum more enlarged to show the nodose character.	
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	Fig. 14, upright view of a large specimen (in United States National Museum), × 2; fig. 14a, calicular view of the same, × 4; fig. 15, longitudinal section of a corallum, × 5, to show ornamentation of flat surface of septum; fig. 16 to 16b, three views of the same specimen (from T. H. Aldrich's collection), all × about 5.	
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Figs. 6, 6b, and 21 drawn by J. Henry Blake; fig. 6a by Hunter Harris; all others by Dr. J. C. McConnell.

SPHENOTROCHUS, TURBINOLIA, TROCHOCYATHUS

PLATE VII.

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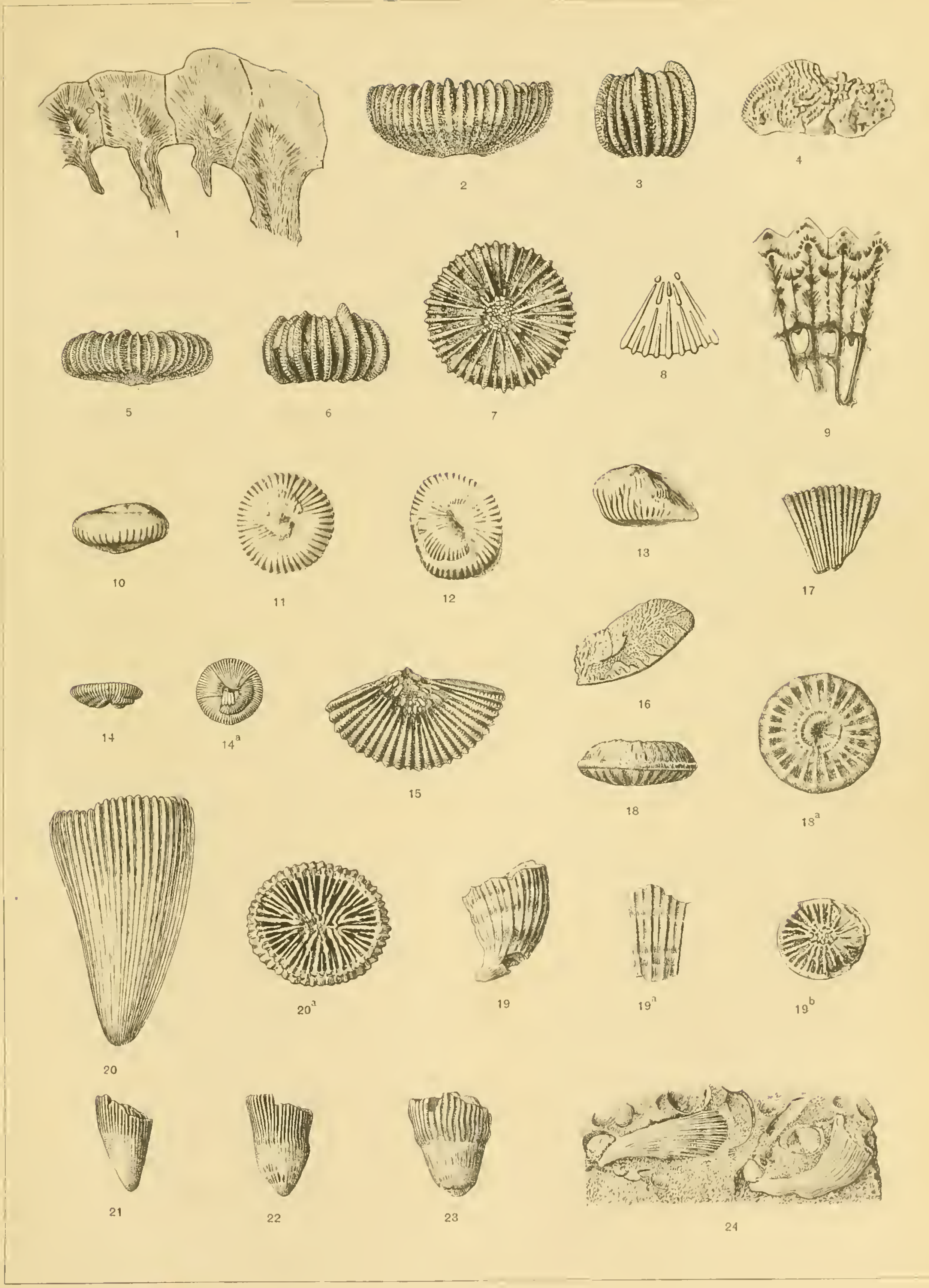
PLATE VII.

TROCHOCYATHUS.

Figs. 2, 5, and 20 drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



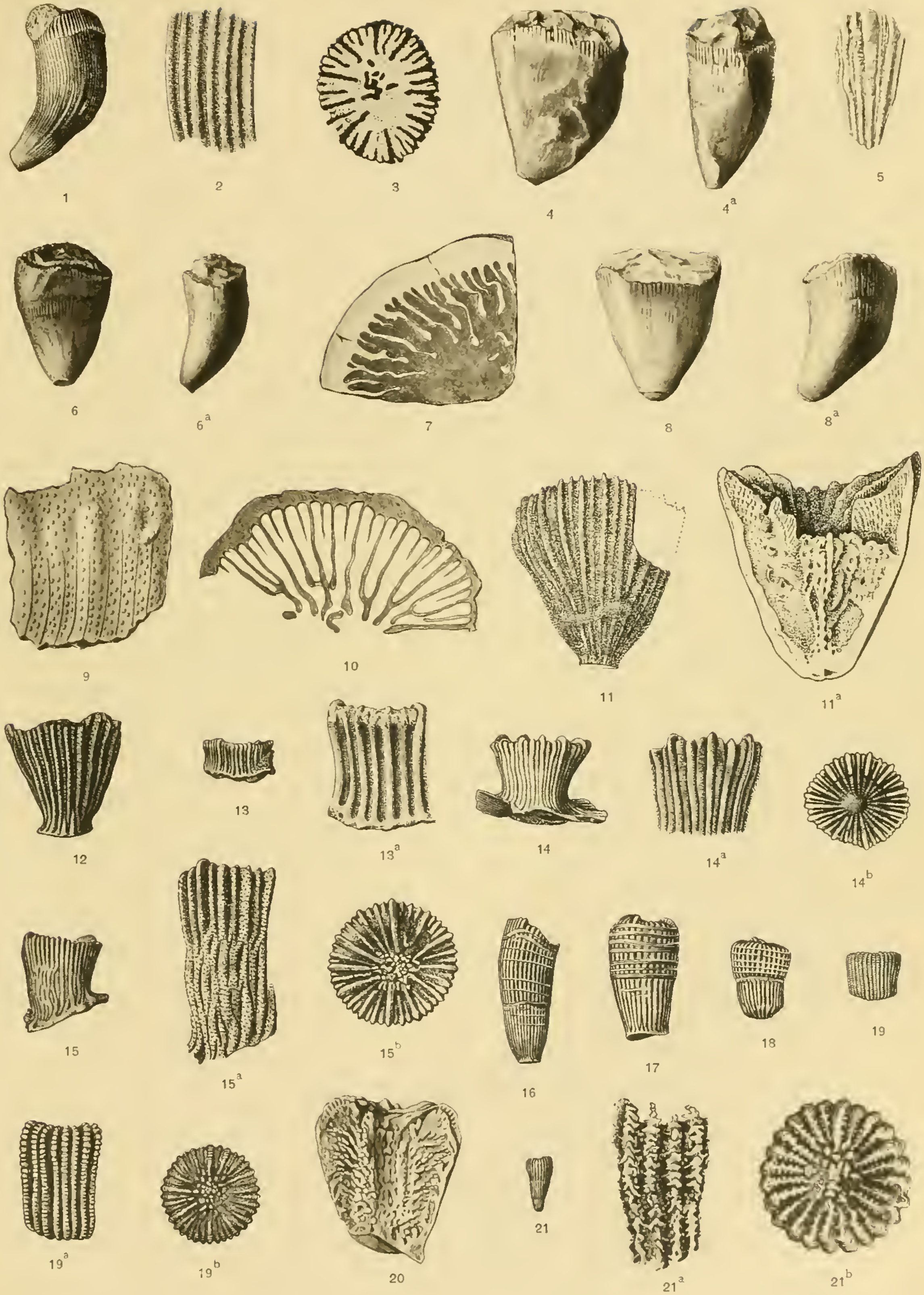
TROCHOCYATHUS

PLATE VIII.

PLATE VIII.

TROCHOCYATHUS, PARACYATHUS.

Figs. 11 and 11a drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



TROCHOCYATHUS, PARACYATHUS

PLATE IX.

PARACYATHUS, CARYOPHYLLIA, STERIPHONOTROCHUS, PARASMILIA, ASTROHELIA.

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Two specimens, figures natural size.	
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Figs. 6, 7, and 10, upright views of three specimens; figs. 6 and 10, natural size; fig. 7, × $1\frac{2}{3}$; fig. 8, looking into calice of a specimen from the side to show tooth-like dentations on inner ends of septa, × 2; fig. 9, a similar view of another specimen—most of the septa have entire margins, some septa have a dentation on the margins; fig. 11, longitudinal section of a corallum, × 2, to show dissepiments (d.); fig. 12, a septum of specimen represented by fig. 6, drawn in profile to show a paliform tooth on the inner termination of the septum; fig. 13, calicular view of a specimen, × 3.	
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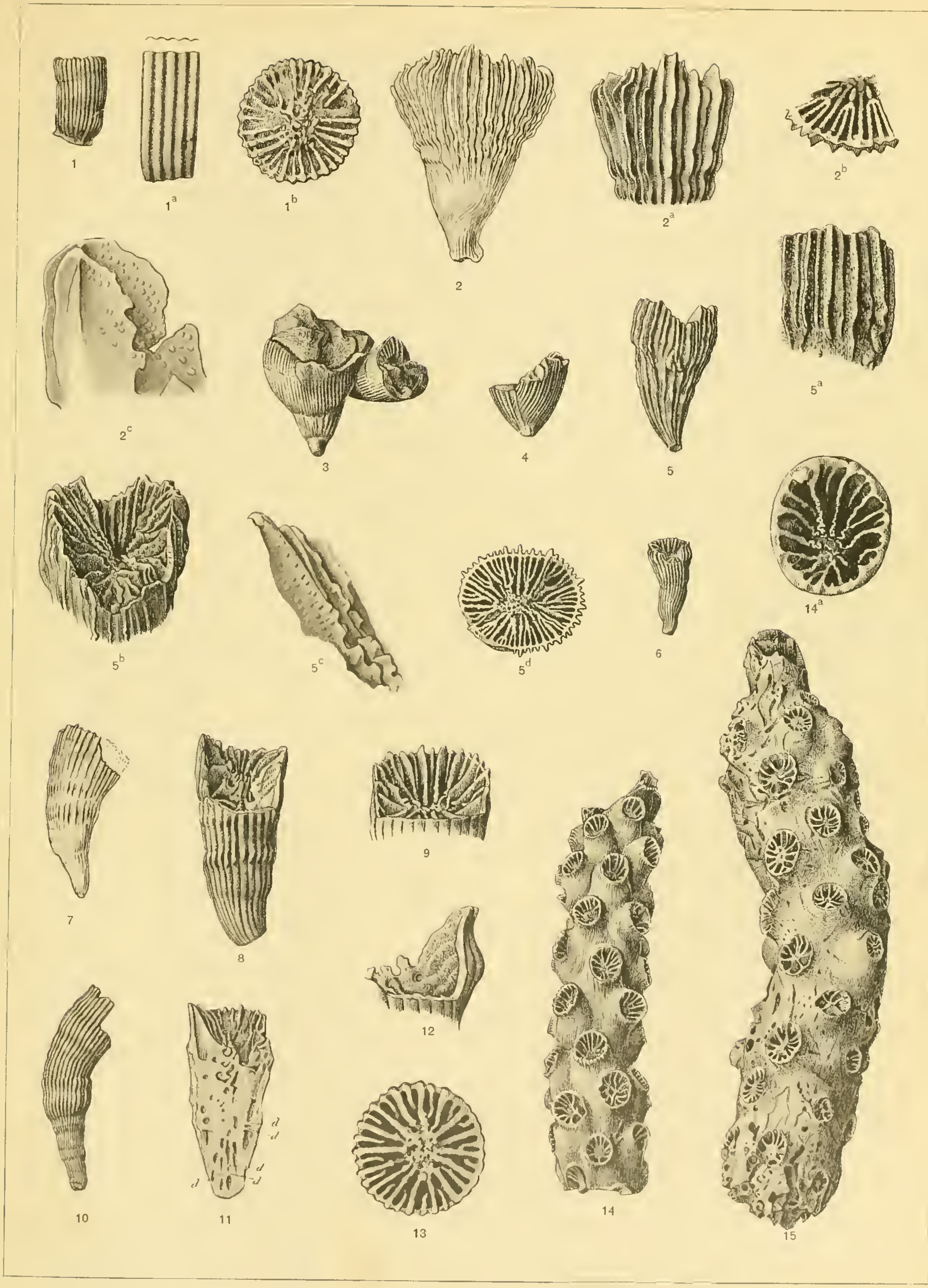
Figs. 14 and 15, general views of two specimens, natural size; fig. 14a, a calice of the specimen represented by fig. 14, × $3\frac{1}{2}$.	

Figs. 2 and 7 drawn by J. Henry Blake; all others by Dr. J. C. McConnell.

PLATE IX.



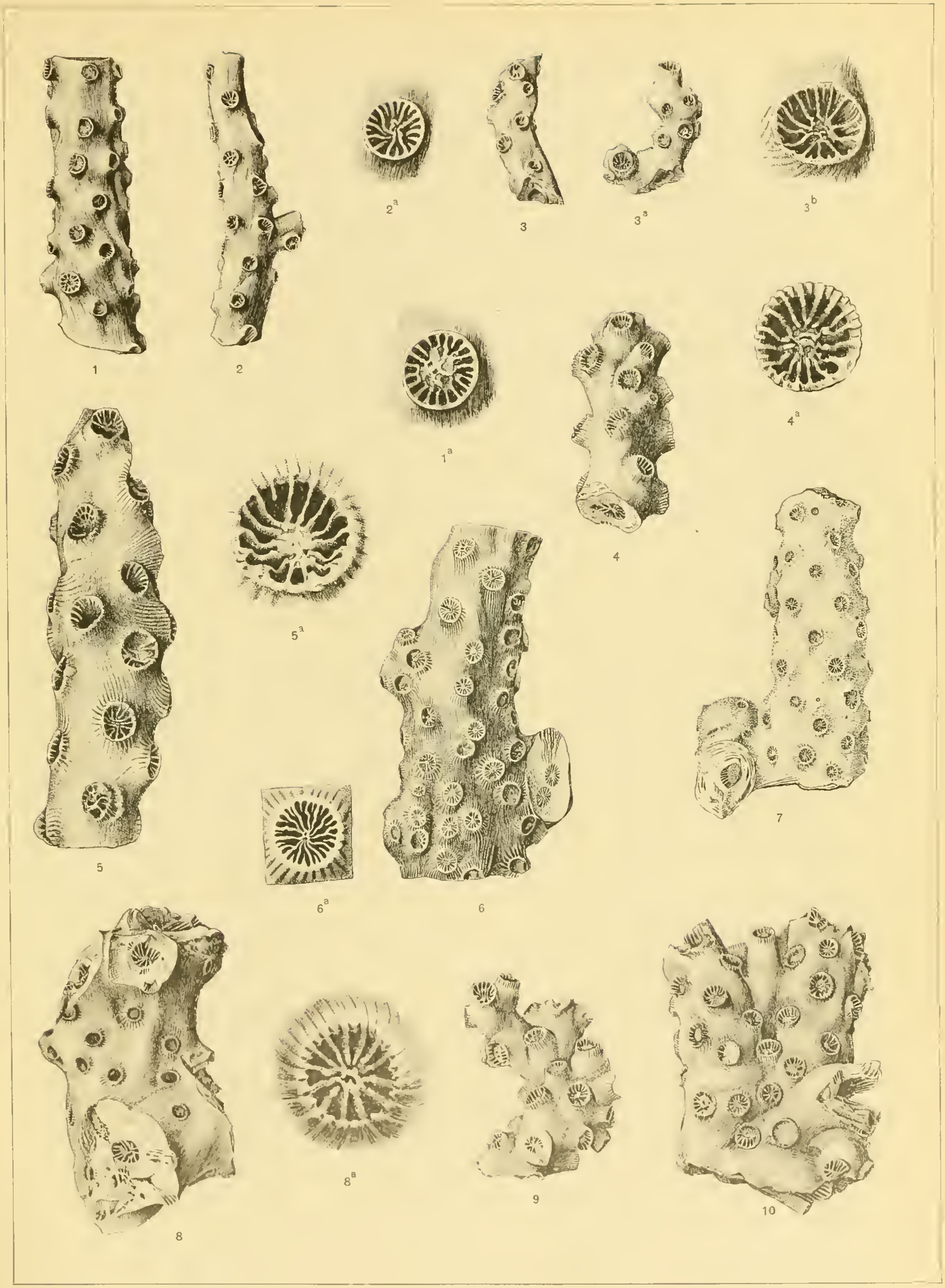
PARACYATHUS, CARYOPHYLLIA, STERIPHONOTROCHUS, PARASMILIA, ASTROHELIA

PLATE X.

PLATE X.

OCULINA, ASTROHELIA.

Fig. 7 drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



OCULINA, ASTROHELIA

PLATE XI.

PLATE XI.

Oculina mississippiensis (Conrad).

(Page 118.)

Figs. 1 and 1a. From Conrad's type in the Philadelphia Academy of Natural Sciences. Fig. 1, general view, natural size; fig 1a, calice, × 3½.

Fig. 2. Another specimen in the Philadelphia Academy of Natural Sciences, natural size.

Figs. 3 to 7. A series showing variation, natural size.

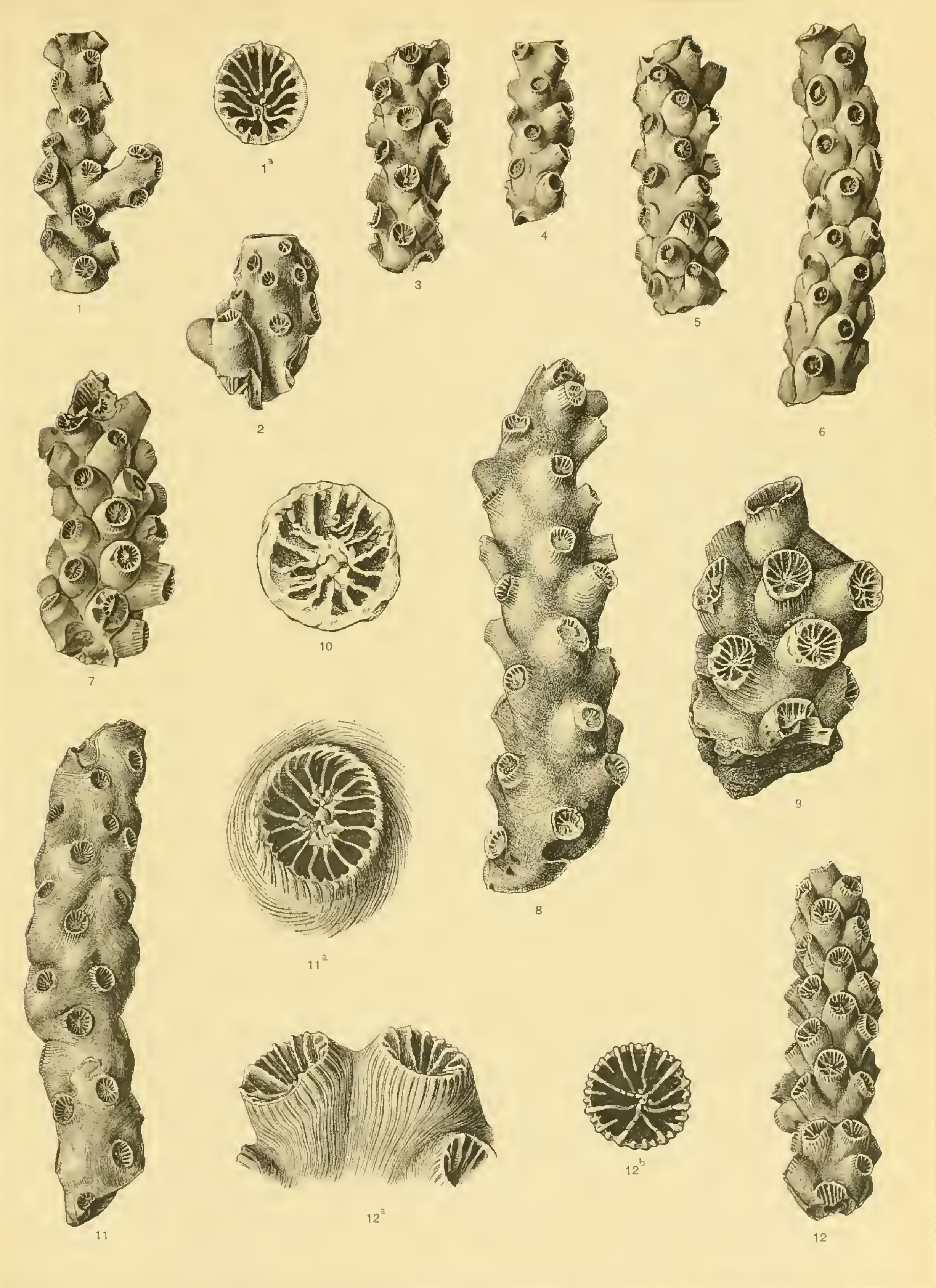
Figs. 8 to 10. Drawn from photographs of Milne-Edwards and Haime's types of *Oculina americana* in the Muséum d'Histoire Naturelle, Paris. Fig. 8, length of specimen, 89 mm.; fig. 9, length of specimen, 28 mm.; fig. 10, diameter of calice, 4 mm.

Fig. 11. A specimen with almost sunken calices, natural size. Fig. 11a, calice, × 3½.

Fig. 12. A specimen with prominent calices, natural size; fig. 12a, outside of two corallites enlarged; fig. 12b, calice, × 3.

All figures drawn by Dr. J. C. McConnell.

[The title at bottom of the facing plate should read Oculina mississippiensis instead of "Oculina vicksburgensis."]



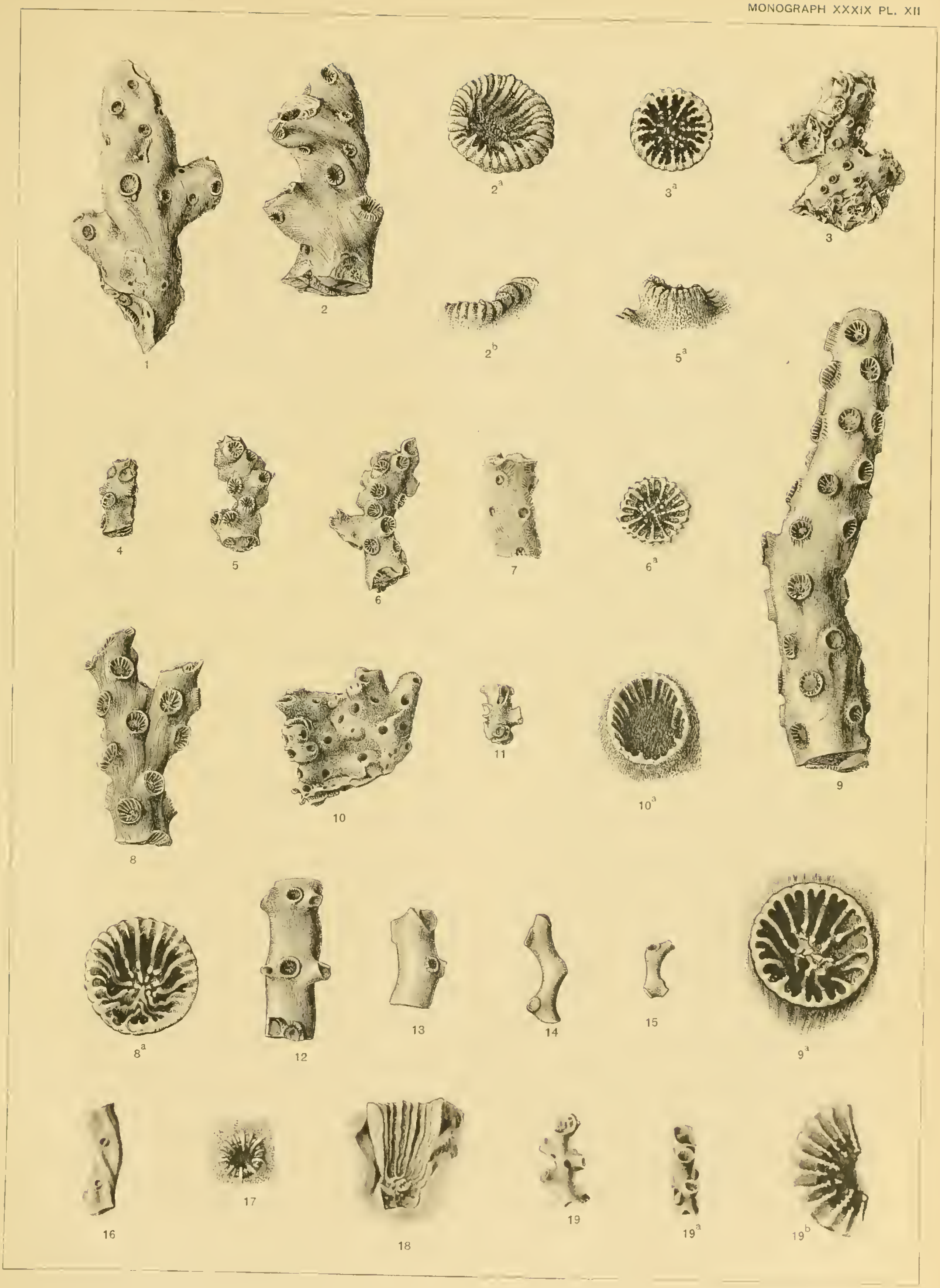
OCULINA ~~VICKSBURGENSIS~~

PLATE XII.

PLATE XII.

OCULINA, AMPHIHELIA, CŒLOHELIA.

All figures drawn by Dr. J. C. McConnell.



OCULINA, AMPHIHELIA, CŒLOHELIA

PLATE XIII.

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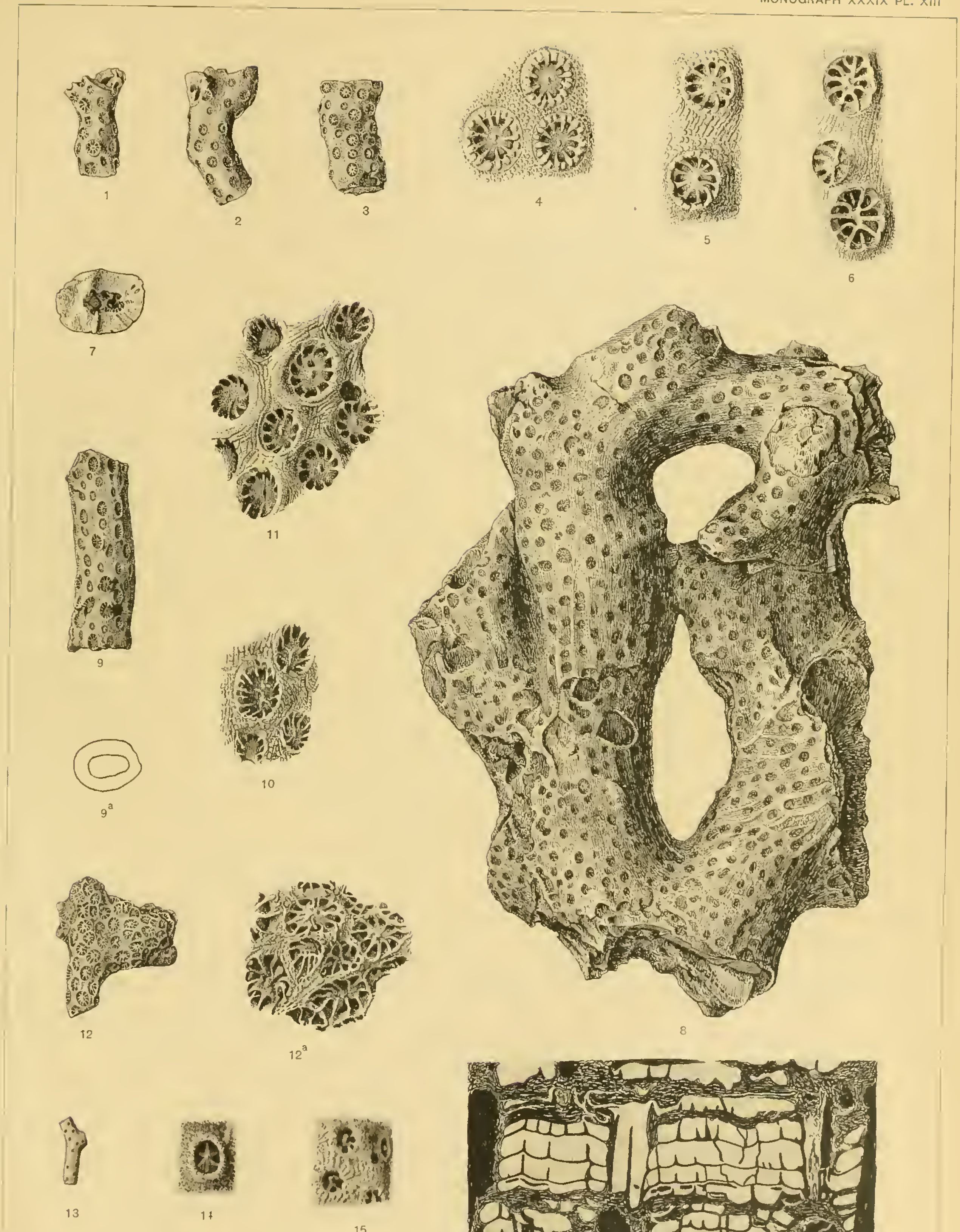
PLATE XIII.

Madracis, Stylophora.

All figures drawn by Dr. J. C. McConnell.



MADRACIS, STYLOPHORA

PLATE XIV.

PLATE XIV.

Stylophora, Astrangia.

Page.

Figs. 1 to 1b. *Stylophora ponderosa* sp. nov 132

Fig. 1, a general view of a specimen, natural size; fig. 1a, some corallites seen in cross section, × 5; fig. 1b, to show structure of cœnenchyma as seen on weathered surface, × 5.

Figs. 2 and 2a. *Stylophora perdubia* de Gregorio (sedis incerta) 198

Smaller figure, natural size.

Figs. 3 to 5. *Astrangia expansa* sp. nov 133

Fig. 3, specimen attached to a valve of *Barbatia cuculloides* (Conrad), natural size; fig. 3a, the same enlarged to show expanded base; fig. 3b, calice of central corallite, × 5; figs. 4 and 5, two other specimens, natural size.

Figs. 6 to 7. *Astrangia ludoviciana* sp. nov 135

Figs. 6 and 7, two colonies, natural size; fig. 6a, calice of specimen represented by fig. 6, × 5.

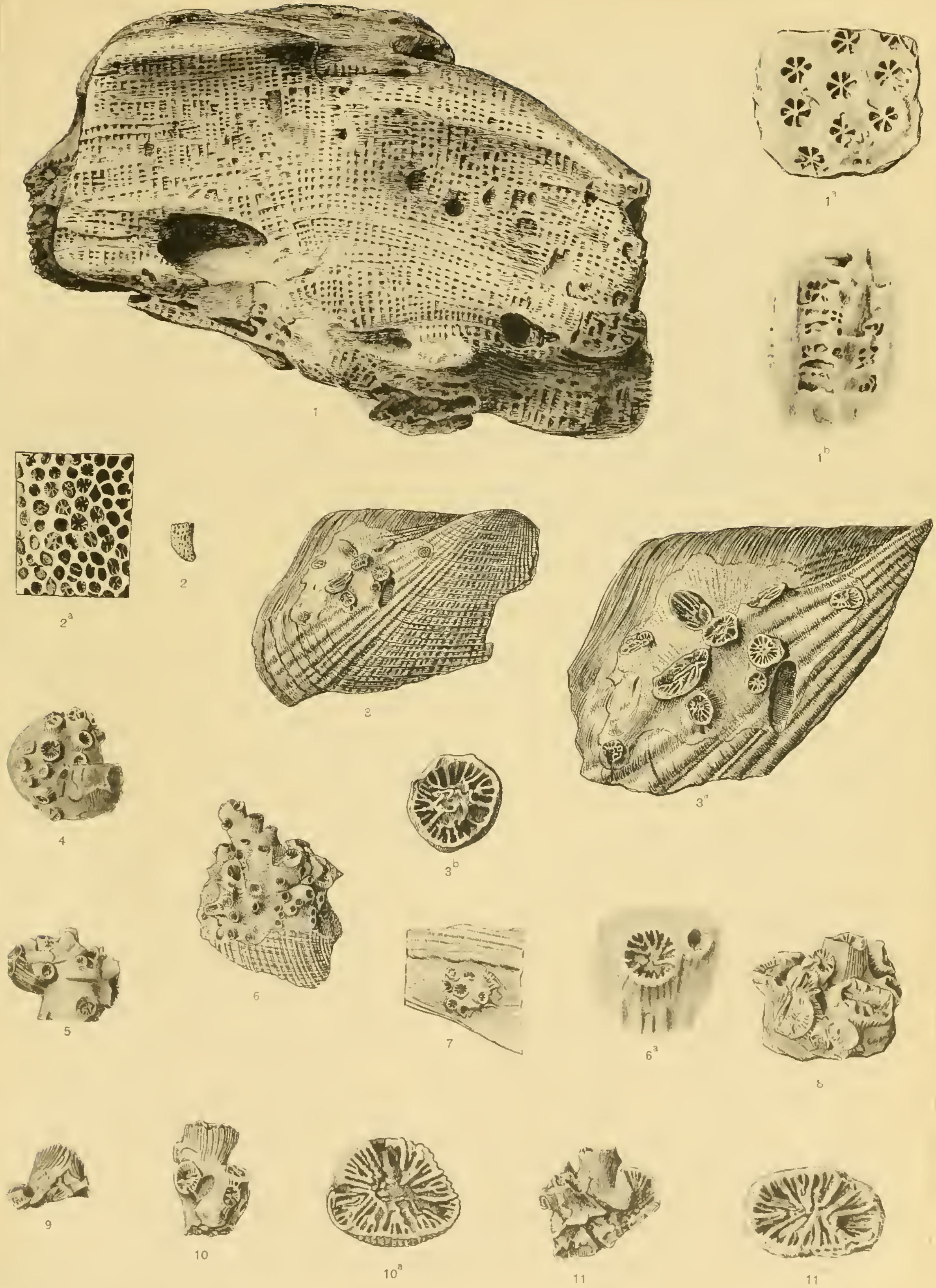
Figs. 8 to 10a. *Astrangia harrisi* sp. nov 136

Figs. 8, 9, and 10, general views of three specimens, natural size; fig. 10a, the largest calice on specimen represented by fig. 10, × 2.

Figs. 11 and 11a. *Astrangia wilcoxensis* sp. nov 137

Fig. 11, general view of a colony, natural size; fig. 11a, calice, × 2½.

All figures drawn by Dr. J. C. McConnell.



STYLOPHORA, ASTRANGIA

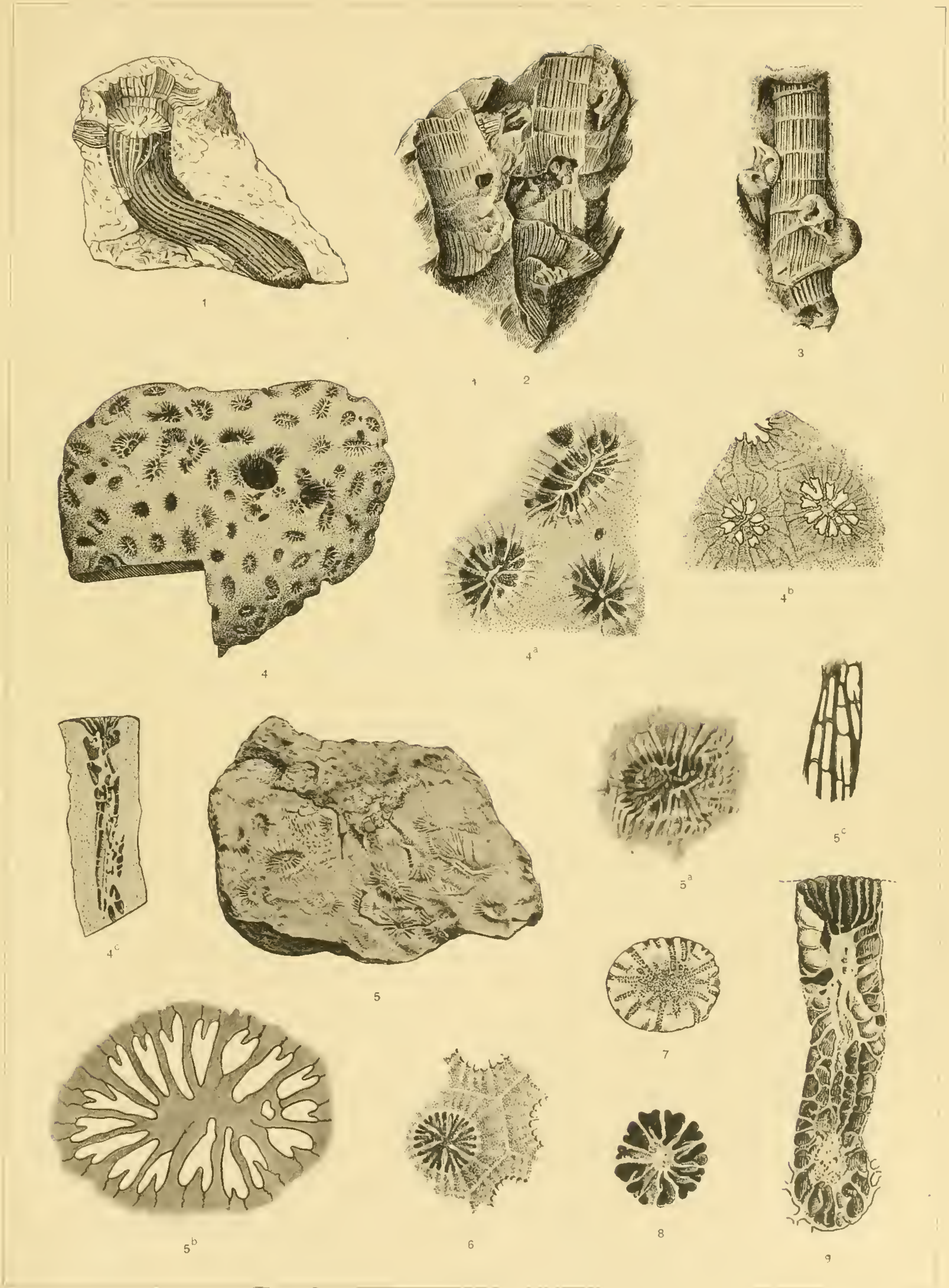
PLATE XV.

PLATE XV.

CLADOCORA, DICHOCŒNIA, FAVIA, HAIMESIASTRÆA.

		Page.
FIGS. 1 to 3.	*Cladocora recrescens* Lonsdale	138
	Fig. 1, copy of Lonsdale's original figure; fig. 2, drawn from a cast in limestone from Jacksonboro, Georgia; fig. 3, drawn from a rubber squeeze made from the cast. All figures natural size.	
FIGS. 4 to 4c.	*Dichocœnia alabamensis* sp. nov	139
	Fig. 4, general view of the corallum, natural size; fig. 4a, calices, $\times$ about 4; fig. 4b, thin section through several corallites, $\times 3\frac{1}{2}$; fig. 4c, longitudinal section of corallite, $\times 2$.	
FIGS. 5 to 5c.	*Favia merriami* sp. nov	142
	Fig. 5, general view of corallum, natural size; fig. 5a, calice, $\times 2\frac{1}{2}$; fig. 5b, cross section of corallite, $\times$ about $7\frac{1}{2}$; fig. 5c, oblique longitudinal section of a corallite to show dissepiments, $\times 3\frac{1}{3}$.	
FIGS. 6 to 9.	*Haimesiastræa conferta* gen. et sp. nov	143
	Fig. 6, several calices, $\times 6\frac{2}{3}$; fig. 7, cross section of a branch, $\times \frac{5}{6}$; fig. 8, cross section of a corallite, $\times 8\frac{1}{3}$; fig. 9, longitudinal section of a corallite, $\times 8\frac{1}{3}$.	

Figs. 6, 7, 8, and 9 drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



CLADOCORA, DICHOCŒNIA, FAVIA, HAIMESIASTRÆA

PLATE XVI.

PLATE XVI.

HAIMESIASTRÆA CONFERTA gen. et sp. nov.

(Page 143.)

FIG. 1. A corallum from Greggs Landing, Alabama, natural size. This specimen is designated as the type of the species.

FIG. 2. Cross section of a corallite, × 7½, shows the mode of formation of the false columella.

FIG. 3. Section through wall of corallite, × 37, showing apparent true thecal centers of calcification.

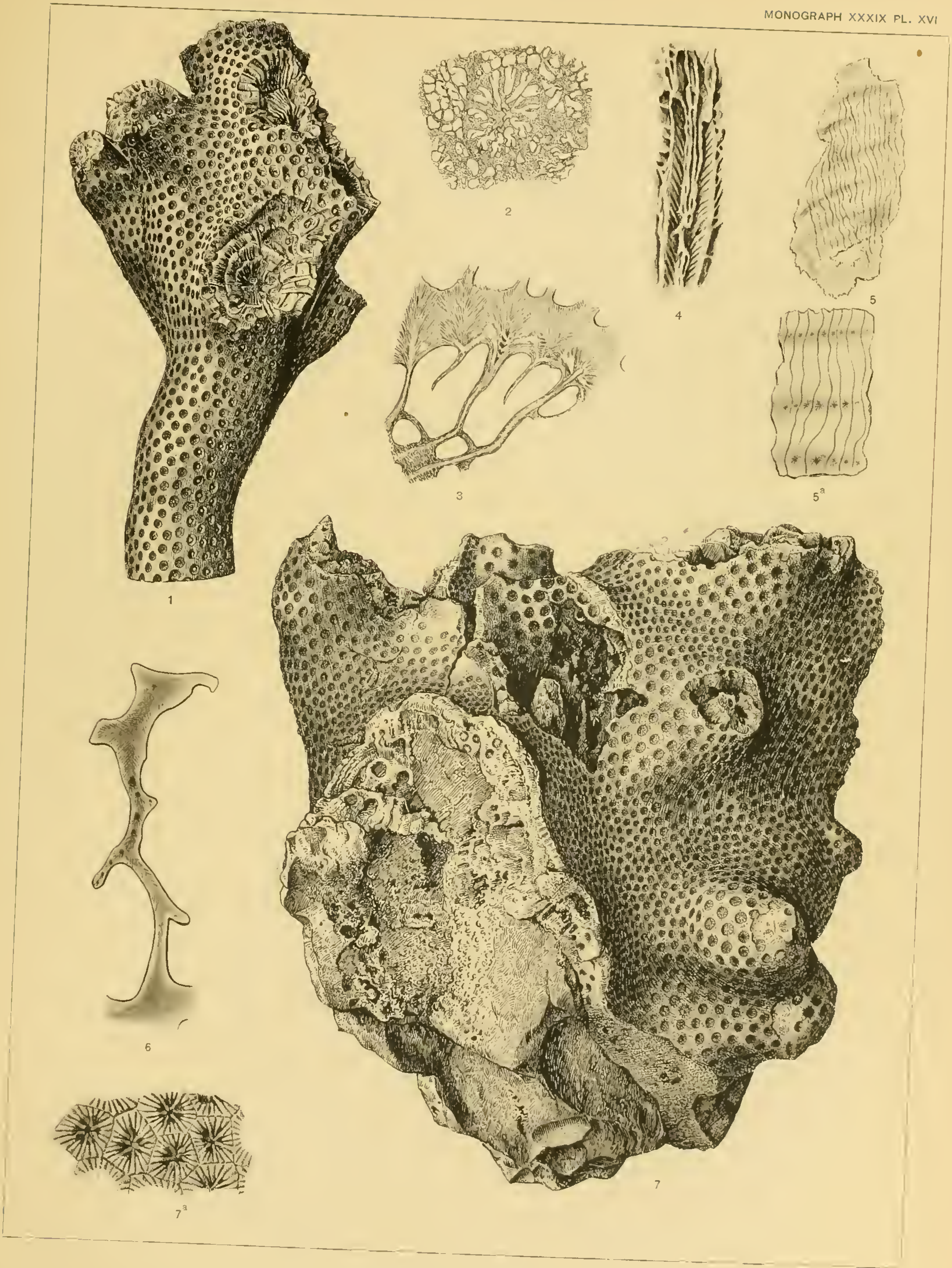
FIG. 4. Longitudinal section of a corallite, × 5, showing lateral ornamentation of septa.

FIG. 5. Thin section parallel to flat surface of septum, × 60, showing trabeculæ; fig. 5a, a portion of the same section more highly magnified; the calcification centers are too diagramatically represented.

FIG. 6. A cross section, slightly oblique, of a septum, × 60.

FIG. 7. A large specimen, referred to this species, from Woods Bluff, Alabama; figure, natural size; fig. 7a, several calices, × 3½.

All figures drawn by Dr. J. C. McConnell.



HAIMESIASTRÆA CONFERTA

PLATE XVII.

PLATE XVII.

HAIMESIASTRÆA, ASTROCŒNIA, PLATYCŒNIA, STEPHANOCŒNIA.

Page.

FIGS. 1 to 6. *Haimesiastræa petrosa* (Gabb) 146

All figures from Gabb's type material in the collection of the University of California, Berkeley, California. Fig. 1, a small specimen, natural size; fig. 2, a calice, $\times 6$, the upper margins of the septa broken off, showing the false columella; fig. 3, a perfect calice, $\times 6$, showing the septal margins meeting in the axial space; fig. 4, an oblique longitudinal section of a corallite, $\times 20$, showing the nodular character of the septa, dissepiments, etc.; fig. 5, cross section of a corallite, $\times 20$, showing pseudotheca and false columella; fig. 6, general view of a rather large mass, natural size.

FIGS. 7 and 7a. *Astrocœnia pumpellyi* sp. nov 149

Fig. 7, general view of the corallum, natural size; fig. 7a, calices, $\times 5$.

FIG. 8. *Astrocœnia* sp. dub. de Gregorio (after de Gregorio) 198

FIGS. 9 to 9c. *Platycœnia jacksonensis* gen. et sp. nov.. 150

Fig. 9, profile view, $\times \frac{5}{6}$; fig. 9a, longitudinal section of corallite, $\times 6\frac{2}{3}$; fig. 9b, view of corallum from above, natural size; fig. 9c, calices seen from above, $\times$ about 4.

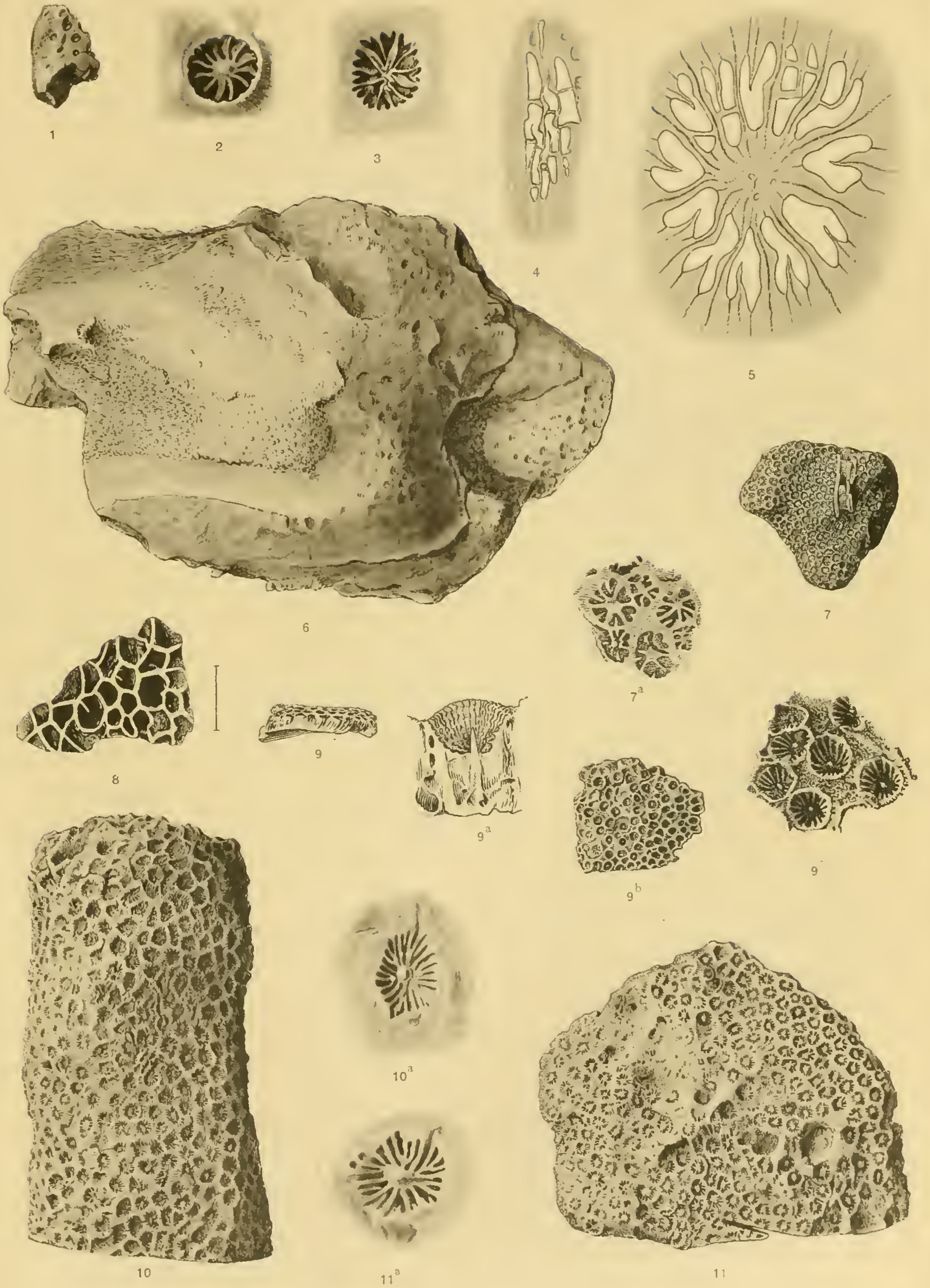
FIGS. 10 and 10a. *Stephanocœnia fairbanksi* var. *columnaris* var. nov 151

Fig. 10, general view, natural size; fig. 10a, calice, $\times$ about 4.

FIGS. 11 and 11a. *Stephanocœnia fairbanksi* sp. nov 151

Fig. 11, general view, natural size; fig. 11a, calice, $\times$ about 4.

All figures drawn by Dr. J. C. McConnell, except figs. 9 and 9a, which were drawn by J. Henry Blake.



HAIMESIASTRÆA, ASTROCŒNIA, PLATYCŒNIA, STEPHANOCŒNIA

PLATE XVIII.

PLATE XVIII.

Siderastrea, Stephanomorpha, Mesomorpha, Balanophyllia.

Page.

Figs. 1 to 4. *Siderastrea hexagonalis* sp. nov 155

Fig. 1, profile view of corallum, $\times \frac{5}{6}$; fig. 2, corallum, viewed from above, natural size; fig. 3, several calices, $\times 3\frac{1}{3}$, detail not precisely correct; fig. 4, portion of wall and some septa, $\times 8\frac{1}{3}$, drawn very carefully, to shew character of wall and distribution of synapticulæ. All figures from the same specimen.

Figs. 5 to 7. *Stephanomorpha monticuliformis* gen. et sp. nov 156

Fig. 5, general view of corallum from side, $\times \frac{5}{6}$; fig. 5a, several calices, $\times 3\frac{1}{3}$; fig. 6, view of a intercorallite area (same specimen), $\times 5$, to show synapticulæ between costæ; fig. 7, longitudinal section, $\times 6$, to show synapticulæ between costæ.

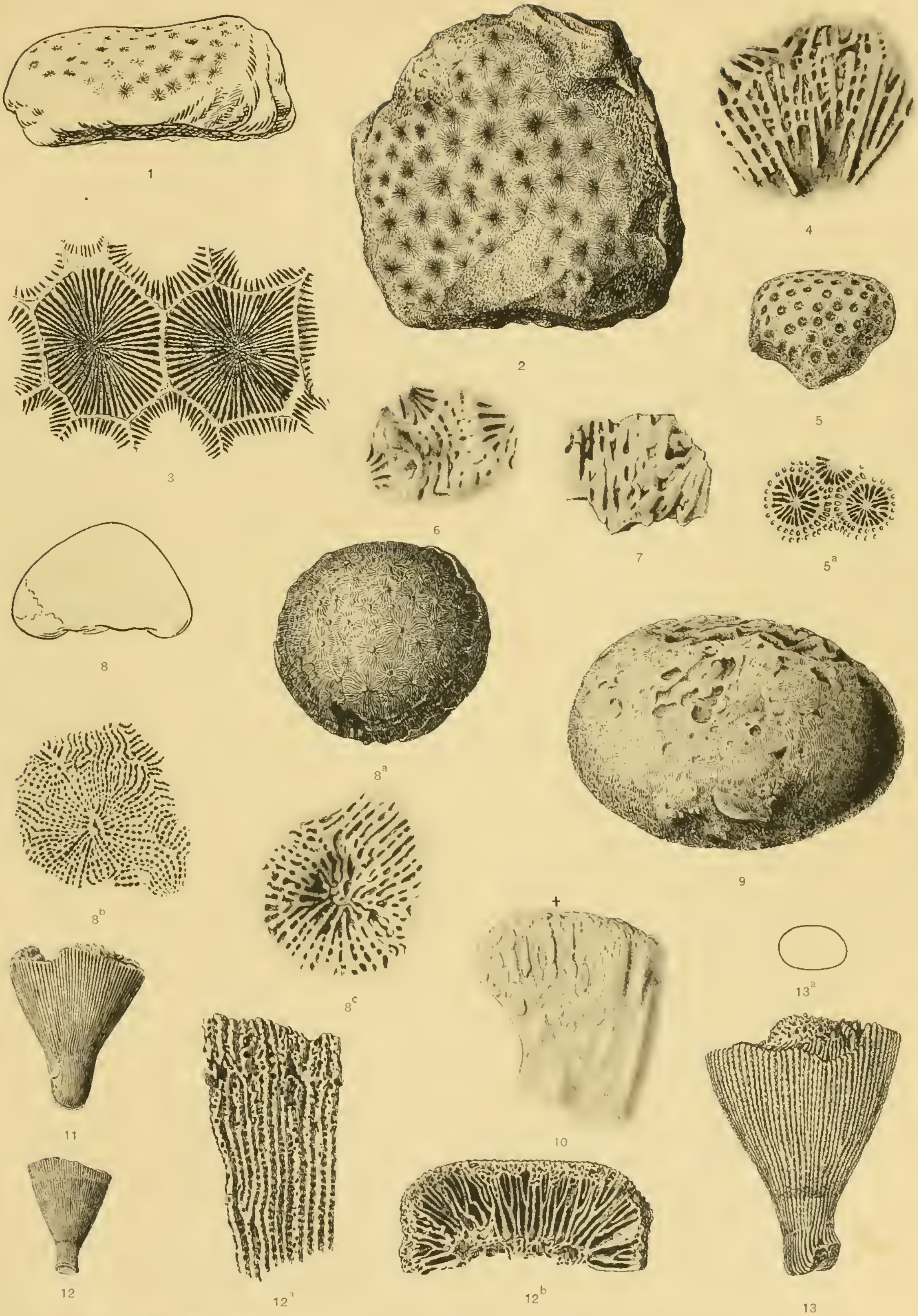
Figs. 8 to 10. *Mesomorpha duncani* sp. nov 159

Fig. 8, profile view of corallum, $\times \frac{5}{6}$; fig. 8a, view of corallum from above, natural size; fig. 8b, several calices, $\times 2\frac{1}{2}$, shows confluent septo-costæ; fig. 8c, one calice, $\times 5$, very carefully drawn to show distribution of synapticulæ; fig. 9, general view of another specimen, natural size; fig. 10, flat surface of two septa, $\times 6$, the cross marks the delimitation between adjacent calices. This figure shows the imperforate character of the septa and the broken ends of the synapticulæ. From the arrangement of the latter, the trabecular constitution can be inferred. The trabeculæ at the line of fusion between adjacent calices are vertical, but toward the inner terminations of the septa they have a slight, though not great, inclination inward.

Figs. 11 to 13a. *Balanophyllia desmophyllum* Milne-Edwards and Haime 164

Figs. 11 and 12, upright views of two specimens, natural size; fig. 12a, costæ enlarged; fig. 12b, portion of calice to show septal arrangement, $\times 3$; fig. 13, upright view of specimen, $\times 2\frac{1}{2}$; fig. 13a, transverse outline, $\times \frac{5}{6}$.

Figs. 1, 3, 5, 5a, 8, 8b, and 13 drawn by J. Henry Blake; all others by Dr. J. C. McConnell.



SIDERASTRÆA STEPHANOMORPHA, MESOMORPHA, BALANOPHYLLIA

PLATE XIX.

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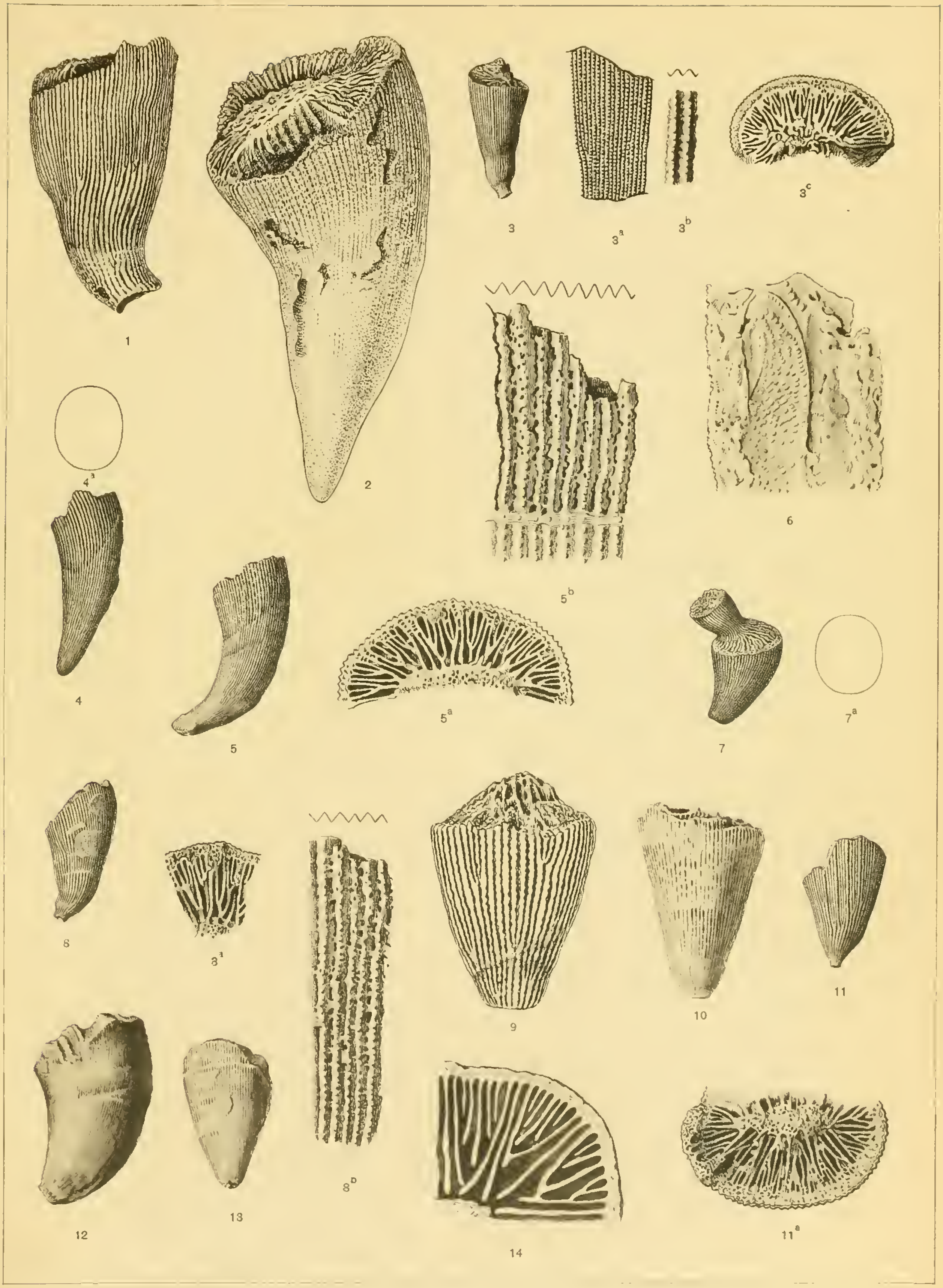
PLATE XIX.

BALANOPHYLLIA.

Figs. 1, 2, and 9 drawn by J. Henry Blake; figs. 4 and 7 by E. Sheppard; all others by Dr. J. C. McConnell.



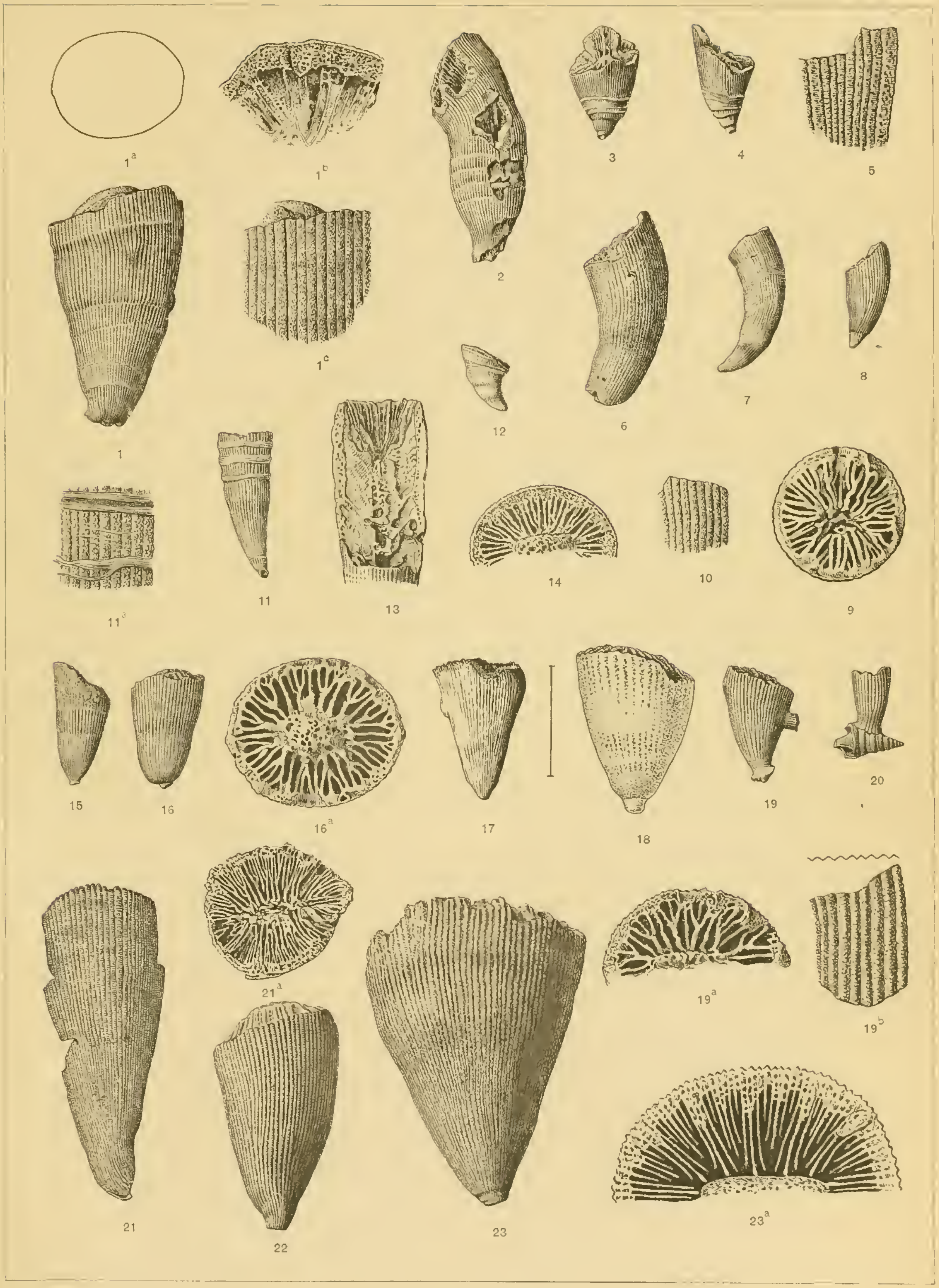
BALANOPHYLLIA

PLATE XX.

PLATE XX.

BALANOPHYLLIA.

Fig. 17 drawn by Hunter Harris; fig. 18 by J. Henry Blake; all others by Dr. J. C. McConnell.



BALANOPHYLLIA

PLATE XXI.

PLATE XXI.

Balanophyllia, Eupsammia, Rhectopsammia, Endopachys.

Page.

Figs. 1 to 2. *Balanophyllia haleana* (Milne-Edwards and Haime) 178

Figs. 1 and 2, upright views of two specimens, each $\times 2\frac{1}{2}$; figs. 1a and 2a, respectively, transverse outlines of the specimens, $\times \frac{5}{6}$.

Figs. 3 to 7. *Eupsammia elaborata* (Conrad) 180

Fig. 3, upright view of Conrad's type in the Philadelphia Academy of Natural Sciences, $\times 2\frac{1}{2}$; fig. 3a, transverse outline of the same, $\times \frac{5}{6}$; fig. 4, upright view of an elongate specimen from Aquia Creek, Virginia, $\times 2\frac{1}{2}$; fig. 4a, transverse outline of the same, $\times \frac{5}{6}$; fig. 5, upright view of a typical specimen from Greggs Landing, Alabama, $\times 2\frac{1}{2}$; fig. 5a, transverse outline of the same, $\times \frac{5}{6}$; fig. 6, transverse section of a corallum, $\times 2$, to show septal arrangement; fig. 7, thin section through wall, to show relations of septa to costæ, the synapticulate character of the wall, septal perforations, etc., $\times 11$.

Figs. 8 to 9a. Copies of de Gregorio's original figures of *Placosmilia* (*Trochosmilia*) *connivens* de Gregorio. This is probably a synonym of *Eupsammia elaborata* (Conrad) 182

Figs. 10 to 10b. *Eupsammia conradi* nom. nov 183

All figures drawn from Conrad's type of "*Turbinolia pileolus*" in the Philadelphia Academy of Natural Sciences. Fig. 10, upright view, $\times \frac{5}{6}$; fig. 10a, transverse outline, $\times \frac{5}{6}$; fig. 10b, view of calice from above, $\times 2$.

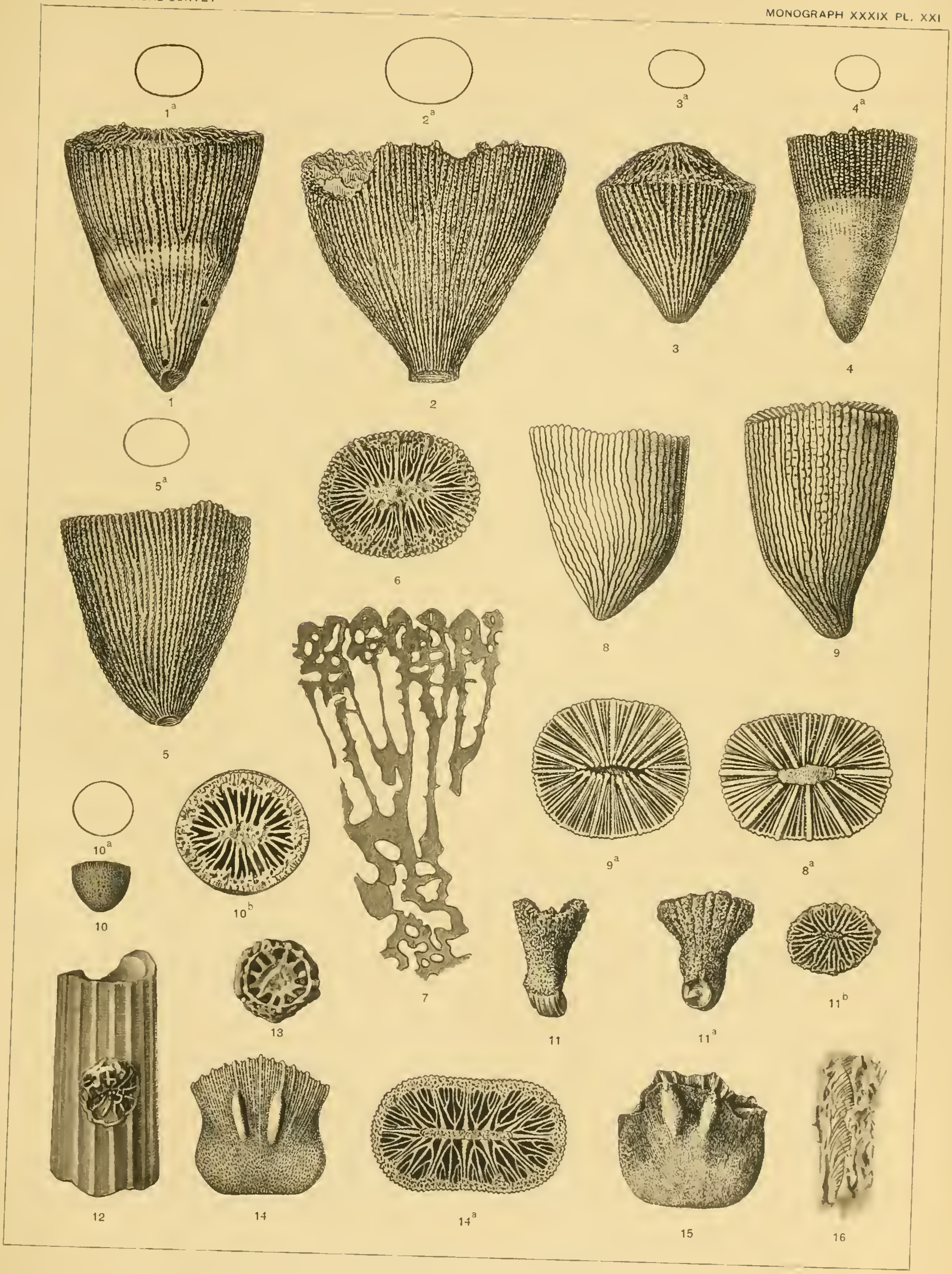
Figs. 11 to 13. *Rhectopsammia clairbornensis* gen. et sp. nov 183

Figs. 11 and 11a, two upright views of the same specimen, $\times 2\frac{1}{2}$; fig. 11b, calicular view of the same specimen, $\times 2\frac{1}{2}$; fig. 12, very young specimen attached to a specimen of *Dentalium blandum* de Gregorio, $\times 6$, shows the basal plate and first formed septa; fig. 13, view of basal end of a very young specimen, $\times 6$, shows a portion of the basal plate adhering to the septa; also shows the mode of overlapping beyond the first epithecal ring of the subsequently formed hard parts.

Figs. 14 to 16. *Endopachys maclurii* (Lea) 186

Fig. 14 and 14a, copies from Milne-Edwards and Haime; fig. 14, upright view; fig. 14a, calicular view, both natural size; fig. 15, view of another specimen, natural size; fig. 16, side of a septum, outer layer peeled off, $\times 4$, to show courses of trabeculæ and mode of insertion of new trabeculæ.

Figs. 1 to 5a drawn by J. Henry Blake; figs. 10 and 10a by E. Sheppard; fig. 15 by Hunter Harris; all others by Dr. J. C. McConnell.



BALANOPHYLLIA, EUPSAMMIA, RHECTOPSAMMIA, ENDOPACHYS

PLATE XXII.

PLATE XXII.

Endopachys, Dendrophyllia, Dendracis.

Page.

Fig. 1. *Endopachys maclurii* (Lea) 186

A specimen approaching var. *tenue* var. nov. The line indicates the size.

Figs. 2 to 5. *Endopachys maclurii* var. *tenue* var. nov 188

All figures natural size.

Fig. 6. *Endopachys maclurii* (Lea) 186

A specimen near variety *tenue*, natural size.

Figs. 7 and 8. *Endopachys maclurii* var. *triangulare* Conrad 188

The figures made from Conrad's type in the Philadelphia Academy of Natural Sciences. Fig. 7, upright view, looking at side; fig. 8, transverse outline; both figures $\frac{5}{6}$ natural size.

Fig. 9. *Endopachys* sp., probably a large specimen of *E. maclurii* var. *triangulare* Conrad 188

Fig. natural size.

Figs. 10 and 10a. *Endopachys lonsdalei* sp. nov 189

Two upright views of the same specimen, both natural size.

Figs. 11 to 14. *Endopachys shaleri* sp. nov 190

Figs. 11 to 13, upright views of three specimens, $\times$ about $2\frac{1}{2}$; fig. 14, skeleton diagram of septa.

Figs. 15 to 18. *Endopachys minutum* sp. nov 190

Figs. 15 to 17, upright views of three specimens, $\times$ 2; figs. 16 and 16a, two views of the same specimen; fig. 18, calicular view of another specimen, $\times$ nearly 5.

Figs. 19 to 19b. *Dendrophyllia striata* sp. nov 191

Figs. 19 and 19a, two views of the type specimen, both natural size; fig. 19b, upper end of the same, $\times$ 3, to show septal arrangement.

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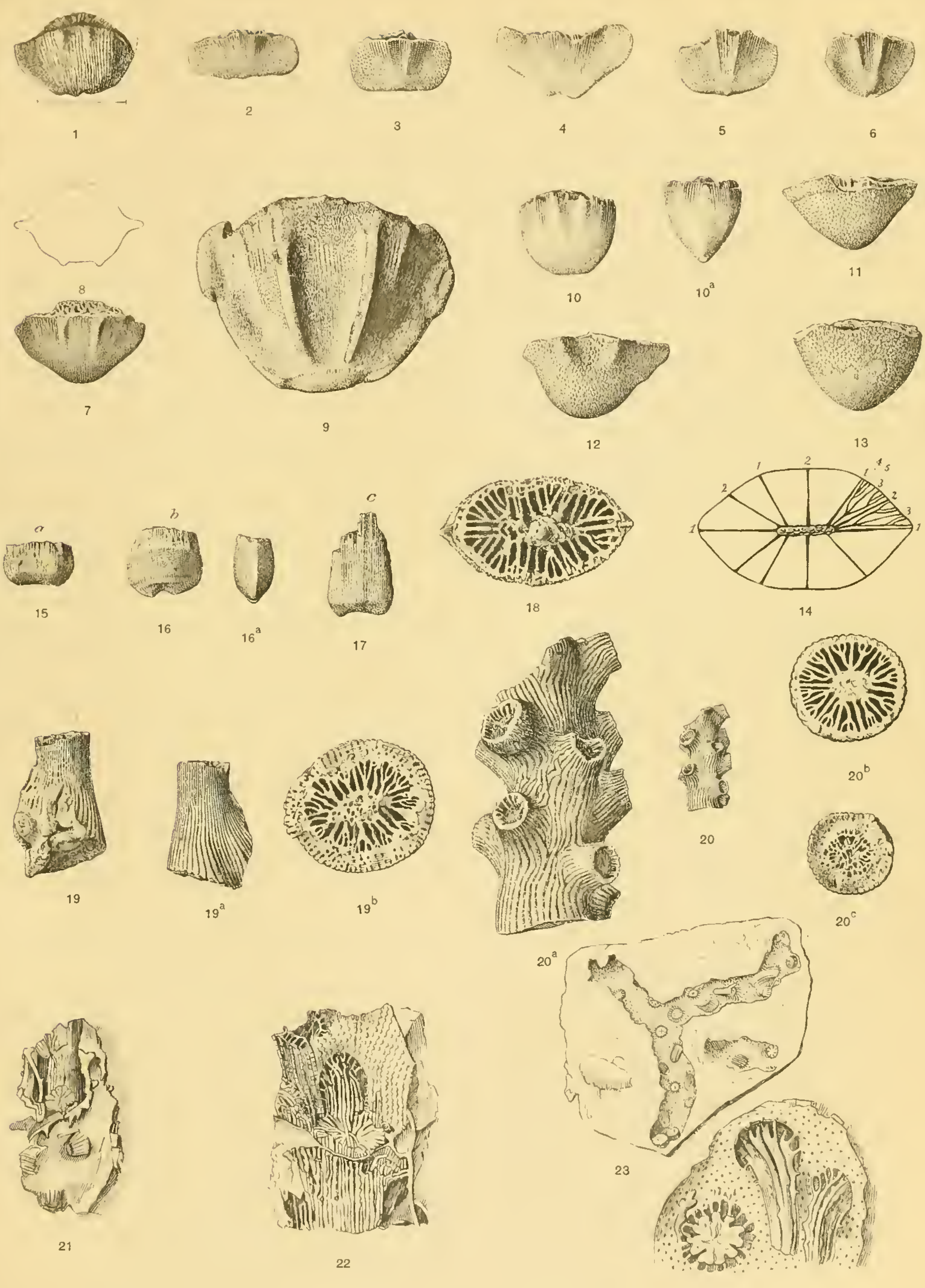
Fig. 1 drawn by Hunter Harris; figs. 7 and 8 by E. Sheppard; all others by Dr. J. C. McConnell.



ENDOPACHYS, DENDROPHYLLIA, DENDRACIS

PLATE XXIII.

PLATE XXIII.

TURBINARIA (?), PORITES.

All drawings made by Dr. J. C. McConnell.

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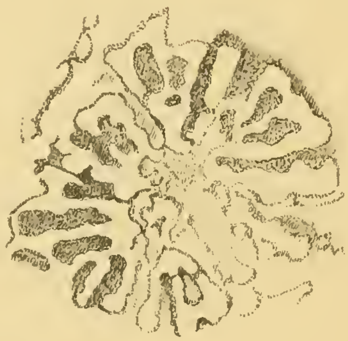

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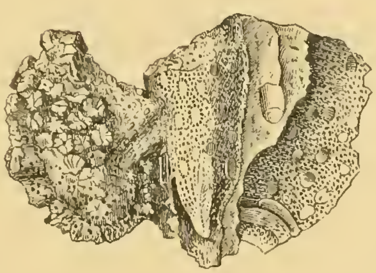

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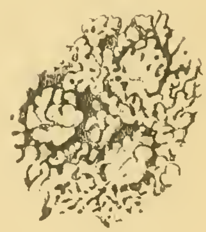

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TURBINARIA (?), PORITES

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PLATE XXIV.

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TURBINARIA (?) ALABAMENSIS

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[Monograph XXXIX.]

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81. Correlation Papers—Cambrian, by Charles Doolittle Walcott. 1891. 8°. 547 pp. 3 pl. Price 25 cents.

82. Correlation Papers—Cretaceous, by Charles A. White. 1891. 8°. 273 pp. 3 pl. Price 20 cents.

83. Correlation Papers—Eocene, by William Bullock Clark. 1891. 8°. 173 pp. 2 pl. Price 15 cents.

84. Correlation Papers—Neocene, by W. H. Dall and G. D. Harris. 1892. 8°. 349 pp. 3 pl. Price 25 cents.

85. Correlation Papers—The Newark System, by Israel Cook Russell. 1892. 8°. 344 pp. 13 pl. Price 25 cents.

86. Correlation Papers—Archean and Algonkian, by C. R. Van Hise. 1892. 8°. 549 pp. 12 pl. Price 25 cents.

87. A Synopsis of American Fossil Brachiopoda, including Bibliography and Synonymy, by Charles Schuchert. 1897. 8°. 464 pp. Price 25 cents.

88. The Cretaceous Foraminifera of New Jersey, by Rufus Mather Bagg, Jr. 1898. 8°. 89 pp. 6 pl. Price 10 cents.

89. Some Lava Flows of the Western Slope of the Sierra Nevada, California, by F. Leslie Ransome. 1898. 8°. 74 pp. 11 pl. Price 15 cents.

90. A Report of Work done in the Division of Chemistry and Physics, mainly during the Fiscal Year 1890-'91. F. W. Clarke, Chief Chemist. 1892. 8°. 77 pp. Price 10 cents.

91. Record of North American Geology for 1890, by Nelson Horatio Darton. 1891. 8°. 88 pp. Price 10 cents.

92. The Compressibility of Liquids, by Carl Barus. 1892. 8°. 96 pp. 29 pl. Price 10 cents.

93. Some Insects of Special Interest from Florissant, Colorado, and Other Points in the Tertiaries of Colorado and Utah, by Samuel Hubbard Scudder. 1892. 8°. 35 pp. 3 pl. Price 5 cents.

94. The Mechanism of Solid Viscosity, by Carl Barus. 1892. 8°. 138 pp. Price 15 cents.

95. Earthquakes in California in 1890 and 1891, by Edward Singleton Holden. 1892. 8°. 31 pp. Price 5 cents.

96. The Volume Thermodynamics of Liquids, by Carl Barus. 1892. 8°. 100 pp. Price 10 cents.

97. The Mesozoic Echinodermata of the United States, by W. B. Clark. 1893. 8°. 207 pp. 50 pl. Price 20 cents.

98. Flora of the Outlying Carboniferous Basins of Southwestern Missouri, by David White. 1893. 8°. 139 pp. 5 pl. Price 15 cents.

99. Record of North American Geology for 1891, by Nelson Horatio Darton. 1892. 8°. 73 pp. Price 10 cents.

100. Bibliography and Index of the Publications of the U. S. Geological Survey, 1879–1892, by Philip Creveling Warman. 1893. 8°. 495 pp. Price 25 cents.

101. Insect Fauna of the Rhode Island Coal Field, by Samuel Hubbard Scudder. 1893. 8°. 27 pp. 2 pl. Price 5 cents.

102. A Catalogue and Bibliography of North American Mesozoic Invertebrata, by Cornelius Breckinridge Boyle. 1892. 8°. 315 pp. Price 25 cents.

103. High Temperature Work in Igneous Fusion and Ebullition, chiefly in Relation to Pressure, by Carl Barus. 1893. 8°. 57 pp. 9 pl. Price 10 cents.

104. Glaciation of the Yellowstone Valley north of the Park, by Walter Harvey Weed. 1893. 8°. 41 pp. 4 pl. Price 5 cents.

105. The Laramie and the Overlying Livingstone Formation in Montana, by Walter Harvey Weed, with Report on Flora, by Frank Hall Knowlton. 1893. 8°. 68 pp. 6 pl. Price 10 cents.

106. The Colorado Formation and its Invertebrate Fauna, by T. W. Stanton. 1893. 8°. 288 pp. 45 pl. Price 20 cents.

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112. Earthquakes in California in 1892, by Charles D. Perrine. 1893. 8°. 57 pp. Price 10 cents.

113. A Report of Work done in the Division of Chemistry during the Fiscal Years 1891–'92 and 1892–'93. F. W. Clarke, Chief Chemist. 1893. 8°. 115 pp. Price 15 cents.

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116. A Geographic Dictionary of Massachusetts, by Henry Gannett. 1894. 8°. 126 pp. Price 15 cents.

117. A Geographic Dictionary of Connecticut, by Henry Gannett. 1894. 8°. 67 pp. Price 10 cents.

118. A Geographic Dictionary of New Jersey, by Henry Gannett. 1894. 8°. 131 pp. Price 15 cents.

119. A Geological Reconnaissance in Northwest Wyoming, by George Homans Eldridge. 1894. 8°. 72 pp. Price 10 cents.

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123. A Dictionary of Geographic Positions, by Henry Gannett. 1895. 8°. 183 pp. 1 pl. Price 15 cents.

124. Revision of North American Fossil Cockroaches, by Samuel Hubbard Scudder. 1895. 8°. 176 pp. 12 pl. Price 15 cents.

125. The Constitution of the Silicates, by Frank Wigglesworth Clarke. 1895. 8°. 109 pp. Price 15 cents.

126. A Mineralogical Lexicon of Franklin, Hampshire, and Hampden counties, Massachusetts, by Benjamin Kendall Emerson. 1895. 8°. 180 pp. 1 pl. Price 15 cents.

127. Catalogue and Index of Contributions to North American Geology, 1732–1891, by Nelson Horatio Darton. 1896. 8°. 1045 pp. Price 60 cents.

128. The Bear River Formation and its Characteristic Fauna, by Charles A. White. 1895. 8°. 108 pp. 11 pl. Price 15 cents.

129. Earthquakes in California in 1894, by Charles D. Perrine. 1895. 8°. 25 pp. Price 5 cents.

130. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for 1892 and 1893, by Fred Boughton Weeks. 1896. 8°. 210 pp. Price 20 cents.

131. Report of Progress of the Division of Hydrography for the Calendar Years 1893 and 1894, by Frederick Haynes Newell, Topographer in Charge. 1895. 8°. 126 pp. Price 15 cents.

132. The Disseminated Lead Ores of Southeastern Missouri, by Arthur Winslow. 1896. 8°. 31 pp. Price 5 cents.

133. Contributions to the Cretaceous Paleontology of the Pacific Coast: The Fauna of the Knoxville Beds, by T. W. Stanton. 1895. 8°. 132 pp. 20 pl. Price 15 cents.

134. The Cambrian Rocks of Pennsylvania, by Charles Doolittle Walcott. 1896. 8°. 43 pp. 15 pl. Price 5 cents.

135. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1894, by F. B. Weeks. 1896. 8°. 141 pp. Price 15 cents.

136. Volcanic Rocks of South Mountain, Pennsylvania, by Florence Bascom. 1896. 8°. 124 pp. 28 pl. Price 15 cents.

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138. Artesian-Well Prospects in the Atlantic Coastal Plain Region, by N. H. Darton. 1896. 8°. 228 pp. 19 pl. Price 20 cents.

139. Geology of the Castle Mountain Mining District, Montana, by W. H. Weed and L. V. Pirsson. 1896. 8°. 164 pp. 17 pl. Price 15 cents.

140. Report of Progress of the Division of Hydrography for the Calendar Year 1895, by Frederick Haynes Newell, Hydrographer in Charge. 1896. 8°. 356 pp. Price 25 cents.

141. The Eocene Deposits of the Middle Atlantic Slope in Delaware, Maryland, and Virginia, by William Bullock Clark. 1896. 8°. 167 pp. 40 pl. Price 15 cents.

142. A Brief Contribution to the Geology and Paleontology of Northwestern Louisiana, by T. Wayland Vaughan. 1896. 8°. 65 pp. 4 pl. Price 10 cents.

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144. The Moraines of the Missouri Coteau and their Attendant Deposits, by James Edward Todd. 1896. 8°. 71 pp. 21 pl. Price 10 cents.

145. The Potomac Formation in Virginia, by W. M. Fontaine. 1896. 8°. 149 pp. 2 pl. Price 15 cents.

146. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1895, by F. B. Weeks. 1896. 8°. 130 pp. Price 15 cents.

147. Earthquakes in California in 1895, by Charles D. Perrine, Assistant Astronomer in Charge of Earthquake Observations at the Lick Observatory. 1896. 8°. 23 pp. Price 5 cents.

148. Analyses of Rocks, with a Chapter on Analytical Methods, Laboratory of the United States Geological Survey, 1880 to 1896, by F. W. Clarke and W. F. Hillebrand. 1897. 8°. 306 pp. Price 20 cents.

149. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1896, by Fred Boughton Weeks. 1897. 8°. 152 pp. Price 15 cents.

150. The Educational Series of Rock Specimens collected and distributed by the United States Geological Survey, by Joseph Silas Diller. 1898. 8°. 398 pp. 47 pl. Price 25 cents.

151. The Lower Cretaceous Gryphæas of the Texas Region, by R. T. Hill and T. Wayland Vaughan. 1898. 8°. 139 pp. 35 pl. Price 15 cents.

152. A Catalogue of the Cretaceous and Tertiary Plants of North America, by F. H. Knowlton. 1898. 8°. 247 pp. Price 20 cents.

153. A Bibliographic Index of North American Carboniferous Invertebrates, by Stuart Weller. 1898. 8°. 653 pp. Price 35 cents.

154. A Gazetteer of Kansas, by Henry Gannett. 1898. 8°. 246 pp. 6 pl. Price 20 cents.

155. Earthquakes in California in 1896 and 1897, by Charles D. Perrine, Assistant Astronomer in Charge of Earthquake Observations at the Lick Observatory. 1898. 8°. 47 pp. Price 5 cents.

156. Bibliography and Index of North American Geology, Paleontology, Petrology, and Mineralogy for the Year 1897, by Fred Boughton Weeks. 1898. 8°. 130 pp. Price 15 cents.

157. The Gneisses, Gabbro-Schists, and Associated Rocks of Southeastern Minnesota, by Christopher Webber Hall. 1899. 8°. 160 pp. 27 pl. Price 45 cents.

158. The Moraines of Southeastern South Dakota and their Attendant Deposits, by James Edward Todd. 1899. 8°. 171 pp. 27 pl. Price 25 cents.

159. The Geology of Eastern Berkshire County, Massachusetts, by B. K. Emerson. 1899. 8°. 139 pp. 9 pl. Price 20 cents.

160. A Dictionary of Altitudes in the United States (Third Edition), compiled by Henry Gannett. 1899. 8°. 775 pp. Price 40 cents.

161. Earthquakes in California in 1898, by Charles D. Perrine, Assistant Astronomer in Charge of Earthquake Observations at the Lick Observatory. 1899. 8°. 31 pp. 1 pl. Price 5 cents.

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163. Flora of the Montana Formation, by Frank Hall Knowlton. 1900. 8°. 118 pp. Price 15 cents.

164. Reconnaissance in the Rio Grande Coal Fields of Texas, by Thomas Wayland Vaughan, including a report on Igneous Rocks from the San Carlos Coal Field, by E. C. E. Lord. 1900. 8°. 100 pp. 11 pl. and maps. Price 20 cents.

165. Contributions to the Geology of Maine, by Henry S. Williams and Herbert E. Gregory. 1900. 8°. 212 pp. 14 pl. Price 25 cents.

166. A Gazetteer of Utah, by Henry Gannett. 1900. 8°. 43 pp. 1 map. Price 15 cents.

167. Contributions to Chemistry and Mineralogy from the Laboratory of the United States Geological Survey, Frank W. Clarke, Chief Chemist. 1900. 8°. 166 pp. Price 15 cents.

168. Analyses of Rocks, Laboratory of the United States Geological Survey, 1880 to 1899, tabulated by F. W. Clarke, Chief Chemist. 1900. 8°. 308 pp. Price 20 cents.

169. Altitudes in Alaska, by Henry Gannett. 1900. 8°. 13 pp. Price 5 cents.

In preparation:

170. Idaho-Montana Boundary Line, by Richard Urquhart Goode.

— Bibliography and Catalogue of the Fossil Vertebrata of North America, by Oliver Perry Hay.

WATER-SUPPLY AND IRRIGATION PAPERS.

By act of Congress approved June 11, 1896, the following provision was made:

"*Provided*, That hereafter the reports of the Geological Survey in relation to the gauging of streams and to the methods of utilizing the water resources may be prin ed in octavo form, not to exceed one hundred pages in length and five thousand copies in number; one thousand copies of which shall be for the official use of the Geological Survey, one thousand five hundred copies shall be delivered to the Senate, and two thousand five hundred copies shall be delivered to the House of Representatives, for distribution."

Under this law the following papers have been issued:

1. Pumping Water for Irrigation, by Herbert M. Wilson. 1896. 8°. 57 pp. 9 pl.
2. Irrigation near Phœnix, Arizona, by Arthur P. Davis. 1897. 8°. 97 pp. 31 pl.
3. Sewage Irrigation, by George W. Rafter. 1897. 8°. 100 pp. 4 pl.
4. A Reconnoissance in Southeastern Washington, by Israel Cook Russell. 1897. 8°. 96 pp. 7 pl.
5. Irrigation Practice on the Great Plains, by Elias Branson Cowgill. 1897. 8°. 39 pp. 12 pl.
6. Underground Waters of Southwestern Kansas, by Erasmus Haworth. 1897. 8°. 65 pp. 12 pl.
7. Seepage Waters of Northern Utah, by Samuel Fortier. 1897. 8°. 50 pp. 3 pl.
8. Windmills for Irrigation, by Edward Charles Murphy. 1897. 8°. 49 pp. 8 pl.
9. Irrigation near Greeley, Colorado, by David Boyd. 1897. 8°. 90 pp. 21 pl.
10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker. 1898. 8°. 51 pp. 11 pl.
11. River Heights for 1896, by Arthur P. Davis. 1897. 8°. 100 pp.
12. Underground Waters of Southeastern Nebraska, by N. H. Darton. 1898. 8°. 55 pp. 21 pl.
13. Irrigation Systems in Texas, by William Ferguson Hutson. 1898. 8°. 67 pp. 10 pl.
14. New Tests of Pumps and Water-Lifts used in Irrigation, by O. P. Hood. 1898. 8°. 91 pp. 1 pl.
15. Operations at River Stations, 1897, Part I. 1898. 8°. 100 pp.
16. Operations at River Stations, 1897, Part II. 1898. 8°. 101–200 pp.
17. Irrigation near Bakersfield, California, by C. E. Grunsky. 1898. 8°. 96 pp. 16 pl.
18. Irrigation near Fresno, California, by C. E. Grunsky. 1898. 8°. 94 pp. 14 pl.
19. Irrigation near Merced, California, by C. E. Grunsky. 1899. 8°. 59 pp. 11 pl.
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21. Wells of Northern Indiana, by Frank Leverett. 1899. 8°. 82 pp. 2 pl.
22. Sewage Irrigation, Part II, by George W. Rafter. 1899. 8°. 100 pp. 7 pl.
23. Water-Right Problems of Bighorn Mountains, by Elwood Mead. 1899. 8°. 62 pp. 7 pl.
24. Water Resources of the State of New York, Part I, by G. W. Rafter. 1899. 8°. 99 pp. 13 pl.
25. Water Resources of the State of New York, Part II, by G. W. Rafter. 1899. 8°. 101–200 pp. 12 pl.
26. Wells of Southern Indiana (Continuation of No. 21), by Frank Leverett. 1899. 8°. 64 pp.
27. Operations at River Stations, 1898, Part I. 1899. 8°. 100 pp.
28. Operations at River Stations, 1898, Part II. 1899. 8°. 101–200 pp.
29. Wells and Windmills in Nebraska, by Erwin H. Barbour. 1899. 8°. 85 pp. 27 pl.
30. Water Resources of the Lower Peninsula of Michigan, by Alfred C. Lane. 1899. 8°. 97 pp. 7 pl.
31. Lower Michigan Mineral Waters, by Alfred C. Lane. 1899. 8°. 97 pp. 4 pl.
32. Water Resources of Puerto Rico, by Herbert M. Wilson. 1899. 8°. 48 pp. 17 pl.
33. Storage of Water on Gila River, Arizona, by Joseph B. Lippincott. 1900. 8°. 98 pp. 33 pl.
34. Geology and Water Resources of SE. South Dakota, by J. E. Todd. 1900. 8°. 34 pp. 19 pls.

In preparation:

35. Operations at River Stations, 1899, Part I.
36. Operations at River Stations, 1899, Part II.
37. Operations at River Stations, 1899, Part III.
38. Operations at River Stations, 1899, Part IV.
39. Operations at River Stations, 1899, Part V.

TOPOGRAPHIC MAP OF THE UNITED STATES.

When, in 1882, the Geological Survey was directed by law to make a geologic map of the United States there was in existence no suitable topographic map to serve as a base for the geologic map. The preparation of such a topographic map was therefore immediately begun. About one-fifth of the area of the country, excluding Alaska, has now been thus mapped. The map is published in atlas sheets, each sheet representing a small quadrangular district, as explained under the next heading. The separate sheets are sold at 5 cents each when fewer than 100 copies are purchased, but when they are ordered in lots of 100 or more copies, whether of the same sheet or of different sheets, the price is 2 cents each. The mapped areas are widely scattered, nearly every State being represented. About 900 sheets have been engraved and printed; they are tabulated by States in the Survey's "List of Publications," a pamphlet which may be had on application.

The map sheets represent a great variety of topographic features, and with the aid of descriptive text they can be used to illustrate topographic forms. This has led to the projection of an educational series of topographic folios, for use wherever geography is taught in high schools, academies, and colleges. Of this series the first folio has been issued, viz:

1. Physiographic types, by Henry Gannett, 1898, folio, consisting of the following sheets and 4 pages of descriptive text: Fargo (N. Dak.-Minn.), a region in youth; Charleston (W.Va.), a region in maturity; Caldwell (Kans.), a region in old age; Palmyra (Va.), a rejuvenated region; Mount Shasta, (Cal.), a young volcanic mountain; Eagle (Wis.), moraines; Sun Prairie (Wis.), drumlins; Donaldsonville (La.), river flood plains; Boothbay (Me.), a fiord coast; Atlantic City (N. J.), a barrier-beach coast.

2. Physiographic types, by Henry Gannett, 1900, folio, consisting of the following sheets and 11 pages of descriptive text: Norfolk (Va.-N. C.), a coast swamp; Marshall (Mo.), a graded river;

Lexington (Nebr.), an overloaded stream; Harrisburg (Pa.), Appalachian ridges; Poteau Mountain (Ark.-Ind. T.), Ozark ridges; Marshall (Ark.), Ozark Plateau; West Denver (Colo.), hogbacks; Mount Taylor (N. Mex.), volcanic peaks, plateaus, and necks; Cucamonga (Cal.), alluvial cones; Crater Lake special (Oreg.), a crater.

GEOLOGIC ATLAS OF THE UNITED STATES.

The Geologic Atlas of the United States is the final form of publication of the topographic and geologic maps. The atlas is issued in parts, progressively as the surveys are extended, and is designed ultimately to cover the entire country.

Under the plan adopted the entire area of the country is divided into small rectangular districts (designated *quadrangles*), bounded by certain meridians and parallels. The unit of survey is also the unit of publication, and the maps and descriptions of each rectangular district are issued as a folio of the Geologic Atlas.

Each folio contains topographic, geologic, economic, and structural maps, together with textual descriptions and explanations, and is designated by the name of a principal town or of a prominent natural feature within the district.

Two forms of issue have been adopted, a "library edition" and a "field edition." In both the sheets are bound between heavy paper covers, but the library copies are permanently bound, while the sheets and covers of the field copies are only temporarily wired together.

Under the law a copy of each folio is sent to certain public libraries and educational institutions. The remainder are sold at 25 cents each, except such as contain an unusual amount of matter, which are priced accordingly. Prepayment is obligatory. The folios ready for distribution are listed below.

No.	Name of sheet	State.	Limiting meridians.	Limiting parallels.	Area, in square miles.	Price, in cents.
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2	Ringgold	Georgia Tennessee	85°–85° 30′	34° 30′–35°	980	25
3	Placerville	California	120° 30′–121°	38° 30′–39°	932	25
4	Kingston	Tennessee	84° 30′–85°	35° 30′–36°	969	25
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6	Chattanooga	Tennessee	85°–85° 30′	35°–35° 30′	975	25
7	Pikes Peak (out of stock)	Colorado	105°–105° 30′	38° 30′–39°	932	25
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13	Fredericksburg	Maryland Virginia	77°–77° 30′	38°–38° 30′	938	25
14	Staunton	Virginia West Virginia	79°–79° 30′	38°–38° 30′	938	25
15	Lassen Peak	California	121°–122°	40°–41°	3,634	25
16	Knoxville	Tennessee North Carolina	83° 30′–84°	35° 30′–36°	925	25
17	Marysville	California	121° 30′–122°	39°–39° 30′	925	25
18	Smartsville	California	121°–121° 30′	39°–39° 30′	925	25
19	Stevenson	Alabama Georgia Tennessee	85° 30′–86°	34° 30′–35°	980	25
20	Cleveland	Tennessee	84° 30′–85°	35°–35° 30′	975	25
21	Pikeville	Tennessee	85°–85° 30′	35° 30′–36°	969	25
22	McMinnville	Tennessee	85° 30′–86°	35° 30′–36°	969	25
23	Nomini	Maryland Virginia	76° 30′–77°	38°–38° 30′	938	25
24	Three Forks	Montana	111°–112°	45°–46°	3,354	50
25	Loudon	Tennessee	84°–84° 30′	35° 30′–36°	969	25
26	Pocahontas	Virginia West Virginia	81°–81° 30′	37°–37° 30′	951	25
27	Morristown	Tennessee	83°–83° 30′	36°–36° 30′	963	25
28	Piedmont	Maryland West Virginia	79°–79° 30′	39°–39° 30′	925	25
29	Nevada City: Nevada City Grass Valley Banner Hill	California	121° 00′ 25″–121° 03′ 45″ 121° 01′ 35″–121° 05′ 04″ 120° 57′ 05″–121° 00′ 25″	39° 13′ 50″–39° 17′ 16″ 39° 10′ 22″–39° 13′ 50″ 39° 13′ 50″–39° 17′ 16″	11.65 12.09 11.65	50
30	Yellowstone National Park: Gallatin Canyon Shoshone Lake	Wyoming	110°–111°	44°–45°	3,412	75
31	Pyramid Peak	California	120°–120° 30′	38° 30′–39°	932	25
32	Franklin	Virginia West Virginia	79°–79° 30′	38° 30′–39	932	25
33	Briceville	Tennessee	84°–84° 30′	36°–36° 30′	963	25
34	Buckhannon	West Virginia	80°–80° 30′	38° 30′–39°	932	25
35	Gadsden	Alabama	86°–86° 30′	34°–34° 30′	986	25
36	Pueblo	Colorado	104° 30′–105°	38°–38° 30′	938	50
37	Downieville	California	120° 30′–121°	39° 30′–40°	919	25

No.	Name of sheet.	State.	Limiting meridians.	Limiting parallels.	Area, in square miles.	Price, in cents.
38	Butte Special	Montana	112° 29′ 30″–112° 36′ 42″	45° 59′ 28″–46° 02′ 54″	22.80	50
39	Truckee	California	120°–120° 30′	39°–39° 30′	925	25
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42	Nueces	Texas	100°–100° 30′	29° 30′–30°	1,035	25
43	Bidwell Bar	California	121°–121° 30′	39° 30′–40°	918	25
44	Tazewell	Virginia; West Virginia	81° 30′–82°	37°–37° 30′	950	25
45	Boise	Idaho	116°–116° 30′	43° 30′–44°	864	25
46	Richmond	Kentucky	84°–84° 30′	37° 30′–38°	944	25
47	London	Kentucky	84°–84° 30′	37°–37° 30′	950	25
48	Tenmile District Special	Colorado	106° 8′–106° 16′	39° 22′ 30″–39° 30′ 30″	55	25
49	Roseburg	Oregon	123°–123° 30′	43°–43° 30′	871	25
50	Holyoke	Massachusetts; Connecticut	72° 30′–73°	42°–42° 30′	885	50
51	Big Trees	California	120°–120° 30′	38°–38° 30′	938	25
52	Absaroka: Crandall, Ishawooa	Wyoming	109° 30′–110°	44°–44° 30′	1,706	25
53	Standingstone	Tennessee	85°–85° 30′	36°–36° 30′	963	25
54	Tacoma	Washington	122°–122° 30′	47°–47° 30′	812	25
55	Fort Benton	Montana	110°–111°	47°–48°	3,273	25
56	Little Belt Mountains	Montana	110°–111°	46°–47°	3,295	25
57	Telluride	Colorado	107° 45′–108°	37° 45′–38°	236	25
58	Elmoro	Colorado	104°–104° 30′	37°–37° 30′	950	25

STATISTICAL PAPERS.

Mineral Resources of the United States [1882], by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

Mineral Resources of the United States, 1883 and 1884, by Albert Williams, jr. 1885. 8°. xiv, 1016 pp. Price 60 cents.

Mineral Resources of the United States, 1885. Division of Mining Statistics and Technology. 1886. 8°. vii, 576 pp. Price 40 cents.

Mineral Resources of the United States, 1886, by David T. Day. 1887. 8°. viii, 813 pp. Price 50 cents.

Mineral Resources of the United States, 1887, by David T. Day. 1888. 8°. vii, 832 pp. Price 50 cents.

Mineral Resources of the United States, 1888, by David T. Day. 1890. 8°. vii, 652 pp. Price 50 cents.

Mineral Resources of the United States, 1889 and 1890, by David T. Day. 1892. 8°. viii, 671 pp. Price 50 cents.

Mineral Resources of the United States, 1891, by David T. Day. 1893. 8°. vii, 630 pp. Price 50 cents.

Mineral Resources of the United States, 1892, by David T. Day. 1893. 8°. vii, 850 pp. Price 50 cents.

Mineral Resources of the United States, 1893, by David T. Day. 1894. 8°. viii, 810 pp. Price 50 cents.

On March 2, 1895, the following provision was included in an act of Congress:

"*Provided*, That hereafter the report of the mineral resources of the United States shall be issued as a part of the report of the Director of the Geological Survey."

In compliance with this legislation the following reports have been published:

Mineral Resources of the United States, 1894, David T. Day, Chief of Division. 1895. 8°. xv, 646 pp., 23 pl.; xix, 735 pp., 6 pl. Being Parts III and IV of the Sixteenth Annual Report.

Mineral Resources of the United States, 1895, David T. Day, Chief of Division. 1896. 8°. xxiii, 542 pp., 8 pl. and maps; iii, 543–1058 pp., 9–13 pl. Being Part III (in 2 vols.) of the Seventeenth Annual Report.

Mineral Resources of the United States, 1896, David T. Day, Chief of Division. 1897. 8°. xii, 642 pp., 1 pl.; 643–1400 pp. Being Part V (in 2 vols.) of the Nineteenth Annual Report.

Mineral Resources of the United States, 1897, David T. Day, Chief of Division. 1898. 8°. viii, 651 pp., 11 pl.; viii, 706 pp. Being Part VI (in 2 vols.) of the Nineteenth Annual Report.

Mineral Resources of the United States, 1898, David T. Day, Chief of Division. 1899. 8°. viii, 616 pp.; ix, 804 pp., 1 pl. Being Part VI (in 2 vols.) of the Twentieth Annual Report.

The money received from the sale of the Survey publications is deposited in the Treasury, and the Secretary of that Department declines to receive bank checks, drafts, or postage stamps; all remittances, therefore, must be by MONEY ORDER, made payable to the Director of the United States Geological Survey, or in CURRENCY—the exact amount. Correspondence relating to the publications of the Survey should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

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