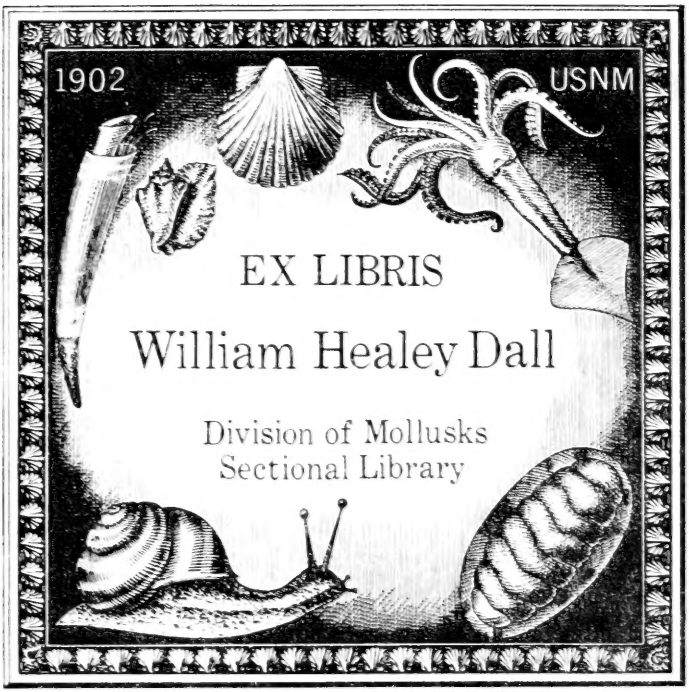

1902
USNM
EX LIBRIS
William Healey Dall
Division of Mollusks
Sectional Library

CONTRIBUTIONS FROM THE GEOLOGICAL DEPARTMENT
OF COLUMBIA UNIVERSITY
VOL. XXI. NO. 1

THE PHYLOGENY OF CERTAIN CERITHIIDÆ

BY

ELVIRA WOOD, A. M.

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Pure Science, Columbia University

[Reprinted from the ANNALS of the New York Academy of Sciences, Vol. XX, No. 1, Part I, pp. 1–92, Pll. I–IX. Published 14 May, 1910]

CONTRIBUTIONS FROM THE GEOLOGICAL DEPARTMENT
OF COLUMBIA UNIVERSITY
VOL. XXI. NO. 1

THE PHYLOGENY OF CERTAIN CERITHIIDÆ

BY

ELVIRA WOOD, A. M.

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Faculty of Pure Science, Columbia University

---

[Reprinted from the ANNALS of the New York Academy of Sciences, Vol. XX, No. 1, Part I, pp. 1–92, Pll. I–IX. Published 14 May, 1910]

[Annals N. Y. Academy of Sciences, Vol. XX, No. 1, Part I, pp. 1–92, Pll. I–IX. 14 May, 1910]

THE PHYLOGENY OF CERTAIN CERITHIIDÆ

By Elvira Wood

(*Presented in abstract before the Academy, February 7, 1910*)

CONTENTS

Note. The author alone is responsible for the terminology used throughout this article. Editor.

I. Introduction

The literature of the genus *Cerithium* is already extensive, including papers which treat the subject from both the paleontological and the zoölogical point of view. The genus is treated to a greater or less extent in all general works on conchology, but such treatment is confined to descriptions of the genus and of the different species referred to it, without any attempt to trace phylogenetic relationships, and the same is true, with few exceptions, of paleontological papers on the subject.

Recently M. Cossmann [1906] has published a monograph on the Cerithiidæ, in which he takes account of the relationship between different forms and presents an elaborate classification of the various genera and sub-genera included within the family.

M. Cossmann's conclusions are largely based on characters appearing late in the life history of the individual, and he lays especial stress upon the various features of the aperture. The present paper, being founded upon a different method of work, as explained below, necessarily reaches conclusions somewhat different from those of M. Cossmann.

A complete bibliography of the works consulted in the preparation of this paper is given on pages 86 to 91.

The principles of phylogenetic development discovered and formulated by Häckel, Hyatt, Cope and others have been successfully applied in studies of the phylogeny of several groups of greater or less extent, such as Hyatt's studies on the Cephalopoda, Jackson's on the Echinodermata and Grabau's on the Fusidæ. The present paper is an attempt to apply these principles in working out the relationships of such species of *Cerithium* as could be obtained.

The fundamental law upon which all the work is based is the law of morphogenesis, which has been stated by Hyatt[1] as follows:

> A natural classification may be made by means of a system of analysis in which the individual is the unit of comparison, because its life in all its phases, morphological and physiological, healthy or pathological, embryo, larva, adolescent, adult and old (ontogeny), correlates with the morphological and physiological history of the group to which it belongs (phylogeny).

According to this principle, a study of the life history of individuals furnishes a ready and most reliable means of tracing the development of the group to which they belong. Hence, in the present investigation, the starting point has been the study of individual development and a comparison of the records thus obtained. Similarity in the character

[1] A. Hyatt: "Genesis of the Arietidæ," p. viii. 1889.

and order of introduction of the various features of the shell are indications of relationship, and the comparison of a sufficient number of life histories will furnish a phylogenetic tree whose completeness depends upon the abundance and perfection of the material available for study. In making such comparisons, it is important to take account of parallelism in development, in consequence of which similar characteristics may appear for a greater or less portion of the life history in individuals belonging to divergent groups. An illustration of this is to be found in *Vicinocerithium bouei* Desh. and *V. parallelum* sp. nov. of the Eocenic of the Paris basin. These shells are closely similar in the adult and have been referred to the same species, but they differ in developmental history. Both have, in the adult, one extremely prominent spiral around the middle of the whorl, with strong ribs crossing it and a less prominent spiral below. The remainder of the surface is covered with spirals of secondary, tertiary, and higher orders. In the young, *Vicinocerithium bouei* has three spirals, the lowest of which is the most prominent (plate VII, fig. 6). Later, in the growth of the shell, finer spirals are intercalated, and all are crossed by ribs. At a still later stage, the upper spiral of the three primary ones becomes the most prominent and finally develops into the strong carina of the adult (plate VIII, fig. 6, and plate IX, figs. 5, 6). *Vicinocerithium parallelum* also begins with three spirals, of which the lowest one is the most prominent, but ribs are present as soon as the third spiral appears (plate VII, figs. 4, 5). Later, the median spiral becomes as prominent as the lower, and for several volutions the two are equally prominent, while the upper spiral diminishes in proportion, and additional fine spirals are introduced on the shoulder thus formed (plate VIII, figs. 4, 5). The median spiral continues to increase until it forms the carina of the adult (plate IX, figs. 3, 4), a feature which was formed in the preceding species by increase in the upper spiral of the three primary ones. These shells are parallel in the adult, but differ in development and are to be traced to different ancestors.

The phylogenetic record is obscured by the fact that not all of the history of a group is expressed in the ontogeny of a single species. As new characters are introduced in the evolution of the group the record becomes too long to be repeated during the lifetime of a single individual, and each of the ancestral stages occupies a shorter and shorter portion of the length of the shell, until some stages disappear altogether. An individual thus shows the adult characteristics of its ancestors at an early period of its life history. These facts are expressed as follows in Hyatt's law of acceleration:[2]

[2] A. Hyatt: "Genesis of the Arietidæ," p. ix. 1889.

All modifications and variations in progressive series tend to appear first in the adolescent or adult stages of growth, and then to be inherited in successive descendants at earlier and earlier stages according to the law of acceleration, until they either become embryonic, or are crowded out of the organization, and replaced in the development by characteristics of later origin.

This law is well illustrated in the development of two Paris Basin shells, *Potamidopsis tricarinata* LAMARCK of the Calcaire Grossier and *Potamidopsis roissyi* DESH. of the Sables Moyens. In the young, the surface ornamentation of the latter species consists of two rows of nodes, the lower being the more prominent. The same is true of the young *P. tricarinata,* but this stage lasts much longer in the latter than in the former species. The stage with two rows of nodes is followed by one in which there is an additional row of fine nodes intercalated between the two, and the lowest row is still the most prominent. At about the ninth volution of *P. roissyi* this ornamentation is fully developed, and it represents the adult ornamentation of *P. tricarinata,* which is found at a lower geological horizon. The adult characteristics of *P. tricarinata* last for hardly more than one volution on *P. roissyi,* which soon develops its own characteristic adult ornamentation of three rows of nodes, the uppermost of which are largest and transversely elongated. (See Deshayes, 1824, plate L, fig. 13.) *P. tricarinata* is the ancestor from which *P. roissyi* developed, and the latter records this fact in its ontogeny.

Two individuals belonging to the same phyletic series and living during the same time period frequently do not reach the same degree of complexity in structure. One may retain its primitive characteristics until late in its life history, only diverging from the ancestral type on becoming fully adult, while another may pass through its ancestral stages early in life and show a long succession of characteristics of later origin. The former is retarded in its development in comparison with the latter. *Cerithium tuberosum* is an illustration of a retarded shell, retaining, as it does, the two equally strong spirals until the tenth volution, the whorls only acquiring their acute angled outline on the twelfth volution. *Cerithium adansoni* passes through the same ancestral stages as *C. tuberosum,* but loses the obtuse angled outline of the whorls at about the sixth volution and after that acquires nodes, blunt spines and numerous additional spirals. It is a highly accelerated recent shell.

Acceleration and retardation are expressed not only in the ontogeny of the individual as a whole, but each character may be independently accelerated or retarded. *Cerithium graciliforme* (Tryon, 1887, plate XXII, fig. 77) retains the obtuse angled outline of the whorls to the ninth volution, while *C. echinatum* (Kobelt, 1898, plate XX, fig. 6) loses

this type of outline at about the seventh volution. *C. graciliforme* is therefore a more retarded shell than *C. echinatum* in this respect. In the acquisition of nodes, however, it is accelerated, for it acquires nodes on the ninth volution, while *C. echinatum* does not develop them until the thirteenth volution. This differential acceleration and retardation often produces a wide difference in the appearance of adult shells, without the introduction of any new character.

Individuals having the same development for a greater or less portion of their life history, but differing in the adolescent or adult stages, may be regarded as divergent descendants from the same ancestral stock. A striking illustration of such divergence is found among recent species of Cerithium in the group of which *C. tuberosum* may be taken as a type.

In addition to the types of variation already noted, there is a kind of individual variation which seems to differ from all, and that is in the slight accentuation of the characters of the shell from their earliest appearance to the last volution. This is seen in individuals of *Cerithium lamellosum,* some of which show secondary spirals distinctly on all the whorls, while on others these spirals are but faintly indicated. This may be due to some condition in the environment, possibly to more lime in the water or to better food supply in the case of the well-marked individuals, or it may be due only to an inherent tendency to variation.

Acceleration and retardation and the introduction of new characters may cause divergence sufficient to serve as a basis for the separation of species, or they may appear to a less degree in individuals referred to the same species. Where many individuals are present, we find gradations in the various characters compelling us to establish varieties, and the more extensive the material the more insensible the gradations become, so that if our collections were sufficiently extensive, it would doubtless be possible to establish a perfect gradational series among various species of *Cerithium,* as in the classic example of the *Planorbis* of Steinheim.[3]

As might be expected, the greatest difficulty encountered in determining the phylogeny of *Cerithium* has been due to the scarcity of material. It has been impossible to secure specimens of shells from the early Mesozoic horizons which might be expected to furnish the ancestors of the forms occurring in such abundance in the Eocenic. A similar difficulty arises in connection with late Tertiary and early Quaternary material in which we should expect to find the connecting links between Eocenic and recent species. In the absence of specimens of shells, figures and descriptions have been freely used, but the figures of the early portions of

[3] A. HYATT: Mem. Boston Soc. Nat. Hist. 1880.

the shell are unreliable, and in all the older works they were considered too unimportant even to be mentioned in the descriptions. In most later works, also, insufficient attention has been given to the character of the protoconch and early conch stages of the shell. For this reason all suggestions concerning phylogeny which are based on figures and descriptions alone are to be considered as merely theoretical and as subject to revision, if actual specimens become available.

Acknowledgments and thanks are extended with pleasure to those who have rendered assistance during the preparation of this paper; to Dr. Carlotta J. Maury for the loan of Oligocenic shells from the Paris Basin, and to Dr. Amadeus W. Grabau for many helpful suggestions The writer desires especially to express her appreciation of the very liberal manner in which Mr. Samuel Henshaw, Director of the Museum of Comparative Zoölogy, has placed at her disposal the resources of the collection in his care. The following officers of the American Museum of Natural History have also been most generous in providing opportunities for the study of the material in that museum: Dr. Hermon C. Bumpus, Director, and Prof. R. P. Whitfield and Dr. E. O. Hovey, Curators of the Department of Geology and Invertebrate Paleontology. Valuable assistance in collecting the literature of the subject has also been given by the librarians of both the above mentioned institutions.

II. Selection of a Genotype for Cerithium sensu stricto

The selection of a type of the genus *Cerithium* has given rise to much difference of opinion, and the determination of the proper species to be used as a standard of comparison for other species of the genus has led to a revision of the literature on the subject.

The name *Cerithium* was first used by Fabii Columnæ [1616] in his treatise, "De aquatilibus aliisque nonnulis animalibus." He figures a shell under the name of *Buccinum tuberosum,* which in his description he says should be referred to "Cerithia." On the margin of the page opposite this reference are the two names *Buccinum tuberosum* and *Cerithium parvum.* No description or figure accompanies the latter name, and it is possible that Columnæ intended to substitute this name for that of *Buccinum tuberosum,* for the shell figured on page 53 of his work; but since this is not definitely stated, the specific name *tuberosum* is retained for the shell figured and referred to *Cerithium.* Columnæ gives no description of the genus *Cerithium,* and his description of the species *tuberosum* is meager, but his figure of the latter is sufficiently good clearly to identify his shell with the one described by Lamarck [1843, p. 292]

under the name of *Cerithium erythræonense* and by Sowerby [1855] and Reeve [1866] as *Cerithium tuberosum.*

Adanson [1757] described and figured a shell from Senegal which he believed to be identical with that of Columnæ. His figure closely resembles *Cerithium tuberosum,* except in the aperture, which is more like that of the shell from Senegal described by Bruguière as *Cerithium adansoni.* Adanson was describing a shell collected by himself at Senegal, and his description seems to indicate quite definitely that his shell is really *C. adansoni* BRUGUIÈRE, since it mentions the strongly spinose tubercles not found on *C. tuberosum* and gives the size as two inches, or about 50 mm. The youngest specimen of *C. tuberosum* seen in the collections studied was 57 mm. long, and full-grown individuals are 64 mm. or more in length. The similarity in the figures may perhaps be accounted for by a tendency on the part of the artist to imitate a figure already published and believed to be of the same species. Adanson named his shell simply "Le Cerite," and this name would not stand, since it does not conform to the binomial nomenclature.

The first published description of the genus *Cerithium* is by Bruguière [1792]. He divides the genus into three groups, the first of which corresponds to *Vertagus* KLEIN and the second to *Cerithium* sensu stricto. The first species of this second group is *Cerithium nodulosum,* which the author believed to be of the same species as *C. tuberosum* COLUMNÆ, since he cites the latter species in his synonymy. The description, however, corresponds with *C. nodulosum,* as the name is now applied. The second species of this group is *C. adansoni,* the description of which corresponds closely with that of "Le Cerite" by Adanson, and Bruguière states definitely that he is describing a shell of the same species as Adanson's shell.

At a still earlier date Martyn [1784] figured under the generic name of *Clava* four species which Dall [1907, p. 366] now refers to *Cerithium,* as follows:

1. *Clava rugata* MARTYN = *Murex asper* LINNÉ.
2. *Clava herculea* MARTYN = *Cerithium ebeninum* BRUGUIÈRE.
3. *Clava maculata* MARTYN = *Cerithium clava* BRUGUIÈRE.
4. *Clava rubus* MARTYN = *Cerithium echinatum* LAMARCK.

On the strength of these figures, Dall [ibid., p. 368] claims for Martyn the first recognition of the genus *Cerithium,* but Martyn published no descriptions either generic or specific, and it hardly seems that these figures alone furnish a valid reason for changing the name of the genus from *Cerithium* to *Clava* MARTYN. *Clava* has long been established as

the name of a genus of hydroids, and the confusion that would arise in the literature furnishes another reason for avoiding such a change.

In the first published description of the genus *Cerithium* by Bruguière no genotype was designated, and the first to make a definite selection was Lamarck [1799].[4] He chose *Murex aluco* LINNÉ, which was described by Bruguière with the name of *Cerite chenille*. This shell belongs to the first of the three groups described by Bruguière, and it might well remain the type of that group to which the name *Pseudovertagus* has since been applied. It does not belong in the same group with the shell to which Columnæ gave the name of *Cerithium*, as will be seen by comparing the life histories of the two species as given on plate III, figs. 2, 3, 4; plate IV, figs. 2, 3; plate V, figs. 1, 2; plate III, fig. 6; plate IV, figs. 6, 7; plate V, figs. 5, 6, and plate VI, figs. 4, 5. Lamarck himself seems to have been dissatisfied with his own choice of a genotype, for two years later [1801, p. 85] he redescribed the genus and mentioned *Cerithium nodulosum* as an example of it.

Later authors have adjusted the claims of their predecessors in various ways. Most credit the genus to Bruguière, but others refer it to Lamarck or Adanson. A few of these may be mentioned: thus Montfort [1810] credits the genus to Lamarck, choosing the genotype selected by him in 1799. Link [1807] and Schumacher [1817] solve the difficulty by dividing the genus into two groups, the former following Lamarck, in 1799, for his first group, and Bruguière, with *Cerithium adansoni* as an example of his second group, to which he gives the name *Aluco*. Schumacher retains the name *Cerithium* for both his groups, crediting them to Lamarck, with *C. aluco* as genotype for one and *C. nodulosum* for the other. Among the authors who refer the genus to Adanson are Deshayes [1824], d'Orbigny [1842-1843], Sowerby [1855], Fischer [1887] and Tryon [1887]. Bruguière, being the first to describe the genus as such, is still more widely recognized, and a few of the authors who have followed him are Swainson [1840], Reeve [1866], Cossmann [1906] and Dall [1907].

In the choice of a genotype equal diversity is shown, for Fischer, while he refers the genus to Adanson, chooses *C. nodulosum* as the genotype. Deshayes is consistent in choosing for the type of the genus *C. adansoni*. Of those who refer the genus to Bruguière, Swainson and Cossmann choose *C. nodulosum*, and Dall and Dautzenberg and Dollfus [1882-1885] choose *Murex aluco* LINNÉ as the type of the genus.

Summarizing the facts already given, it appears that Columnæ was

[4] The author has been unable to see this work, and is indebted to Dall [1907, p. 364] for the reference.

the first to propose the name *Cerithium*, which he did in connection with a description and an easily determinable figure of a well-known species. He gave it a name which conforms to the Linnæan system of nomenclature, and it appears to the writer that these facts are sufficient ground for referring the genus to Columnæ. Apparently the only reason for discrediting his work and referring the genus to a later author is found in the rule of the International Congress of Zoölogists, according to which the date 1758 is taken as the starting point of the binomial nomenclature. This rule is useful, but to enforce it indiscriminately would do great injustice to the pioneers in science whose work conforms with the standards at present in use. This is especially true when, as in the present case, there are additional reasons for recognizing the earlier work. In actual practice the rule is not closely followed, since many genera described previous to the year 1758 are still retained under the name of the original author. For example, among the Cephalopoda we have *Belemnites* LISTER, 1678; *Orthoceras* BREYN, 1732; *Lituites* BREYN, 1732, and among Gastropoda *Planorbis* GUETTARD, 1756, and *Haliotis* LINNÉ, 1735. Furthermore, the reference of the genus to Columnæ would have the great practical advantage of settling at once the vexed question of a genotype, and this type is of such a character that it would, on the basis of phylogenetic studies, retain within the genus *Cerithium* a large number of the species known by that name throughout the literature of the subject.

The work of Adanson, like that of Columnæ, is pre-Linnæan, and it furthermore fails to conform to the binomial nomenclature.

If the rule of discrediting pre-Linnæan descriptions be rigidly adhered to, the genus would be referred to Bruguière, and the choice of *Cerithium nodulosum* as genotype seems to come nearest to that author's own conception of the genus. The choice of *Murex aluco* for a genotype, as at first suggested by Lamarck [1799], would result in substituting the name *Cerithium* for *Pseudovertagus* and the use of a new name for the group to which the former was originally applied. This would cause great confusion in the literature and make the genus a different one from what was intended by the early writers on the subject, since Bruguière was obviously trying to follow both Columnæ and Adanson in describing first, *C. nodulosum*, which he believed to be identical with Columnæ's shell, and second, *C. adansoni*, which was "Le Cerite" of Adanson. He merely fell into the common error of including under one name groups of shells which he himself recognized to be different.

Cerithium nodulosum bears a superficial resemblance to *C. tuberosum* and has been considered by some authors to be of the same species. It is, however, quite distinct. According to the youngest specimens of

C. nodulosum at first obtainable, it seemed that the two species belonged to the same phyletic series, but the absence of ribs on a somewhat younger individual, received later, throws some doubt upon this supposed relationship. The point can only be determined by a study of younger stages of *C. nodulosum* than are now available, and in case the latter shell proves to be different in its development from *C. tuberosum,* it must represent a very restricted group, for among species now referred to *Cerithium* the absence of ribs on individuals having a well developed shoulder is an extremely rare feature. In this case also, with *C. nodulosum* as genotype, the name *Cerithium* would be used in a very restricted sense, and a new name would have to be given to the genus as understood by Columnæ and Bruguière.

For the purposes of this paper, *Cerithium tuberosum* COLUMNÆ will be used as a standard of comparison for other species of the genus.

III. GENUS CERITHIUM Columnæ

1616. *Cerithium* FABII COLUMNÆ, De Aquatilibus, pp. 53, 57.
1784. *Clava* MARTYN, The Universal Conchologist, London.
1792. *Cerithium* BRUGUIÈRE, Hist. Nat. des Vers., Encyc. Méth., I, pt. 2, 467.
1799. *Cerithium* LAMARCK, Prodrome nouv. class., p. 73 (not seen).
1801. *Cerithium* LAMARCK, Syst. des animaux sans vert., p. 85.
1898. *Cerithium* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 2.
1906. *Cerithium* COSSMANN, Essais de Paléoconch. Comp., VII, 65.

FIG. 1.—*Cerithium tuberosum.* Copy of Columnæ's original figure × 1.

After the description of *Buccinum maximum* and mention of other species of *Buccinum,* Columnæ refers to this species as follows:

Sed rariorem hanc parui Buccini tuberosi candidi, ad Cerithia referendam, oris margine supra tubulum elata, et incumbens non inuersa ut in alijs magnis

effigiem omittere noluimus, quanimus huiusmodi alias differentias habeamus, colore cinero orbitas depressioribus, magis densis minutisque tuberculis asperas.

While this description is meager, it is sufficient, with the aid of the figure, for the identification of the species designated. The characterization of the shell as a small one excludes *Cerithium nodulosum*, with which it has been confused. The reference to the margin of the mouth as raised above the canal and resting upon it is like *C. tuberosum* and unlike *C. adansoni*. The figure also resembles *C. tuberosum* in its high spire, in the character of the aperture and of the ornamentation, so far as this is indicated by the imperfect figure.

Description of *Cerithium* by Bruguière:

Genre de coquilles univalves, uniloculaire, à spire regulière, qui a pour caractère,

Une coquille turriculée, l'ouverture oblique, terminée à la base par un canal étroit, totalement recourbé, ou moyennement recourbé, ou droit et très-court, mais jamais échancré.

Genotype selected by Lamarck, 1799, *Murex aluco* LINNÉ; 1801, *Cerithium nodulosum* BRUGUIÈRE.

The protoconch of the genus *Cerithium* has been observed in many species and is found to be uniform in character. It forms a low, regular spiral of usually about one and one-half volutions. The limits of the protoconch are not sharply defined, as the ornament begins faintly at first and becomes gradually stronger, but for convenience the protoconch has been assumed to end where the first traces of ornament appear. Practically the only difference found in the earliest whorls of the species studied is in the extent of the smooth portion of the shell, which varies from one and one-fourth to one and one-half volutions. This is due to difference in degree of acceleration, the more accelerated forms having the ornamentation crowded back to an early stage in shell growth.

The surface ornamentation of *Cerithium* consists of spirals, ribs and nodes, the great diversity observable in the ornamentation of the different species being due to the relative development which each of these features attains. In forms sufficiently retarded to show the order of introduction of the various features of the ornamentation, it appears to begin as one spiral, or in accelerated forms as more than one, additional spirals coming in above the first. Ribs next appear and nodes are formed by the concentration of material where the ribs and spirals cross. In a few cases ribs appear after the first and before the formation of a second spiral, but in no case have ribs been observed before the appearance of at least one spiral. Intercalated spirals may come in either before or after

the introduction of ribs, and they often become extremely numerous. While the order of introduction of the types of surface ornamentation is fairly constant, the precise volution at which a new feature will appear is dependent on the degree of acceleration which the shell has attained and often shows considerable variation within the same Linnæan species. In highly accelerated forms, both spirals and ribs may appear together at the close of the protoconch stage. This is seen in *Cerithium adansoni,* plate III, fig. 3.

The amount of embracing of the whorls in shells of this genus varies within considerable limits, but as a rule the body volution is shorter than the remainder of the spire.

The aperture is oval, with an oblique, more or less widely open anterior canal. Primitive forms have no posterior tooth, but in some Eocenic and later forms a projection of the callus of the inner lip forms a distinct tooth which defines a short canal between itself and the outer lip.

In the earlier literature of the subject, the name *Cerithium* was applied to all forms having in common the characters of a high spire, a short body whorl and a short anterior canal, although Bruguière himself recognized the heterogeneous character of the genus, for he separated it into three groups which are now properly recognized as distinct genera. Further subdivision has been found necessary from time to time, until in M. Cossmann's Essais de Paléoconchologie, volume 7, after the separation of several groups of family rank, we find seventeen genera, thirty-one subgenera and forty-five sections.

Choosing *Cerithium nodulosum* BRUGUIÈRE as the genotype, M. Cossmann lays especial stress upon the projecting tooth on the anterior portion of the outer lip, and he restricts the genus so as to include those forms in which this tooth crosses the opening of the canal. This enables him to place only two species within the genus, the genotype and *Cerithium erythræonense* (= *C. tuberosum*), but a close study of the anterior tooth seems to indicate that its importance as a basis for classification has been greatly overestimated. It appears on the last portion of the body whorl, a position in which the highest degree of variation in the shell is to be expected, and features appearing at this stage should serve as reasons for separating end members of evolutionary series, but not for uniting species as genera, if the classification is to be a natural one—that is, based on community of descent. The tooth is formed by the more rapid growth of the anterior part of the outer lip, and when a spiral is present on this part of the shell, it often determines the point at which an extra amount of calcareous material is deposited. The de-

velopment of this tooth is extremely variable among individuals undoubtedly of the same species; for example, among six adult individuals of *C.* ? *nodulosum* showing no trace of fracture, two develop this feature to a very slight extent and do not form a tooth which crosses the aperture.

C. echinatum is referred to a different section on account of the less development of this tooth, but certain individuals have the tooth developed to a greater extent than some specimens of *C. nodulosum*.

Not only is the tooth variously developed in species which are shown by their ontogeny to be related, such as *C. tuberosum* and *C. echinatum*, but it is strongly developed in species undoubtedly of different descent; for example, *Pseudovertagus aluco* and related species have such a tooth very strongly developed, yet the wide difference between the ontogeny of *Pseudovertagus aluco* and *Cerithium tuberosum* will be readily appreciated by comparing the figures of *C. tuberosum* in the first column of plates III to VI with those of *Pseudovertagus aluco* in the fourth column of the same plates.

Of the genera and subgenera of Cerithiidæ already established, there will be considered in this paper only the *Cerithium tuberosum* group and others closely related to it.

In the description of species which follow no attempt has been made to give a complete synonymy. In each case the original description or a reference to it is given, and also a reference to a good modern description. Where necessary to make the identification of the species clearer, additional references are given. Descriptions are based on one individual which may be considered typical of the species, but where variations such as differences in color, in the number of varices and the like are characteristic features, other individuals are considered. Measurements are also from one individual, usually the largest of those referred to the species. The method of taking measurements of the apical angle is similar to that described by d'Orbigny [1842-1843, pp. 10-14], with the exception that in the case of convex or concave shells two measurements are given representing the extreme angles obtained, and, as nearly as possible, the volution at which the change takes place. The sutural angle is measured as described by d'Orbigny, holding the aperture of the shell downward and taking the upper angle made by the suture with the right side of the shell in dextral forms and the left side in sinistral forms.

IV. Ontogenetic Description of Species

A. Recent species

1. *Cerithium tuberosum Group*

a. European Species

Cerithium tuberosum *Columnæ*

Plate I; plate II, fig. 4; plate III, fig. 4; plate IV, fig. 1; plate VI, figs. 1, 2.

1616. *Cerithium* [*Buccinum*] *tuberosum* Fabii Columnæ, De aquatilibus, pp. 53, 57.
1843. *Cerithium erythræonense* Lamarck, Animaux sans vertébres, éd. 2, IX, 292.
1855. *Cerithium tuberosum* Sowerby, Thesaurus Conch., II, 855, pl. 178, fig. 49.
1866. *Cerithium tuberosum* Reeve, Conch. Iconica, XV, pl. 1, fig. 5, No. 5.
1898. *Cerithium erythræonense* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 78, pl. 15, figs. 2, 3.
1887. *Cerithium erythræonense* Tryon, Manual of Conch., IX, 123, pl. 20, fig. 16.
1906. *Cerithium erythræonense* Cossmann, Essais de Paléoconch., VII, 67.

The original description by Fabii Columnæ is given under the discussion of the genus.

Measurements: Length, 64 mm.; greatest diameter, 29 mm.; apical angle, 34°, changing on the 9th volution to 29.5°; sutural angle, 91°.
Color: Pale brown or brownish yellow.

The protoconch is not preserved on any of the specimens obtainable. The first volution retained is .7 mm. in diameter, and this corresponds in size with the first volution beyond the protoconch of *Cerithium adansoni*. The surface features are entirely obliterated on this volution, but the next shows traces of the ornamentation, which is apparently the same as that of *C. adansoni* at the same age. The fourth volution has two strong spirals, the upper of which defines the shoulder, with one spiral intercalated between them. There are also four equal spirals above and two below the primary ones. All the spirals are crossed by ribs, of which there are nine on this volution. On the succeeding volutions more spirals are added on the shoulder and the lower slope of the whorls, and their number is also increased by intercalation between those already existing. At about the eighth volution the spirals become much crowded, and are raised into a strong ridge just below the suture. The same type of ornamentation persists for eleven volutions, but on the twelfth the lower of the two equal spirals becomes weaker, and the outline of the

whorl changes from an obtuse angle to one both of whose sides stand at angles of about 45° with the axis of the shell. This tendency increases until, on the body whorl, the lower primary spiral is inconspicuous, and the upper forms the most projecting portion of the strong nodes into which the ribs have become contracted. The sub-sutural ridge above described is, on this volution, raised at short intervals into a row of smaller nodes, and on the lower portion of the body whorl there are three strong nodose ridges formed, like the sub-sutural ridge, of groups of fine spirals. On the under side of the body whorl ribs and nodes are nearly obliterated along the surface upon which the animal rested when withdrawn into its shell; but just beyond this area, on the side of the volution opposite the outer lip, the surface is raised into a strong varix.

The aperture is oval, with a strong posterior tooth. The outer lip is slightly flaring, with its margin crenulated by the spirals of the outer surface. The lower portion of the outer lip grows more rapidly than the upper portion, and the lowest of the nodose ridges is produced into a toothlike process which, in some individuals, crosses the opening of the anterior canal. The length of this process varies considerably in different specimens of the species. The inner lip has a strong callus. The anterior canal is long and comparatively narrow.

HORIZON AND LOCALITIES: Recent. Red Sea and Indian Ocean.
No. 20124, Columbia University collection.

REMARKS: *Cerithium tuberosum* is especially well adapted to serve as a type of the group of shells to which it belongs, since it is a retarded form passing through the various stages in its development slowly and retaining primitive characteristics until a late period of its life.

Cerithium ? nodulosum *Bruguière*

Plate III, fig. 5; plate IV, figs. 4, 5.

1792. *Cerithium nodulosum* BRUGUIÈRE, Hist. naturelle des Vers, Encycl. Méth., I, pt. 2, 478.
1887. *Cerithium nodulosum* TRYON, Manual of Conch., IX, 122, pl. 19, figs. 13, 14; pl. 20, fig. 15.
1898. *Cerithium nodulosum* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 76, pl. 15, fig. 1.
1906. *Cerithium nodulosum* COSSMANN, Essais de Paléoconch. Comp., VII, 66.

MEASUREMENTS: Length, 95 mm.; greatest diameter, 47 mm.; apical angle, 37°; sutural angle, 84°.

COLOR: Grayish white, more or less closely covered with interrupted bands and patches of dark brown.

The youngest volution available for study is 1.9 mm. in diameter, and it is probable that several volutions have been broken away above this. It has a sharply angled outline, with the most projecting portion slightly above the middle of the whorl. It is ornamented with three strong, continuous spirals, the uppermost of which is stronger than the others. Two finer spirals are present on the shoulder, and one is visible just above the suture. The entire surface is roughened by exceedingly fine, thread-like costæ crossing the spirals at right angles. They are too fine and too closely set to appear like ribs, and ribs of the usual kind are entirely absent at this stage. The ornamentation remains similar in type, with the intercalation of finer spirals between those already existing, until the sixth volution, on which widely spaced ribs appear. At this stage the volution is about 6 mm. in diameter. The fine spirals increase rapidly in number, and on the later volutions the primary spirals seem to be made up of clusters of finer spirals with the clusters separated by deep, smooth grooves. At about the ninth volution the median of the three spirals becomes almost as strong as the uppermost spiral, so that for two or three volutions the obtuse angled outline of the whorl characteristic of *Cerithium* is suggested. The upper spiral, however, soon becomes again the most prominent one, and this tendency increases until, on the body volution, this spiral forms the margin of very large, blunt, flat-topped nodes, with the ribs nearly obsolete above and below them. On the late whorls the finer spirals are sometimes confluent and the former cluster becomes a broad, flattened ridge defined by a narrow groove on either side. The body volution below the nodes bears three broad nodose spirals.

The aperture is oval, with the outer lip flaring and thrown into strong folds by the coarse spirals of the outer surface. The lowest of the spirals on the body whorl is sometimes produced to such an extent that it forms a projecting tooth which crosses the opening of the canal. The inner lip bears a strong callus with a prominent tooth near the posterior portion of the aperture. The siphonal canal is broad and deep and slightly bent backward.

HORIZON AND LOCALITIES: Recent. Moluccas, Philippines, Indian Ocean.
No. 40203, Columbia University collection.
The young individual figured is from the exhibition collection of the Museum of Comparative Zoölogy.

REMARKS: Although the adult of this species bears some resemblance to *Cerithium tuberosum*, its development is unlike that of any species of Cerithiidæ studied. The formation of a distinct shoulder so long before the appearance of ribs and the presence of the fine costæ crossing the

spirals are features which have not been observed elsewhere. So far as the information at present available goes, it would appear that *C. ? nodulosum* is the sole representative known of a distinct genus, but it is left for the present in the genus *Cerithium*, awaiting an opportunity to study still younger stages of the shell and to obtain other shells which will throw light upon this peculiar type of development.

Cerithium adansoni *Bruguière*

Plate I; plate II, fig. 3; plate III, figs. 2, 3, 4; plate IV, figs. 2, 3; plate V, figs. 1, 2.

1757. "Le Cerite" ADANSON, Histoire Naturelle du Sénégal, 152, pl. 10, fig. 2.
1792. *Cerithium adansoni* BRUGUIÈRE, Hist. Nat. des Vers, Ency. Méthod., I, pt. 2, 479.
1855. *Cerithium adansoni* SOWERBY, Thesaurus Conch., II, pl. 178, fig. 45.
1898. *Cerithium adansoni* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 142, pl. 27, figs. 4, 5.

The following is Adanson's description of "Le Cerite":

Fabius Columna s'est servi du mot grec latinisé Cerithium pour defigurer une espèce du genre des coquillages que je vais décrire sous le nom commun de Cerite.

La coquille de cette espèce n'a guères que deux pouces de longueur et une fois moins de largeur.

On n'y compte que douze spires, renflies dans leur milieu, qui est garni d'un rang de boussettes assez grosses, élevées sur une côte parallel a sa longueur. Le reste de leur surface est entouré de dix à douze petit filets peu élevés. La seconde spire porte quelquefois un gros bourrelet sur la gauche.

La longueur du sommet surpasse presque une fois sa largeur et la première spire.

L'ouverture est exactement ronde, et paroit beaucoup plus evasée que la précédente, parce qu'elle se porte presqu' entièrement hors de la coquille, sur sa droite. Son canal inférieur est creusé en demi-cylindre, recouvert en partie par une côte assez grosse, elevée sur la base de la lèvre gauche. Le canal supérieur est reserré, et de moitié plus profond que large.

La lèvre droit n'est pas sensiblement prolongée dans sa partie supérieure, et elle ne forme pas l'auvent comme dans la première espèce.

La lèvre gauche n'est pas non plus repliée comme la sienne; elle est recouverte seulement par une lame courte, mais épaisse, et relevée en bas d'un filet assez gros qui tourne en dedans de la coquille.

Sa couleur est blanche, sans melange dans les jeunes, et légèrement tachée de brun dans les vieilles.

Je n'ai remarqué dans cette coquille qu' une légère variété, qui consiste en ce que les boussettes des spires sont quelquefois assez longues et pointues: cela se rencontre ordinairement dans les jeunes; et c'est vraisemblablement le frottement qui les use et les arrondit dans les vieilles.

Cette espèce vit aussi dans la vase mais on ne la voit qu'en petite quantité dans le fleuve Gambie, vis-à-vis le comptoir d'Albreda.

The description of this species given by Bruguière is closely similar to that of Adanson, and much of it is even worded in the same way. Practically the only addition made by Bruguière was in giving the species a binomial name.

MEASUREMENTS: Length, 43 mm.; greatest diameter, 3 mm.; apical angle, 50° to the eighth volution, changing to 31.5°; sutural angle, 72.5°.

COLOR: White, sparingly dotted with pale brown.

The protoconch of *Cerithium adansoni* consists of about one and one-fourth volutions. The ornamentation begins as two spirals crossed by distant ribs on the first volution beyond the protoconch (plate III, fig. 2). The second volution bears three fine spirals on the shoulder. These are increased by a fourth fine spiral on the third volution, and an intercalated spiral appears between the two primary ones. Tertiary spirals and those of higher order are soon developed, and these fine spirals do not increase greatly in size, but they become extremely numerous, so that the entire surface of the adult is covered with thread-like costæ. On the fourth volution, just below the upper suture, there is an elevation of the surface to form a coarse spiral which carries with it the fine spirals already existing. Later in the life of the shell other coarse spirals arise in a similar manner on the shoulder and below the two primary spirals. The lower of the primary spirals becomes gradually weaker and the upper more prominent, until at about the sixth volution the outline of the whorl has lost its vertical element formed by the two equal spirals and has become an acute angle. On the next volution the center of the rib becomes so prominent that it might almost be called a spine, and on this volution also rows of large nodes are formed by the breaking up of the coarse spirals just below the upper suture and above the lower one. On the eleventh volution there are three coarse spirals above and three below the central extremely prominent one, all of which are irregularly nodose.

The median spiral of the body volution is spinose on the dorsal side, but on the ventral side the spines are represented by low nodes only. Below the prominent spiral on the body volution there are six or more coarse spirals with finer intercalated ones, and the whole is covered, like the rest of the surface, with the fine costæ described above.

The aperture is a broad oval in outline. The outer lip is thick, somewhat flaring, and crenulated by the spirals of the outer surface. The inner lip has a thick callus, raised into a strong blunt tooth which, with the outer lip, forms a short canal at the posterior end of the aperture. The anterior canal is short and slightly curved, and its opening is narrowed by the rapid growth of the lower portion of the outer lip. This

growth does not, however, form a distinct tooth as in *Cerithium tuberosum* and some forms of *C. echinatum*.

HORIZON AND LOCALITIES: Recent. Senegal, west coast of Africa and sparingly near the mouth of the Gambia River. M. Cossmann [1906, p. 66] assumes that this shell is a fresh-water form, but this is hardly borne out by the statement of Adanson, who collected the animals in their native locality. According to his account of the habitat quoted above, it seems that the animal is typically marine, and comparatively few individuals have migrated up the Gambia River.

No. 20125, Columbia University collection.

Museum of Comparative Zoölogy, museum collection.

REMARKS: This shell, from the protoconch to the seventh volution, corresponds exactly in development with *Cerithium tuberosum*. It is, however, a more accelerated shell, since the stage with two equal spirals persists in *C. tuberosum* for ten volutions, while in *C. adansoni* this feature is lost on the sixth volution. The adult of *C. tuberosum* corresponds approximately to the seventh volution of *C. adansoni*, but the correspondence is not exact, for at this stage *C. adansoni* has not acquired a sub-sutural row of fine nodes, while its ribs have become even more spinose than those of *C. tuberosum*. *C. adansoni* is not to be regarded as a descendant of *C. tuberosum*, but rather the two are descended from a common ancestor, *C. adansoni* passing through its ancestral stages rapidly and adding new characters, while *C. tuberosum* is retarded in its development and never attains the high degree of ornamentation characteristic of the adult *C. adansoni*.

Cerithium echinatum *Lamarck*

1843. *Cerithium echinatum* LAMARCK, Animaux sans vert., éd. II, IX, 291.
1887. *Cerithium echinatum* TRYON, Manual of Conch., IX, 123, pl. 20, figs. 25-27.
1898. *Cerithium echinatum* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 100, pl. 20, figs. 5-8.
1906. *Gourmyia echinatum* COSSMANN, Essais de Paléoconch., VII, 69.

MEASUREMENTS: Length, 49.4 mm.; greatest diameter, 27.3 mm.; apical angle to the ninth volution, 45°, changing to 37.5°; sutural angle, 82.5°.

COLOR: Grayish white, sometimes marked with transverse patches of brown, which is deepest on the spirals.

The protoconch of *Cerithium echinatum* is much worn on the only available specimen showing that feature, but so far as can be determined, it is precisely like that of *C. adansoni*, and the first four volutions are indistinguishable on the two shells. On the fifth volution there is less contrast between the primary spirals and those of higher order than on

C. adansoni. In other words, the primary spirals are not so highly developed, and spirals of higher order are coarser. This difference persists throughout the remainder of the shell growth. On the sixth volution, beyond the protoconch, the upper of the two primary spirals becomes more prominent. This tendency increases until, on the body volution, the ribs have become contracted into spines, of which the upper primary spiral forms the most projecting portion. The spirals of higher order increase rapidly in number until they become so crowded that they coalesce, forming broad, flattened ridges which are in places finely striated, indicating the original spirals of which they are composed. On the body whorl the uppermost spiral breaks up into fine nodes, and just before the end of this volution three spirals on the shoulder become similarly nodose. On the lower slope of the volution there are also three strong spirals which become nodose toward the end of the whorl. Spines are absent from the under side of the body volution, as in *C. adansoni.*

The aperture is broadly oval. The inner lip bears a strong callus, with a well-developed tooth forming, with the outer lip, a short canal at the posterior portion of the aperture. The anterior canal is short and slightly curved. The outer lip is flaring, its margin being crenulated by the spirals of the outer surface. The lower margin of the outer lip grows more rapidly than the upper, forming a projection somewhat as in *Cerithium tuberosum,* but not so strongly developed as in the latter species. There is considerable difference in the degree to which this feature is developed on several individuals of *C. echinatum.*

HORIZON AND LOCALITY: Recent. Zanzibar.
No. 40181, Columbia University collection.

REMARKS: This shell bears a strong resemblance to *C. adansoni,* but differs in the coalescence of the fine spirals, which on *C. adansoni* remain distinct throughout the life of the shell, covering all the coarser features with fine thread-like lines. On *C. echinatum* also nodes are developed to a less degree, appearing only on the latest portion of the body volution. The more rapid growth of the lower portion of the outer lip on *C. echinatum* is an important distinguishing feature, since it does not occur on *C. adansoni.*

C. echinatum, as shown by its early development, is closely related to *C. tuberosum,* but it is a more accelerated shell, since it loses the vertical element from its outline on the sixth volution, instead of the tenth, as in *C. tuberosum.* While more accelerated than *C. tuberosum,* it is more retarded than *C. adansoni,* since it does not acquire nodes until near the end of its life history.

Cerithium menkei *Deshayes*

Plate VII, figs. 2, 3; plate VIII, fig. 3; plate IX, fig. 2.

1863. *Cerithium menkei* DESHAYES, Moll. Réunion, p. 97, pl. 9, fig. 15.
1887. *Cerithium columna* TRYON, Manual of Conch., IX, 123, pl. 20, fig. 19.
1898. *Cerithium menkei* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 208, pl. 37, fig. 1.

MEASUREMENTS: Length, 29 mm.; greatest diameter, 16.5 mm.; apical angle to the eighth volution, 47°, changing to 35°; sutural angle, 76.5°.

COLOR: Uniformly cream-colored, or occasionally having a few pale brownish spots scattered irregularly over the surface.

This shell is thin and delicately sculptured, with all the features of the surface ornamentation distinctly shown.

The protoconch is not preserved, but the first volution remaining, which is probably the first beyond the protoconch, is ornamented by two spirals and faint ribs only. This volution has a diameter of .6 mm. On the next volution three fine spirals appear on the shoulder. Intercalated spirals are first developed on the third volution, and they increase rapidly during subsequent growth until, on the body whorl, those of the fifth order may be counted. The two primary spirals remain of equal strength for eight volutions, but on the later volutions the lower spiral becomes weaker, until it is reduced to the size of a secondary spiral, and the outline of the whorl is changed from an obtuse angle to approximately a right angle. At intervals on the later volutions of the shell one rib is slightly stronger than the others, and on the body whorl there is one strong varix. A sub-sutural band, as in *C. tuberosum,* is developed on the ninth and later volutions. Toward the end of the body whorl this band becomes tuberculate, and on the lower slope of this whorl two strong spirals are developed.

The aperture is elongate oval, with a posterior tooth on the narrow callus of the inner lip. The outer lip is flaring, crenulated by the spirals of the outer surface. The anterior canal is comparatively long.

HORIZON AND LOCALITY: Recent. Indian Ocean.
No. 20126, Columbia University collection.

REMARKS: *Cerithium menkei* differs from *C. columna* in having a thinner shell, finer and more delicate sculpture, broader and less widely spaced ribs.

The development of the ornamentation of this shell is so closely parallel to that of *C. tuberosum* that, taken in connection with the similarity in the form of body and aperture, it leaves no room for doubt that the

two are developed from a common ancestor. This is clearly brought out by a comparison of the figures of young whorls on plate VII, figs. 2, 3, and plate III, fig. 4.

Cerithium columna *Sowerby*

1855. *Cerithium columna* SOWERBY, Thesaurus Conch., II, 855, pl. 178, figs. 55-58.
1866. *Cerithium columna* REEVE, Conch. Icon., No. 2, pl. 1, fig. 2.
1887. *Cerithium columna* TRYON, Manual of Conch., IX, 123, pl. 20, figs. 17, 18.
1898. *Cerithium columna* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 85, pl. 16, figs. 7, 8.

MEASUREMENTS: Length, 29.2 mm.; greatest diameter, 17.1 mm.; apical angle, 41°; sutural angle, 87°.

COLOR: Ground, white or cream white, with irregular patches of dark reddish brown, the amount of brown on different individuals varying greatly.

The shell is thick and heavy, with relatively coarse spirals and narrow, sharp ribs.

The youngest volution preserved is 2 mm. in diameter. It bears two strong, equal spirals with intercalated spirals of two higher orders and fine spirals on the shoulder. All are crossed by ribs, which on the later volutions of the shell become narrow, with wide interspaces. The ornamentation retains the same character, with an increase in the number of intercalated spirals for the three succeeding volutions, after which the lower of the two primary spirals becomes weaker, changing the outline of the volution, as described above, from an obtuse angle to a right angle. Varices occur on the later whorls to the number of about two to the volution. The spirals become closely crowded just below the suture, and there is a tendency toward the formation of a sub-sutural band, but it never becomes well developed. On the later portion of the body volution small nodes are developed on the stronger spirals.

The aperture is broadly oval, with a well-developed posterior tooth and short, oblique anterior canal. The callus of the inner lip is thick and rather narrow. The outer lip is flaring and crenulated.

HORIZON AND LOCALITIES: Recent. Indian Ocean, Japan, Oceanica. No. 20127, Columbia University collection.

REMARKS: This species is a near relative of *C. menkei*, differing in the characters enumerated above and, like that species, reveals in its development its relationship to *C. tuberosum*.

Cerithium citrinum *Sowerby*

1855. *Cerithium citrinum* SOWERBY, Thesaurus Conch., II, 855, pl. 179, fig. 66.
1866. *Cerithium citrinum* REEVE, Conch. Icon., No. 1, pl. 1, fig. 1.
1887. *Cerithium citrinum* TRYON, Manual of Conch., IX, 123, pl. 20, fig. 21.
1898. *Cerithium citrinum* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. 1, Abth. 26, 110, pl. 22, fig. 23.

MEASUREMENTS: Length, 50.5 mm.; greatest diameter, 15.5 mm.; apical angle, 37°; sutural angle, 87°.

COLOR: Cream white, with streaks and patches of pale brown.

The youngest volution preserved on this shell is 2 mm. in diameter, and its ornamentation is similar to that of the fourth volution on *C. menkei*. It has two strong equal spirals, one intercalated spiral and five fine spirals on the shoulder. One spiral is on the lower slope of the whorl. The ribs on this species are broad and, for the first five volutions, broader than the spaces between them. The two primary spirals remain equal in strength for seven volutions, after which the lower spiral is weaker, but the outline of the volution never becomes sharply angular, as in the preceding species. The secondary spirals of the shoulder and the lower slope of the whorl become as strong as the primary ones, and the outline of the volution becomes regularly curved. Extremely fine spirals of higher order are rapidly introduced, while the primary and secondary spirals are raised into ridges carrying the finer spirals with them, so that the whole surface appears to be covered with bundles of fine spirals having deep grooves between them. The ribs disappear on the body volution, with the exception of one strong varix on the side opposite the aperture, as is usual in shells of this group. Nodes are absent from the entire surface.

The aperture is broadly oval. The callus of the inner lip is thick and narrow, with a prominent posterior tooth. The anterior canal is long and the margin of the outer lip thick and crenulated.

HORIZON AND LOCALITY: Recent. Bird Islands, Pacific Ocean.
No. 20128, Columbia University collection.

REMARKS: *Cerithium citrinum* differs from *C. columna* in the more delicate surface ornamentation, the rounded outline of the volutions and, with the exception of one varix, the absence of ribs and nodes on the body volution. It also has a longer anterior canal. This species differs from *C. menkei* in the absence of sharply angular volutions and in the disappearance of ribs on the body whorl.

Cerithium citrinum mut. **bicolor** *Hombron et Jacques*

1842-1853. *Cerithium bicolor* Hombron et Jacq. Voyage au Pole Sud., pl. 23, figs. 14, 15.
1887. *Cerithium citrinum* Tryon, Manual of Conch., 123, pl. 2, fig. 22.
1898. *Cerithium citrinum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 111.

Measurements: Length, 29.7 mm.; greatest diameter, 16.3 mm.; apical angle, 44°, changing to 30° on the last three volutions; sutural angle, 86°.
Color: Cream white with patches of a slightly darker yellowish tone.

The first two of the volutions preserved are precisely similar to those of *Cerithium citrinum.* On the third volution the ribs become contracted, leaving broad interspaces, as in *C. columna,* but the spirals retain the characteristic development of *C. citrinum*—that is, bundles of spirals with deep grooves between them. This type of ornamentation is carried still farther on the mutation *bicolor,* until, as early as the seventh volution, the interspaces are smooth and nearly or quite as wide as the groups of spirals themselves. The upper of the two primary spirals becomes slightly stronger than the lower as early as the fourth volution, and the two retain the same relative strength for seven volutions. The eighth volution attains the angular outline characteristic of *C. columna.* All the spirals of this form are prominent and sharply defined, even more so than on either *C. citrinum* or *C. columna.* On the body volution all the strong spirals break up into fine nodes.

The aperture is broadly oval, with a posterior tooth and short, oblique anterior canal. The outer lip is strongly crenulated. The callus of the inner lip is strong and not closely applied to the surface of the shell.

Horizon and locality: Recent. Philippines.
No. 20129, Columbia University collection.

Remarks: This shell has the prominent shoulder of *C. columna,* while retaining the thin shell, fine sculpture and development of spirals characteristic of *C. citrinum.*

Cerithium scabridum *Reeve*

1866. *Cerithium scabridum* Reeve, Conch. Iconica, XV, No. 52, pl. 8, fig. 52.
1887. *Cerithium columna* mut. *scabridum* Tryon, Manual of Conch., IX, 123, pl. 20, fig. 20.
1898. *Cerithium scabridum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 210, pl. 37, fig. 6.

Measurements: Length, 20.5 mm.; greatest diameter, 11.4 mm.; apical angle, 34.5°; sutural angle, 82.5°.
Color: White with the more prominent spirals sparingly touched with brown.

The youngest volution preserved probably corresponds with the fourth volution of *C. menkei,* being 2 mm. in diameter. This volution has two strong, equal spirals and three intercalated ones. The shoulder has five and the lower slope of the whorl one additional spiral. Ribs are present to the number of eleven on this volution. The ornamentation resembles that of *Cerithium citrinum* in being made up of bundles of fine spirals, but the depressions between the groups are less deeply carved than in that species. The two primary spirals remain equal for five volutions, after which the outline of the volution becomes angular, but not sharply so as in *C. menkei.* On this shell, as usual in this group, it is the upper of the primary spirals which is most prominent. The ribs become weaker on the body volution and disappear on the later portion of it. On this portion of the shell, also, all the coarser spirals break up into rows of small nodes. A large varix is present on the side of the body volution opposite the aperture.

The aperture is broadly oval, with a well-developed posterior tooth, narrow callus and short anterior canal. The outer lip is finely crenulated by the spirals of the outer surface and not flaring.

HORIZON AND LOCALITY: Recent. Both Reeve and Kobelt report the locality of the species as unknown. The specimens in the collection of Columbia University referred to this species are from the Bird Islands, Pacific Ocean.

No. 20130, Columbia University collection.

REMARKS: This little shell is nearest to *C. citrinum,* but it differs in its smaller size, white color, less deeply carved surface ornamentation, the more angular outline of the volutions and the short anterior canal. From the mutation *bicolor,* it differs in size and color and in the less prominently developed shoulder.

Cerithium mediterraneum *Lamarck*

1843. *Cerithium mediterraneum* LAMARCK, Animaux sans vert., IX, 313.
1855. *Cerithium mediterraneum* SOWERBY, Thesaurus Conch., II, 865, pl. 178, fig. 50; pl. 101, figs. 128, 131-133.
1866. *Cerithium mediterraneum* REEVE, Conch. Iconica, XV, No. 53.
1887. *Cerithium rupestre* TRYON, Manual of Conch., IX, 126, pl. 21, fig. 48.

MEASUREMENTS: Length, 25 mm.; greatest diameter, 12.4 mm.; apical angle, 39.8°, changing to 25° on the seventh volution; sutural angle, 77.5°.

COLOR: Cream white, mottled with streaks of yellow or brown. Color bands usually passing transversely across the spirals, but when parallel with them seeming to occupy the depressions between the spirals rather than their more convex portions.

The youngest volution preserved is .9 mm. in diameter. This volution

is ornamented by two strong, equal spirals, with two finer spirals on the shoulder and all the spirals crossed by ribs. The succeeding volution has a fine spiral intercalated between each two of the three already existing, and more spirals are rapidly introduced on the later volutions. The spirals on the adolescent and adult whorls of this shell are all flattened, their limits being defined only by the exceedingly fine grooves between them. The lower primary spiral begins to decrease in strength on the sixth volution, and the seventh has a sharply angled outline. On this volution a row of fine nodes is formed just below the upper and above the lower suture. On the body volution the shoulder is lost, and the surface is ornamented by five or more rows of low nodes.

The aperture is oval. The callus of the inner lip is thick and has a strong posterior tooth. The outer lip is thick and smooth. The anterior canal is short and slightly bent backward.

HORIZON AND LOCALITY: Recent. Mediterranean Sea.
No. 20131, Columbia University collection.

REMARKS: *Cerithium mediterraneum* has its nearest relative in *C. citrinum* mut. *bicolor*. It differs in having flattened spirals not grouped in bundles, as in the latter species. On the whorls having an angular outline the reduced primary spiral becomes so much flattened that the outline of the lower as well as the upper slope of the volution is nearly a straight line. In the preceding species, which are similar to *C. mediterraneum,* the lower primary spiral is always stronger and easily distinguishable from the secondary ones. From *C. columna* this species differs in having finer surface ornamentation, with flattened spirals and broader ribs and in the loss of the shoulder on the body volution.

The last five species and one variety, namely, *C. menkei, C. columna, C. citrinum* and its mutation *bicolor, C. scabridum, C. mediterraneum,* constitute a group of closely related forms. They are evidently all developed from a common ancestor and for the early portion of their life history follow the same path of development. The divergence observed in the neanic and ephebic stages of growth are all due to differences in the degree of development or in the grouping of the various features of the surface ornament. In *C. menkei* the development of the spirals and the sharply angled outline of the whorls are emphasized; in *C. columna* the development of the shoulder and of the ribs are distinctive, and in *C. citrinum* and its variety the grouping of the spirals in clusters is noticeable. They might all be regarded as varieties of one species, as suggested by Tryon, or their divergence in the adult stage might be considered great enough to entitle them to rank as distinct species. The

latter method seems to the writer best to represent the degree of development which these shells have reached.

Cerithium dialeucum *Philippi*

1851. *Cerithium dialeucum* Philippi, Abbildungen, III, 14, pl. 1, fig. 5.
1866. *Cerithium dialeucum* Reeve, Conch. Iconica, XV, No. 18.
1887. *Cerithium dialeucum* Tryon, Manual of Conch., IX, 130, pl. 23, figs. 87, 88.
1898. *Cerithium dialeucum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 167, pl. 31, figs. 8, 9.

Measurements: Length, 31.4 mm.; greatest diameter, 15 mm.; apical angle, 45°, changing to 25.2° on the last two volutions; sutural angle, 79°.

Color: Grayish white on the spirals with alternating bands of dark reddish or purplish brown in the grooves between the spirals.

The youngest volution preserved is 1.5 mm. in diameter, but it reveals nothing of the development at this stage, for the ornamentation is nearly obliterated on the first three volutions. The third volution, however, indicates the presence of two strong spirals crossed by ribs. The fourth volution has an oblique-angled outline formed by two primary spirals and three intercalated ones. Spirals of the first, second and third orders are present on the shoulder and all are crossed by prominent ribs, with varices to the number of about three on a volution. The different orders of spirals on this shell are clearly indicated by a marked difference in size. The two primary spirals remain of equal strength for about six volutions, after which the lower becomes somewhat weaker and one of the spirals on the shoulder becomes stronger, so that on the last two volutions the shell has three strong spirals, of which the median one is the most prominent, and intercalated spirals to the fourth order are also present. The whorls of the neanic shell are rounded in outline, and only the later portion of the body volution becomes somewhat angular. The lower slope of the body whorl bears six or more strong spirals with intercalated ones, all of which tend to become nodose toward the end of the whorl.

The aperture is oval. The callus of the inner lip is narrow, with a prominent posterior tooth. The anterior canal is oblique and of moderate length. The interior of the outer lip is deeply grooved to correspond with the spirals of the outer surface. The grooves of this surface are white like the spirals, and the ridges are colored to correspond with the depressions of the outer surface. A narrow margin of the outer lip is thick, smooth and white.

Horizon and locality: Recent. Philippines.
No. 20132, Columbia University collection.

Remarks: This shell is distinguished from all members of the *Cerithium columna* group by the strong and regular variation in the width of the spirals to correspond with their order of introduction. The regular banding in color is also a distinguishing feature. The general form of the shell, its early development and the form of the aperture all indicate its relationship to the *C. tuberosum* group.

Cerithium album *Hombron et Jacques*

1842-1853. *Cerithium album* Hombron et Jacq., Voyage Pole Sud., V, 101, pl. 23, figs. 22, 23.
1887. *Cerithium echinatum* Tryon, Manual of Conch., IX, 124, pl. 20, fig. 26.
1898. *Cerithium echinatum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 102.

Measurements: Length, 31.4 mm.; greatest diameter, 17.3 mm.; apical angle, 52.5°, changing abruptly to 23° on the last two volutions; sutural angle, 76.5°.

Color: White or cream white with occasional streaks of dark brown.

Youngest volution, 3 mm. in diameter, bearing the two strong spirals always found in the young stages of this group, with three intercalated spirals. Fine additional spirals are present on the shoulder and the lower slopes of the whorl. The ribs are numerous and nearly as wide as the spaces between them. Fine spirals are rapidly introduced, becoming so crowded below the suture that they form a broad sub-sutural band which, unlike that of *Cerithium tuberosum,* retains the slope of the remainder of the shoulder. On the fifth volution preserved, which is probably the ninth of a complete shell, this sub-sutural band breaks up into a row of small nodes, and the ribs become ill-denfined, giving place to a row of strong nodes on the upper of the two primary spirals. The angle of the shoulder, except in the youngest stages, is very wide, and on the body volution it disappears altogether, being replaced by strongly nodose spirals, of which there are five on this volution with fine rows of nodes between them.

The aperture is oval, with a well-developed posterior tooth and short, oblique anterior canal. The outer lip is strongly fluted, and the callus of the inner lip is narrow.

Horizon and locality: Recent. Baker's Island, Pacific Ocean.
No. 20133, Columbia University collection.

Remarks: This species has been considered synonymous with *Cerithium echinatum,* but it differs from the latter species in several important respects. Beyond the young stages, the shoulder of *C. album* is never

well defined, and the neanic whorls lack altogether the strongly spinose character of *C. echinatum* at the same age. The apical angle of *C. album* is much wider, and the abrupt change in the slope of the sides on the last two volutions is not found on *C. echinatum*. The youngest stages of this shell are closely similar to those of the species already described, but in the adult the ornamentation develops rows of small nodes instead of the shoulder angle present on many species of the group.

Cerithium graciliforme *Sowerby*

1866. *Cerithium graciliforme* SOWERBY, apud REEVE, Conch. Iconica, XV, No. 49.
1887. *Cerithium eburneum* TRYON, Manual of Conch., IX, 129, pl. 22, fig. 77.
1898. *Cerithium graciliforme* KOBELT, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 124, pl. 24, fig. 9.

MEASUREMENTS: Length, 24.2 mm.; greatest diameter, 9.7 mm.; apical angle, 35.3°, changing on the ninth volution to 26°; sutural angle, 86.7°.
COLOR: White with occasional spots of pale brown.

The youngest volution preserved is .5 mm. in diameter, but it is too much corroded to show its form. The next volution is also much worn, but shows that it has two equal spirals crossed by ribs. On the third volution the same type of ornamentation continues, with three fine spirals on the shoulder. A single spiral is intercalated between the two primary ones on the fourth volution, and there are four fine spirals on the shoulder and one on the lower slope of the whorl. On the fifth volution, three varices are developed, while the ribs between them become much narrower. Varices continue to be formed throughout the life of the shell and constitute a striking feature of its ornament. The shoulder becomes nearly obsolete, and the ribs break up into nodes until, on the tenth volution, the surface is marked by a strong varix and four rows of nodes, of which the second below the suture is weaker than the others. This type of ornamentation continues for the remaining three volutions.

The aperture is broadly oval. A posterior tooth is present, but is not strongly developed. The callus of the inner lip is thin, and the outer lip is nearly smooth. The canal is short and slightly reflexed at the margin.

HORIZON AND LOCALITY: Recent. The locality of this species is not given in any of the descriptions of it that have been published, and the specimen in the Columbia University collection is also unlabeled.
No. 20134, Columbia University collection.

REMARKS: This species resembles most closely *Cerithium eburneum*, and is considered only a variety of that species by Tryon; but it differs in its more slender form, nearly obsolete shoulder and in the great devel-

opment of varices. It differs also in color, being nearly white. The few pale brown spots are visible only with a lens.

b. American Species

Cerithium eburneum *Bruguière*

1792. *Cerithium eburneum* Bruguière, Hist. Nat. des Vers, Encyclop. Méthod., I, pt. 2, 438.
1887. *Cerithium eburneum* Tryon, Manual of Conch., IX, 129, pl. 22, fig. 75.
1898. *Cerithium eburneum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 219, pl. 39, figs. 3-6.

Measurements: Length, 25.7 mm.; greatest diameter, 11 mm.; apical angle, 34°, changing to 29.5° on the ninth volution; sutural angle, 85.5°.

Color: White, irregularly marked with patches of color which vary from golden brown to dark reddish brown.

The youngest volution preserved, which is probably the first beyond the protoconch, is .5 mm. in diameter. It has two equal spirals, which remain the only ornamentation of the shell for about one-fourth of a volution. Less accelerated individuals retain this ornamentation for a complete volution. The next features to appear are ribs and two fine spirals on the shoulder. Intercalated spirals are first introduced on the fourth of the volutions preserved, and the same type of ornamentation continues, with the addition of fine spirals for eight volutions. Beyond this the ribs become ill defined and gradually break up into rows of nodes, which are developed on all the strong spirals until, on the volution before the last, there are five such rows. At about the ninth volution the lower of the two primary spirals becomes weaker, while the upper remains strong and defines a slight shoulder at about the middle of the volution. Varices are irregularly developed with not more than two on a volution, and frequently less than two.

The aperture is oval, and a posterior tooth is well developed. The anterior canal is short and rather widely open. The outer lip is crenulated, and the callus of the inner lip is thick and narrow.

Horizon and localities: Recent. West Indies, Florida.
No. 20135, Columbia University collection.

Remarks: The development of this species and its general form are so closely similar to those of *Cerithium tuberosum* as to leave little doubt of their descent from a common ancestor, in spite of the fact that the two shells come from such widely separated localities as the West Indies and the Red Sea. The American species of other genera, as well as *Cerithium,*

show such strong evidence of relationship with European forms that we must assume some at present unexplained means of intercommunication between species of the east and west shores of the Atlantic. This connection probably existed at some earlier geological period, since Miocenic species show the same similarity to European forms as do the recent species.

Cerithium caudatum *Sowerby*

1855. *Cerithium caudatum* Sowerby, Thesaurus Conch., II, 856, pl. 179, figs. 71, 72.
1866. *Cerithium caudatum* Reeve, Conch. Iconica, XV, No. 16.
1898. *Cerithium caudatum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 112, pl. 22, fig. 4.

Measurements: Length, 31.5 mm.; greatest diameter, 14.2 mm.; apical angle, 41°, changing to 29° on the last three volutions; sutural angle, 75°.

Color: Golden brown. Lighter in color at the apex and on the varices. Margin of the outer lip white streaked with black.

The apex of the shell is much corroded. The youngest volution to show the surface is 2 mm. in diameter, and has the ornamentation characteristic of this group of ribs and two strong spirals. At this stage intercalated spirals are already introduced between the two primary ones, and spirals of at least two orders are present on the shoulder and on the lower slope of the whorl. The surface ornamentation remains of the same type, with the introduction of more spirals, until the eighth volution, after which the ribs become discontinuous and the stronger spirals break up into nodes. On this volution there is a sub-sutural row of nodes, and each of the two primary spirals also forms a row of nodes. The outline of the volution is an obtuse angle, with a sloping or concave upper surface and vertical sides. On the ninth volution preserved the finest of the spirals have become obsolete, and between the rows of nodes the spirals are comparatively few and coarse, with narrow interspaces. On the body volution the nodes of the lower primary spiral become very small, no larger than those of the secondary spirals. This volution has one row of strong nodes—those of the first primary spiral—a row of subsutural nodes somewhat smaller and three rows of fine nodose spirals on the lower slope of the whorl. The intermediate spirals are crenulated, but not distinctly nodose.

The aperture is oval and the callus of the inner lip is thin, with a well-developed posterior tooth. The outer lip is distinctly flaring and finely crenulated along its outer margin. The anterior canal is short and widely open.

HORIZON AND LOCALITY: Recent. Island of Guadeloupe.
No. 20136, Columbia University collection.

The shells of the *Cerithium tuberosum* group, although differing greatly in size, have a general similarity in form and in the essential characteristics of the aperture. Their variation is expressed most strongly in the features of the surface ornamentation. These features consist of spirals of the first and higher orders, ribs, nodes which may develop into spines, and a shoulder varying in extent of development and in form. In order to bring out more clearly the relation between these shells as expressed in their surface ornamentation, they have been plotted in diagrammatic form, arbitrary signs being chosen to represent certain features of the ornamentation. On plate I the numbers at the left of the page indicate the volutions, the protoconch being numbered one. The protoconch, when present, is represented by a circle. The spirals are represented as horizontal lines, for while they are actually longitudinal elements, on the shell they appear horizontal, and the diagram being intended merely to represent certain features in graphic form, it retains the line most readily associated in the mind with what is seen on the shell. For a similar reason ribs are represented as vertical lines. Secondary spirals and those of higher order are represented by two horizontal lines. Nodes are indicated by dots, and the outline of the volution is represented by the lines which would be used in drawing its two upper slopes—that is, an obtuse angle changing to a right angle to agree with the development of certain shells. The diagram is intended to represent resemblances and differences in a general way only. It records the introduction of spirals, ribs and nodes, but does not attempt to show the different kinds and degrees of development which they attain or such features as size, degree of embracing of the whorls, etcetera. More complete details are given in the descriptions and figures of the different species.

The diagram brings out the fact that some species are more retarded than others; for example, *Cerithium menkei* is a more retarded shell than *C. adansoni,* as shown by the fact that on the former species the change in the outline of the whorl does not take place until the ninth volution, and nodes are not acquired until the last volution, while both these changes occur much earlier on *C. adansoni.* A similar comparison has already been made between *C. tuberosum* and *C. adansoni.*

The diagram also shows differential acceleration and retardation of related species as in *C. echinatum* and *C. graciliforme.* On the former the oblique-angled outline is lost on the seventh volution, while retained until the tenth on the latter. Nodes are, however, acquired on the ninth volution of *C. graciliforme,* and do not appear until the twelfth volution of

C. echinatum. As compared with *C. graciliforme*, therefore, *C. echinatum* is accelerated in the acquisition of the sharply angled outline of the volution, but retarded in the development of nodes.

A marked similarity in the early development of these species is well illustrated by the diagram. If a card be placed over the lower part of it the eye is at once struck by the uniformity of the figures; moving the card downward, differences begin to appear, becoming wider as representations of the adult stages are reached. The divergence would be even more marked if all the features of the shell could be indicated, instead of the mere presence or absence of the five features represented.

2. *Genera and Species of Recent Shells closely related to the Cerithium tuberosum Group*

Genus **Vulgocerithium** *Cossmann*

1906. *Vulgocerithium* Cossmann Essais de Paléoconch. Comp., VII, 77.

Genotype *Cerithium vulgatum* Bruguière:

This genus is closely related to *Cerithium* sens. str. The early stages of the genotype *Cerithium vulgatum* are closely similar to those of *C. tuberosum*. The adult differs in a number of rather constant features and therefore may be considered distinct. The surface ornamentation of the adult shell is characterized by the development of ribs or large nodes, a sub-sutural row of smaller nodes, and by the coalescence of the fine spirals into flattened bands defined by extremely narrow grooves. The margin of the anterior canal is usually slightly reflexed.

M. Cossmann's main points of difference from *Cerithium* sens. str. are not only the elongate form of the shell and characteristic surface ornament, but especially the form of the aperture. The absence of the more rapid growth on the anterior part of the outer lip, which forms a projecting tooth in some species of *Cerithium*, is considered of most importance, and the shorter siphonal canal and less flaring outer lip are also mentioned.

Vulgocerithium vulgatum *Bruguière*

1757. *Le Goumier* Adanson, Histoire Naturelle du Sénégal, 1757, p. 156, pl. 10, fig. 3.

1792. *Cerithium vulgatum* Bruguière, Dictionaire, No. 13.

1855. *Cerithium vulgatum* Sowerby, Thesaurus Conch., II, 864, pl. 178, fig. 43; pl. 179, fig. 67.

1898. *Cerithium vulgatum* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 87, pl. 17, figs. 1-8; pl. 18, figs. 1-4.

1906. *Vulgocerithium vulgatum* Cossmann, Essais de Paléoconch. Comp., VII, 77.

MEASUREMENTS: Length, 63.7 mm.; greatest diameter, 21.4 mm.; apical angle, 26.5°, changing to 23° on the twelfth volution; sutural angle, 88°.

COLOR: Background of bluish white, marked by numerous spiral bands of reddish brown, which on the young shell is deepest in the grooves between the spirals, but on the later and adult whorls irregular patches of color cover most of the surface.

The only specimen studied which retains the protoconch is somewhat worn at the apex, but the protoconch appears to be like that of *Cerithium adansoni*. The second and third volutions are so similar as to be well illustrated by the drawings of these two whorls on *C. adansoni* (plate III, figs. 3, 4), but the shell at this age is about twice the size of *C. adansoni* at the same age. The fourth volution is like that of *C. adansoni,* except that about every third rib is much larger, forming a strong varix. These varices occur at gradually wider intervals up to the eleventh volution, when they disappear from the specimen described. The presence of varices is a variable feature, since in a series of specimens otherwise similar the varices are more prominent and persist for a longer time on some specimens than on others. Except for the presence of varices, the surface ornamentation is like that of *Cerithium tuberosum* to the seventh volution, when small nodes appear on the sub-sutural band, one at the end of each rib. Beginning with the ninth volution, the lower of the two primary spirals becomes gradually less prominent and the ribs become less well marked, until on the twelfth volution the upper of the two primary spirals only is prominent, forming a row of nodes slightly above the middle of the volution. The ribs, as such, have disappeared, being replaced by the two rows of nodes. Spirals of secondary and higher orders increase rapidly in number, and on the later whorls the finest spirals become confluent, producing broad, flattened bands, with extremely narrow depressions between them. On the body volution below the lower row of strong nodes from three to five large spirals are faintly nodose.

The aperture is elongate oval, with a distinct but not very prominent tooth defining the posterior canal. The outer lip is slightly flaring and shows faint crenulations. The callus of the inner lip is thin. The anterior canal is wide and short, with its margin slightly reflexed.

HORIZON AND LOCALITIES: Recent. Mediterranean Sea, west coast of Africa, and southward to Senegal.

No. 20137, Columbia University collection.

REMARKS: Individuals of this species vary somewhat in the width of the apical angle, in the strength and spacing of the nodes, and the extent to which the fine spirals coalesce and become flattened. At present the

species is made to include many synonyms and a large number of varieties, some of which, with a more detailed study of the shells, may prove to be distinct species.

The close similarity of the young stages of this shell to those of *Cerithium tuberosum* has already been referred to, but the very considerable divergence at an early period of the ontogeny entitles it to rank as a distinct, though closely related, genus.

Vulgocerithium breve sp. nov.

MEASUREMENTS: Length, 34.1 mm.; greatest diameter, 15 mm.; apical angle, 43°, changing to 25.5° on the last two volutions; sutural angle, 76.2°.

COLOR: Grayish white, mottled with dark brown. Bands of dark brown occupy the depressions between the spirals.

The apex of this shell is much worn. The youngest volution to show the surface ornamentation is 2 mm. in diameter and has the two strong spirals, as in the young of *V. vulgatum*. At this stage intercalated spirals are present, both between the primary spirals, on the shoulder and on the lower slopes of the volutions. On the sixth volution of those preserved the ribs become especially prominent at the level of the upper primary spiral, and a sub-sutural row of nodes is also developed. On the whorl before the last the center of the rib becomes very prominent, and on its lower slope the spirals have a tendency to coalesce and become flattened, but this tendency is never carried very far on this species. On the body volution the ribs become weaker and the sub-sutural row of nodes stronger, until the two are of about equal strength.

The aperture is broadly oval, and the callus of the inner lip is thin, with a prominent posterior tooth. The outer lip is slightly flaring and faintly crenulated. The anterior canal is short, with its margin slightly recurved.

HORIZON AND LOCALITY: Recent. The specimens in the collection of Columbia University were collected by D. M. Sankey in deep water off the mouth of Grand River, northwest Mauritius.

No. 20138, Columbia University collection.

REMARKS: The species is distinguished from *Vulgocerithium vulgatum* by its shorter form, wider apical angle and heavier and more prominent nodes, which make the outline of the volutions sharply angular. The shell is also thicker and the spirals are more rounded than is usual with *V. vulgatum*.

Vulgocerithium plicatum *Philippi*

1836. *Cerithium plicata* Philippi, Enum. Moll. Sicil., p. 192.
1887. *Cerithium vulgatum* Tryon, Manual of Conch., p. 126.

Measurements: Length, 25.1 mm.; greatest diameter, 1.4 mm.; apical angle, 42°, changing to 24° on the last three volutions; sutural angle, 78°.
Color: Background white, thickly mottled with yellow and golden brown.

The apex of the shell is much corroded, but a volution 1 mm. in diameter shows that it possesses ribs and two spirals. The fifth volution is the first to show the ornamentation plainly, and on this the spirals are broad, but not greatly flattened, and the oblique-angled outline is still retained. The embracing of the whorls is so great as to nearly cover the lower slope of the whorl. The succeeding volutions develop a sub-sutural row of nodes and the ribs are strongly defined. The upper primary spirals remain always the more prominent, and the vertical element in the outline of the shell disappears at about the eighth volution. The adult ornamentation consists of strong ribs, which are most prominent at the level of the first primary spiral, and a sub-sutural row of nodes. The spirals are broad and somewhat flattened, with narrow depressions between them. On the body volution the ribs become narrow, crowded and so low as to be nearly obsolete. The sub-sutural row of nodes is here the most prominent feature of the ornamentation.

The aperture is oval, and the callus of the inner lip is thick, with a well-defined posterior tooth. The outer lip is thick and smooth, with an entire margin. The anterior canal is short and widely open.

Horizon and locality: Recent. Locality unknown.
No. 40237, Columbia University collection.

Remarks: *Vulgocerithium plicatum* has been regarded by Tryon as a variety of *Vulgocerithium vulgatum,* but it differs from that species in its smaller size and in its more continuous and more prominent ribs, with their most convex portion at the center of the volution instead of above the center. It also has broader and more rounded spirals, and the anterior canal is proportionally shorter.

This species is related to the *V. vulgatum* group in the development of the young whorls and in the general form of the shell and of the aperture. The sub-sutural row of nodes and the ribs are the most noticeable features of the ornamentation.

Vulgocerithium gracile *Philippi*

1836. *Cerithium gracilis* Philippi, Enum. Moll. Sicil., p. 193.
1887. *Cerithium vulgatum* Tryon, Manual of Conch., p. 126, pl. 21, fig. 43.

Measurements: Length, 30.8 mm.; greatest diameter, 11 mm.; apical angle, 39.5°, changing to 17° on the last three volutions; sutural angle, 82.5°.

Color: Yellowish white, mottled with reddish brown, which usually passes in sinuous lines across the spirals.

The ornamentation is entirely obliterated on four volutions of the best specimen available. The fifth volution has the usual two strong spirals, and there are at this stage three intercalated spirals, with at least four on the shoulder and two on the lower slope of the volution. All the spirals are crossed by ribs, and varices occur to the number of about three to the volution. A similar type of ornamentation persists to the seventh volution. At this stage the spirals are still distinct, and the embracing of the whorls is loose enough to leave a well-marked slope below the lower strong spiral. On the next two volutions the finer spirals gradually coalesce with the coarser ones, which then become broad and flattened. The ribs between the varices become very narrow, and a sub-sutural row of nodes is developed. The adult ornamentation is characterized by numerous narrow ribs projecting in a sharply pointed but not very prominent node at the level of the first primary spiral. The slight shoulder is concave and the lower slope of the whorl gently convex. A sub-sutural row of nodes is present on the adult whorls, and a row of fine nodes appears just above the suture. The ribs become nearly obsolete on the body volution, being represented by two rows of nodes.

The aperture is of the type usual in this group, with an oval outline, a narrow callus and a posterior tooth. The outer lip is slightly flaring, and the anterior canal is a little longer than in the last species, with a narrow opening and slightly reflexed margin.

Horizon and locality: Recent. Locality unknown.
No. 20139, Columbia University collection.

Remarks: The species has been referred to *Vulgocerithium vulgatum*, but it is distinguished by its smaller size, proportionally coarser and more rounded spirals and by the more sharply pointed form of the main row of nodes. The spirals below the slight shoulder become rounded and irregularly nodose, instead of flattened and inconspicuous, as in *V. vulgatum*.

The shell bears a close resemblance to the last species described, but it differs in several important respects. The development is much more retarded than that of *V. plicatum*, since the coalescence of the spirals does

not begin until the seventh volution, as compared with the fourth volution on the preceding species. The embracing of the whorls is not so close as on *V. plicatum*. The adolescent and adult stages are distinguished by the much smaller nodes of the present species and by the form of the node, which is sharp and pointed at the apex in *V. gracile*, as compared with the blunt but more prominent and more elongate nodes of *V. plicatum*. The anterior canal also differs in being longer, narrower and slightly recurved.

Vulgocerithium adenense *Sowerby*

1866. *Cerithium adenense* Sowerby, apud Reeve, Conch. Iconica, XV, No. 89.
1887. *Cerithium adenense* Tryon, Manual of Conch., IX, 124, pl. 20, fig. 30.
1898. *Cerithium adenense* Kobelt, Syst. Conch.-Cabinet von Martini u. Chemnitz, Bd. I, Abth. 26, 196, pl. 35, fig. 12.

Measurements: Length, 23.2 mm.; greatest diameter, 8.4 mm.; apical angle, 32.5°, changing to 21° on the last four volutions; sutural angle, 83.5°.

Color: Yellowish or grayish white, with ill-defined sinuous lines of reddish brown crossing the spirals.

The apex of the shell is broken away. The youngest volution studied is 1.4 mm. in diameter and has the usual two strong spirals, with one intercalated spiral and one or two spirals on the shoulder. Well-developed ribs cross all the spirals. The ornamentation remains of the same type, with the addition of spirals for the next three volutions. On the fifth of the volutions preserved a sub-sutural row of irregular, low nodes is developed, and the upper primary spiral forms sharp-pointed nodes where crossed by ribs. On the later volutions the coarser spirals become broad and flat, with fine grooves between them, and the finer spirals become obsolete. The adult ornamentation is that of widely spaced ribs, which are almost spinose where crossed by the upper primary spiral. The upper slope of the rib is concave and the lower slope straight or slightly convex, which gives the center of the rib the appearance of an upward-pointing, blunt spine. There are three rows of finely nodose spirals on the lower slope of the body volution.

The aperture is elongate oval. The callus of the inner lip is moderately thick, with a well-developed posterior tooth, and the outer lip is thin. The anterior canal is short and widely open.

Horizon and localities: Recent. Island of Karak, Persian Gulf, Gulf of Aden.

No. 20140, Columbia University collection.

Remarks: This little species is nearest to *V. vulgatum* but is distinguished by the great difference in the size of the shell and the size and

extreme sharpness of the principal row of nodes, which give the volution a distinctly angular outline. The sub-sutural row of nodes is less well defined than on *V. vulgatum*.

The species is distinguished from *V. plicatum* and *V. gracile* by its sharp nodes and the greatly flattened spirals.

B. PLEISTOCENIC SPECIES OF VULGOCERITHIUM

Vulgocerithium vulgatum

M. Cossmann figures, on plate 3, fig. 14, of his Essais de Paléconchologie, a specimen from the Pleistocenic of Saix, which he refers to this species. It is smaller than the normal recent individuals, and the nodes of the principal row are prominent and somewhat widely spaced.

C. PLIOCENIC SPECIES OF CERITHIUM

No specimens of the *Cerithium tuberosum* group from the Pliocenic of the Eastern Hemisphere are available for study, and the information furnished by the literature is meager.

Cerithium crenatum Brocchi, figured in Quenstedt's Petrefaktenkunde Deutschlands, plate 204, fig. 46, is of a small specimen from the Pliocenic of Asti, which may belong in this group. It has the oval aperture, posterior tooth, and crenulated outer lip of *Cerithium* sens. str. It also has in the young stages two rows of nodes which are stronger than the others, but in the absence of specimens it is impossible to be sure that it is correctly placed here.

In the American Pliocenic several species occur which apparently belong in this group. Of these only two actual specimens were obtainable, but good figures and descriptions aid in determining the relationship of others.

Cerithium callisoma *Dall*

Plate VII, fig. 1; plate VIII, figs. 1, 2; plate IX, fig. 1.

1892. *Cerithium callisoma* Dall, Trans. Wagner Free Institute of Sci., III, pt. 2, 282, pl. 14, fig. 8.

Measurements: Length, 20.8 mm.; greatest diameter, 8 mm.; apical angle, 35°, changing to 26° on the last three volutions; sutural angle, 80°.

The youngest volution preserved on the specimens studied is .4 mm. in diameter and has three spirals, of which the two lower are equal in size and stronger than the upper one. Ribs are also present at this stage.

On the fourth of the volutions preserved one spiral is intercalated between each pair of primaries and the upper primary spiral becomes weaker, making the shoulder more pronounced. The sixth volution has three fine spirals intercalated between the two strong primary ones, with one above and one below the third primary spiral. The lower slope of the volution has at this stage two spirals, one stronger than the other. The same type of ornamentation persists throughout the growth of the shell, with an increase in the number of spirals, which vary in strength according to the order of their introduction. The third primary spiral on the shoulder remains always stronger than any secondary spiral, but not so strong as the other two primaries. The latter become very prominent and produce the well-defined oblique-angled outline of the volution so characteristic of *Cerithium tuberosum*.

The aperture has the usual oval form of the shells of this group, with a narrow, thick callus and prominent posterior tooth. The anterior canal is short and widely open.

HORIZON AND LOCALITY: Pliocenic of the Caloosahatchie beds, Florida. No. 12569, American Museum collection.

REMARKS: The first three volutions preserved on this shell recall the seventh, eighth and ninth volutions of the Eocenic species, *Cerithium retardatum* (plate IV, fig. 10; plate V, fig. 9). On the latter shell three spirals are developed, the two lower of which are stronger than the upper, and the first intercalated spiral appears between the strong spirals. A similar development is seen on *C. callisoma,* but it is more accelerated than *C. retardatum,* since its shoulder is distinguishable from the first, while *C. retardatum* never acquires a distinct shoulder, but retains the primitive rounded outline of its volutions throughout life.

C. callisoma is most closely related to the recent species *C. tuberosum,* but it is more primitive than the latter species, since it retains the oblique-angled outline of the volutions throughout life without a trace of weakening of the lower spiral, while on *C. tuberosum* the lower primary spiral becomes gradually less prominent, until on the body volution the outline is sharply angular. The resemblance of the adult *C. callisoma* to the young *C. tuberosum* is most striking, and if the latter species were from a less distant locality, we might at once assume it to be the Pliocenic ancestor of *C. tuberosum.* As it is, we may suppose that *C. callisoma* is the American representative of this ancestor, which existed in the vicinity of the Red Sea or the Indian Ocean, but has not yet been recorded from that locality.

Cerithium floridanum *Mörch*

1876. *Cerithium floridanum* Mörch, Malacologia Blätter, XXIII, 114.
1892. *Cerithium floridanum* Dall, Trans. Wagner Free Institute of Sci., Phila., III, pt. 2, Dec., 282, pl. 14, fig. 10.

Measurements: Length, 34.2 mm.; greatest diameter, 14 mm.; apical angle, 29°, changing to 22° on the twelfth volution; sutural angle, 86°.

The protoconch of the specimen studied is much worn, but is apparently of the same form as that of *Cerithium adansoni*. The succeeding three volutions are too much worn to show the ornamentation. The first volution on which surface features appear distinctly is the fifth, which has a diameter of 1.9 mm. It bears ribs and two strong spirals. The shoulder is long and has three fine spirals, with a sub-sutural band composed of two elevated spirals. A single spiral is intercalated between the two strong ones, and the lower slope of the volution is very short. The earlier whorls of the shell bear an irregular number of varices averaging about two or three on a volution. On the sixth and seventh volutions the sub-sutural band gradually breaks up into a row of nodes and the spirals become larger, but do not increase rapidly in number. On the eighth and ninth volutions the larger spirals become nodose where crossed by the ribs, and on the next volution the nodes of the sub-sutural row and those of the first primary spiral become larger than the others and of equal strength. At the same time the nodes of the second primary spiral become weaker. On the two succeeding volutions the large nodes just below the suture and those of the upper primary spiral are in line vertically, forming distinct ribs, while the nodes of the lower primary spiral are small and twice as numerous as those of the upper row. The spirals on both the shoulder and lower slopes of the whorl alternate in strength according to their order of introduction and are strongly defined by the deep, narrow grooves between them. On the thirteenth and last volution the nodes of the lower primary spiral become very small and numerous—a mere line of beading around the shell.

The body volution and the aperture are much broken, but the inner lip is preserved, showing that it has a thick callus with a blunt posterior tooth, and the anterior canal is short and rather widely open.

Horizon and localities: Pliocenic. Caloosahatchie beds and Osprey, Manatee County, Florida.
No. 12568, American Museum collection.

Remarks: The adult ornamentation of this little shell shows some variation from the figure given by Dall [1892, plate 14, fig. 10] in the

marked difference in the strength of the subordinate spirals and in the more angular outline of the adult volutions, but the shell agrees with the description and figure in essential respects. Its early development and the general character of its adult features show it to belong undoubtedly to the *Cerithium tuberosum* group.

Cerithium glaphyrea *Dall*

1892. *Cerithium glaphyrea* DALL, Trans. Wagner Free Institute of Sci., Phila., III, pt. 2, p. 283, pl. 14, fig. 4.

MEASUREMENTS (Dall): Length, 16 mm.; greatest diameter, 6 mm.; REMAINING MEASUREMENTS FROM FIGURE: Apical angle, 23°; sutural angle, 88°.

No specimen of this species has been obtainable, but from the original description and figure the following features of interest in this connection may be determined. From the figure it appears that the shell has two spirals stronger than the others, with fine spirals between the two primary ones and on the shoulder. A third strong spiral on the shoulder becomes nodose, but is not so strong as the two main spirals. All the spirals are crossed by numerous closely set ribs. The two strong spirals remain of equal strength and continue to form an oblique angle for the whorl until the body volution is reached, when the lower of the two becomes weaker.

The aperture is of the type usual in the *Cerithium tuberosum* group, with a narrow callus and strong posterior tooth, flaring, crenulated outer lip and short anterior canal.

HORIZON AND LOCALITY: Pliocenic of the Caloosahatchie beds, Florida.

REMARKS: This species has a strong fundamental resemblance to *Cerithium callisoma* in the form of the body and of the aperture, and in the persistence of the oblique-angled outline of the whorls formed by two strong spirals with a weaker one on the shoulder. The most striking difference is in the very numerous ribs of *C. glaphyrea,* which are so closely set as to appear like rows of nodes where crossed by the coarser spirals. *C. glaphyrea* appears to have the essential characteristics of the *C. tuberosum* group, but probably represents a lateral branch from the main line, expressing its divergence in the development of numerous ribs.

Cerithium glaphyrea mut. litharium *Dall*

1892. *Cerithium glaphyrea* var. *litharium* DALL, Trans. Wagner Free Institute of Sci., Phila., III, pt. 2, 284, pl. 14, fig. 9.

MEASUREMENTS (Dall): Length, 19 mm.; greatest diameter, 6.5 mm.

The mutation *litharium* evidently belongs to the same phyletic series as the species to which it is related, differing only in minor features of the ornamentation, such as more prominent nodes and additional rows of fine beading.

Cerithium algicola ADAMS and *C. muscarum* SAY, from the character of their apertures and the general appearance of the shells, seem to be related to this group, but in the absence of specimens and with very imperfect figures, it is impossible to be certain of their position.

D. MIOCENIC SPECIES

1. *Cerithium.*

So far as can be determined from the literature, the Miocenic of the Eastern Hemisphere furnishes few specimens of the *Cerithium tuberosum* group. This is due doubtless to lack of preservation, rather than to a paucity of species existing during that period.

Cerithium bronni PARTSCH, of the Miocenic of the Vienna Basin, may possibly belong here. [See HÖRNES and PARTSCH, 1856, plate 42, figs. 12*a, b*.] The figure, which gives no clue to the ornamentation of the young shell, is insufficient evidence for placing the shell definitely, but the aperture corresponds with that of *C. tuberosum*, and the ornamentation of the adult is similar in type to that of other species of *Cerithium* sens. str.

An unnamed variety of *C. crenatum* BROCCHI is mentioned by HÖRNES and PARTSCH [1856, p. 409] as occurring in the Miocenic of the Vienna Basin. According to their figures [*loc. cit.*, plate 42, figs. 13, 14], the shell has the adult characteristics of this group, but the features of the young shell cannot be determined from the figures.

Cerithium mediterraneum, described with recent species of *Cerithium*, is recorded by HÖRNES and PARTSCH [1856, p. 393] from the Miocenic of the Vienna Basin.

Cerithium calculosum *Basterot*

1825. *Cerithium calculosum* BASTEROT, Mem. géol. sur les environs de Bordeaux, p. 58, pl. 3, fig. 5.

MEASUREMENTS: Length, 29.8 mm.; greatest diameter, 14.1 mm.; apical angle, 37.2°; sutural angle, 79.3°.

The protoconch is absent from this shell, but the youngest volution preserved is probably the first beyond the protoconch, and it is 1 mm. in diameter. This volution is ornamented by ribs and two equal spirals.

The second volution is like the first, except that it has a third weaker spiral just below the suture and numerous ribs are present at this stage. On the sixth volution of those preserved the sub-sutural spiral becomes nearly as strong as the two primary spirals, and all three become strongly nodose where crossed by the ribs. On the next two volutions the shoulder practically disappears, and the volution seems to be ornamented by three rows of strong nodes with intercalated spirals between them. Varices are irregularly developed from the fifth volution onward and on the later whorls become extremely prominent, forming a conspicuous feature of the ornamentation. Both ribs and varices are set at an angle with the vertical axis of the shell, so that they appear to twist in passing from whorl to whorl. On the tenth volution of those present the two lower spirals again become more prominent than the sub-sutural row, giving an oblique-angled outline to the volution, which has vertical sides and a row of strong nodes on the shoulder. Rather coarse intercalated spirals cover all the surface between the rows of nodes. Just above the suture a row of fine nodes is partially concealed by the succeeding whorl. On the body volution the shoulder is nearly obsolete, and there are six rows of nodes, of which the two upper are the strongest. A very strong varix is present on the side opposite the outer lip.

The aperture is elongate oval, with a narrow, thick callus and well-developed posterior tooth. The outer lip in some individuals is extremely thick, and the aperture in these specimens is somewhat constricted by the addition of material to the inner margin. Other specimens do not show such thickening of the lip. The siphonal canal is short and slightly reflexed at the margin. At an earlier stage of growth the canal was bent toward the left, but the animal has abandoned this position and continued the canal in a downward direction, the earlier growth being left as a curious knob on the outside of the tube.

HORIZON AND LOCALITY: Miocenic. Martillac near Bordeaux.
No. 20141, Columbia University collection.

REMARKS: This species bears a striking resemblance to the Florida species, *C. glaphyrea,* in the closely set ribs, the number of the spirals and the form of the aperture; but it differs in being a more closely coiled form and in having numerous very strong varices.

This species has been made the type of a new genus, *Chondrocerithium*, the distinguishing characteristics being the presence of a columnellar plication and slight differences in the aperture. The development of the species shows its close relationship to *Cerithium*, and the aperture does not differ in any essential respect from many species of that genus. A faint

trace of columnellar plication was found on only one of the seven specimens studied, and this barely distinguishable feature seems insufficient ground for the establishment of a new genus.

Cerithium calculosum, mut. **globulus** n. mut.

Like *Cerithium glaphyrea, C. calculosum* has a variety which differs from the type in having finely nodose spirals intercalated between the stronger ones and in having the row of fine nodes just above the suture fully exposed rather than covered by the next whorl, as in the case of the original species.

HORIZON AND LOCALITY: Miocenic. Martillac near Bordeaux.
No. 20142, Columbia University collection.

Cerithium chipolanum *Dall*

1892. *Cerithium chipolanum* DALL, Trans. Wagner Free Institute of Sci., Phila., III, pt. 2, 285, pl. 22, fig. 7.

MEASUREMENTS (Dall): Length, 10 mm.; greatest diameter, 4.5 mm.

A specimen of this species has not been obtainable, but a good figure and description make possible the determination of its relationship with a fair degree of probability. The author of the species describes four spirals on each volution, and the figure shows that in the young shell two of these are more prominent than the others, forming the oblique-angled outline of the whorl characteristic of the *Cerithium tuberosum* group. Later in the growth of the shell the lower of the two strong spirals becomes weaker, giving a sharply angled outline to the whorl. On the body whorl two of the spirals on the shoulder increase in size, so that the ornamentation of this volution consists of a shoulder with two strong spirals on its slope and two below the shoulder angle.

The aperture is of the type usual in this group, with a well-developed posterior tooth and short, widely open anterior canal.

HORIZON AND LOCALITY: Older Miocenic of the Chipola beds, northwest Florida.

REMARKS: Dall states that *C. chipolanum* is not closely related to any of his preceding species, which would include *C. callisoma* and *C. glaphyrea,* but he does not say in what respect the divergence is expressed, unless the high development of varices mentioned is considred such a difference. Varices are, however, characteristic features of *Cerithium* sens. str. This little species is more closely coiled than the Pliocenic *C. calli-*

soma or the recent *C. tuberosum* and resembles in that respect *C. adansoni*. It may be the American representative of the Miocenic ancestor of the latter species rather than a member of the direct line toward *C. tuberosum*.

2. *Vulgocerithium*

Specimens of *Vulgocerithium vulgatum* are reported by Hörnes and Partsch [1856, p. 388] from the Miocenic of Italy and the Vienna Basin. The species seems to persist through the Miocenic and Pliocenic to recent time.

Hörnes and Partsch describe several other species which are evidently closely related to *V. vulgatum*.

Vulgocerithium minutum *Serres*

This species is recorded by Hörnes and Partsch [1856, p. 390] from the Miocenic of the Vienna Basin. Specimens have been obtained from the upper Oligocenic of Saucats, and the species is described with others from that horizon. The Oligocenic specimens differ from the figures of Hörnes and Partsch [1856, plate 41, figs. 8, 9] in their smaller size and the less prominent nodes of the median row.

Vulgocerithium zelebori *Hörnes* and *Partsch*

1856. *Cerithium zelebori* Hörnes and Partsch, Abhand. der k. k. geol. Reichsanstalt, III, 391, pl. 41, fig. 10.

This species seems to be closely related to *V. minutum*, differing in the more rounded nodes, less continuous ribs and the greater distinctness of the sub-sutural row of nodes. The young stages are not described in detail, and the figures are not sufficiently enlarged to show them clearly, but the general form, aperture and surface ornamentation are so similar to those of *V. vulgatum* that they may be referred to the same group with a high degree of probability.

Vulgocerithium doliolum *Brocchi*

1814. *Cerithium doliolum* Brocchi, Conchiologia fossile subappen., II, 442, pl. 9, fig. 10.

1856. *Cerithium doliolum* Hörnes and Partsch, Abhand. der k. k. geol. Reichsanstalt, III, 392, pl. 41, fig. 11.

Hörnes and Partsch record this species from the Miocenic of Italy and the Vienna Basin. It has a somewhat shorter spire than most species of *Vulgocerithium*, but it is similar to shells of this group in the character

of the ornamentation and the form of the aperture. The nodes of the sub-sutural row and of the first primary spiral have a somewhat more rounded form than most species of the genus, and rows of fine nodes are intercalated between them.

A variety represented by fig. 12*a, b,* has the high spire characteristic of the typical *Vulgocerithium.*

Vulgocerithium rubiginosum *Eichwald*

1830. *Cerithium rubiginosum* Eichwald, Naturh. Skizze von Lithauen, Volhynien u. s. w., p. 224.
1856. *Cerithium rubiginosum* Hörnes and Partsch, Abhand. der k. k. geol. Reichsanstalt, III, 396, pl. 41, figs. 16, 18.

So far as can be learned from the descriptions and figures, this little species has all the characteristics of *Vulgocerithium.* It differs from the last species in the absence of the intercalated rows of fine beading, and the nodes are somewhat more prominent. The species is recorded by Hörnes and Partsch from the Miocenic of the Vienna Basin.

E. OLIGOCENIC AND EOCENIC SPECIES

1. *Cerithium*

The relationship between the Oligocenic and Eocenic species is so close that it has been thought best to consider them together, taking up the forms in the phylogenetic rather than the stratigraphic order.

Cerithium æquispirale sp. nov.

Plate II, fig. 5; plate V, figs. 3, 4; plate VI, fig. 3.

Measurements (last five volutions): Length, 23 mm.; greatest diameter, 10.1 mm.; apical angle, 33.5°, changing to 26.8° on the last three volutions; sutural angle, 85°.

The general form of this shell is high and narrow, with moderately embracing whorls and but slightly impressed sutures. The apex of the shell is broken away, and the earliest volution preserved has a diameter of 4 mm. and height of 1.4 mm. On this volution, two spirals are stronger than the others and are equal in strength. A third primary spiral at the base of the whorl is partly covered by the succeeding volution. Between the stronger primary spirals a secondary and two tertiary ones appear, and one primary, with four secondary spirals, is above the shoulder angle. This volution bears eleven strong, rounded ribs, which are well

developed from suture to suture. The first, fourth and eighth ribs are much stronger than the others, forming varices. On the later volutions, these varices appear at irregular and less frequent intervals, having in the adult from five to ten ribs between the varices. On the succeeding volutions more spirals appear, until those of the fifth order may be counted. These are very fine, but still preserve their rounded character, and several of equal strength are crowded between the coarser spirals. The strong shoulder and the two equal primary spirals persist until the body volution is reached. On the latter volution the primary spiral on the shoulder becomes as strong as the primary ones below it, and the shoulder, which is still present on the preceding volution, disappears. The body volution bears below the three primary spirals already mentioned three more strong spirals, with finer ones between them. Here, too, the ribs become weaker, the spirals stronger, and at the crossing of the two there is a tendency to form nodes, though the development does not go far enough to form actual nodes. On the later portion of the body whorl the sub-sutural spiral becomes as strong as the two primary ones.

The aperture of the shell is oval, with short, reflexed anterior canal. A well-defined posterior canal is also present, the inner margin of which is bounded by a ridge, but not a distinct tooth, such as appears in *Cerithium tuberosum*. The inner lip is covered by a narrow callus, and the outer lip is slightly flaring and notched to correspond with the strong spirals of the exterior surface.

HORIZON AND LOCALITY: The precise horizon of this species is not known, but it was found in a collection of unidentified shells from the Eocenic of the Paris Basin.

No. 10323, Columbia University collection.

REMARKS: *Cerithium æquispirale* has a close resemblance in form and in the features of the aperture to *C. lamellosum*, but it differs from that species in the character of the spirals, which are strongly developed and have a rounded form instead of appearing like imbricating lamellæ, as in the latter species. *C. lamellosum* also differs in the loss of its secondary spirals on the adult whorls.

C. æquispirale has the two strong spirals and the numerous spirals of higher order characteristic of *C. tuberosum*, and it retains these features throughout life. The body volution has especially strong spirals on its lower slope, and the lower part of the outer lip grows a little more rapidly than the upper part. The persistence and development of this tendency would in time produce a strong projection of the lower spirals like that seen on the aperture of *C. tuberosum*. At the same time the prominent

sub-sutural spiral on the later part of the body volution of *C. æquispirale* suggests the *Vulgocerithium* group. The species may well be a type from which the *C. tuberosum* group arose, but *Vulgocerithium* probably arose from the ancestor of *C. æquispirale, C. cornuelianum.*

The young stages of *C. æquispirale* are unfortunately missing, but the adult shell is so similar in general character to *C. lamellosum* that the young stages may also have been similar, although this is not certain to be true, for similarity in adults does not necessarily mean similarity in the young.

Cerithium lamellosum *Bruguière*

Plate III, figs. 7, 8; plate IV, fig. 8; plate V, figs. 7, 8; plate VI, fig. 6.

1792. *Cerithium lamellosum* BRUGUIÈRE, Encycl. Méthod., p. 488.
1824. *Cerithium lamellosum* DESHAYES, Desc. des coquilles foss. des environs de Paris, p. 370, pl. 64, figs. 8, 9.
1866. *Cerithium lamellosum* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 159.
1906. *Ptychocerithium lamellosum* COSSMANN, Essais de Paléoconch. Comp., VII, 81.

MEASUREMENTS: Length, 48.4 mm.; greatest diameter, 13.8 mm.; apical angle, 29°, changing to 18° on the eleventh volution; sutural angle, 84°.

The volutions of this species embrace but slightly, producing a long, slender shell. The general outline of the whorls is gently rounded, with slightly impressed sutures.

The early stages of growth are best seen on a young individual of nine volutions. The beginning of the protoconch of this specimen is not preserved, but it seems to have comprised about one and one-half volutions. Beyond this a spiral appears at about the middle of the whorl, the portions above and below the spiral becoming flattened until a distinct shoulder is produced. On the second volution beyond the protoconch the spiral has become elevated at regular intervals to form faint nodes, and on the third volution another spiral appears below the first, while the nodes are elongated into faint ribs. The second spiral soon becomes as strong as the first, and the two form a slight projection around the median portion of the whorl. The two equal spirals remain stronger than the others throughout the life of the animal, but the shoulder is never a conspicuous feature of the ornamentation. On the succeeding volution, the fourth beyond the protoconch, there is a faint constriction of the shell below the suture, which, with the suture itself, outlines an indistinct spiral. The two volutions which follow are like the

fourth, with a gradual strengthening of the characters already introduced. On the seventh volution faint secondary spirals are intercalated between the first two and on the shoulder above the first spiral. The ribs are well defined and extend from suture to suture, about one on each volution being enlarged to form a varix, a feature which persists on all the later whorls. The ninth volution differs only in having an additional faint spiral just below the sutural one.

An adult individual shows twelve volutions, from which, as shown by comparison with the young, about four volutions in addition to the protoconch have been broken away. On the eleventh volution of this specimen the spirals are five in number, with ribs extending from suture to suture, and separated by interspaces slightly wider than themselves. Although the surface is much dissolved, faint traces of secondary and tertiary spirals may be seen. The strength of all the spirals varies considerably, not only with the condition of preservation, but in different individuals similarly preserved. Some individuals show the secondary and tertiary spirals distinctly, while they are hardly visible on others. The spirals of this species, especially on the later volutions, have their upper edge projecting sharply and their lower edge merging into the surface of the shell, so that the whorls appear to be made up of overlapping lamellæ with their edges turned upward. On the later part of the body volution the spiral just below the suture is broken up into nodes, and the three spirals below the central band become extremely strong.

The aperture is oval, with a deep anterior canal and a well-defined posterior canal. The callus of the inner lip is narrow but comparatively thick. The outer lip is folded into a series of prominent lobes, which correspond in position with the spirals on the outside of the shell.

HORIZON AND LOCALITIES: Calcaire Grossier (Upper Eocenic). Chaussy and Grignon, Paris Basin.

No. 20143, Columbia University collection.

REMARKS: This species begins its life history in a much simpler manner than any of the species thus far described, and it is not until the sixth volution that it fully acquires the shoulder, which in recent accelerated forms begins immediately after the protoconch. The primitive stages preceding the formation of ribs, and with one volution only, have been crowded out of the ontogeny by acceleration in such forms as *Cerithium adansoni* and *C. tuberosum.*

Cerithium lamellosum does not continue its development in the direction of *C. tuberosum*, for, after having acquired intercalated spirals of high orders, it nearly or quite loses them on the adolescent and adult

whorls, and the form of the spirals changes to the imbricated type described above. On account of this divergence expressed in the adult shell, *C. lamellosum* may be considered a lateral branch from the line developing in the direction of *C. tuberosum*. No descendants of *C. lamellosum* have been found in the material studied, and it may have died out at the end of the Eocenic without giving rise to later species.

The young of *C. lamellosum* gives a clue to the kind of development which preceded the stage with ribs and two strong spirals, and it is to be expected that from such primitive conditions development would take place in several different directions. This we find to be the case, as illustrated by several of the following species.

M. Cossmann refers this species to *Ptychocerithium* on account of the narrow opening of the canal and the strong varix opposite the outer lip. He considers it as closely related to *Vulgocerithium*, but from the development of the early stages it seems to be more closely related to *Cerithium* than to either of these.

Cerithium inabsolutum *Deshayes* ?

1866. *Cerithium inabsolutum* Deshayes, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 170, pl. 74, fig. 28.
1906. *Ptychocerithium inabsolutum* Cossmann, p. 80.

Measurements (young individual): Length, 10 mm.; greatest diameter, 4 mm.; apical angle, 23.5°; sutural angle, 85°.

Two very small individuals probably represent the young of *C. inabsolutum*, but are referred to that species with doubt, since no adult is available for comparison with them.

A part of the protoconch is present on one specimen and, so far as can be determined, is like that of *C. adansoni*. The first complete volution is .3 mm. in diameter and bears two continuous spirals, one of which appears slightly before the other. This type of ornamentation continues for six volutions, but on the seventh ribs are developed, fine spirals appear on the shoulder and a spiral is intercalated between the two primary spirals. Strong varices to the number of one or two to the volution are developed on the remaining whorls. On the eighth volution a constriction below the suture defines a sub-sutural band which is raised into nodes where crossed by the ribs, and numerous spirals of higher order are introduced. The shell comprises eleven volutions, and the two strong, equal spirals characteristic of *Cerithium* remain undiminished in strength on the last volution present. The lower slope of the body volution bears two strong spirals with three finer ones below them.

The aperture is oval, with a long columella and poorly formed siphonal canal. No callus is present on the inner lip, and the outer lip is too much broken to determine its character.

HORIZON AND LOCALITY: Calcaire grossier. Grignon, Paris Basin.
No. 2564, Museum of Comparative Zoölogy collection.

REMARKS: The absence of a callus on the inner lip and the poorly formed siphonal canal accompanying a surface ornamentation characteristic of young *Cerithium* seem to indicate that these specimens are young individuals. They are referred to *C. inabsolutum* on account of the elongation of the lower part of the aperture and the character of the ornamentation, which seems to correspond with that described for the species. Whether or not the specific identification is correct, they belong undoubtedly to the genus *Cerithium* sens. str.

Cerithium calcitrapoides *Lamarck*

1804. *Cerithium calcitrapoides* LAMARCK, Ann. du Mus. Nat. d'hist. naturelle de Paris, III, 274.
1824. *Cerithium calcitrapoides* DESHAYES, Desc. des coquilles foss. des environs de Paris, 347, pl. 46, figs. 18, 19, 23.
1906. *Batillaria calcitrapoides* COSSMANN, Essais de Paléoconch. Comp., VII, 134.

MEASUREMENTS: Length, 50 mm.; greatest diameter, 18 mm.; apical angle, 25°; sutural angle, 87°.

The youngest volution studied has an ornamentation of one spiral only. On the next volution a second spiral appears above the first, and on the fourth volution of those preserved, the two spirals are crossed by ribs, but it is not until the fifth volution that the two spirals become equal in strength. At this stage the shell has the shoulder characteristic of *Cerithium*, with two equal spirals crossed by ribs. On the seventh volution a spiral is intercalated between the two primary spirals, and fine ones appear also on the shoulder and on the lower slope of the whorl. On the ninth volution the lower primary spiral has become weaker than the upper, a tendency which increases until, on the twelfth and later volutions, the lower primary spiral is reduced to the size of the secondary ones, and the upper spiral forms the projecting margin of a sharply angled volution.

The aperture is elongate oval, with a thick callus on the inner lip and short, widely open canal. The outer lip is slightly crenulated.

HORIZON AND LOCALITIES: Calcaire grossier, Sables Moyens. Grignon and many other localities in the Paris Basin.
No. 3377, American Museum collection.

REMARKS: This species resembles *C. æquispirale* in the young but diverges from the type of development illustrated by that species in the adult. It may be considered a lateral branch from the main line of evolution of *Cerithium*.

Cerithium bicarinatum *Deshayes*

Plate II, fig. 8.

1824. *Cerithium bicarinatum* DESHAYES, Desc. des coquilles foss. des environs de Paris, p. 356, pl. 53, figs. 14, 15.

MEASUREMENTS: Length, 24 mm.; greatest diameter, 9.5 mm.; apical angle, 30°; sutural angle, 85.5°.

The youngest volution preserved on the specimen described is .7 mm. in diameter and is ornamented by two spirals, the lower of which is the stronger. Ribs are absent at this stage. The two succeeding volutions are like the first, except that the upper spiral becomes equal to the lower in strength. On the fourth of the volutions preserved ribs appear, and on the fifth a faint constriction below the suture defines a slight subsutural band, which, however, lasts for only two volutions and is not seen on the adolescent and adult stages. The specimen thus far described is a young individual preserving only eight volutions, but the same type of ornamentation persists on full-grown specimens, the adult ornamentation being simply two strong spirals with a long shoulder slope, a concave surface between the two spirals and a short lower slope. The body volution has two spirals below the primary ones.

The aperture is nearly circular, with a short siphonal canal so widely open that its cross-section does not represent a curve of more than 180°. The callus of the inner lip is narrow and has a slight projection near the posterior end, although a distinct tooth is not formed. The outer lip is broken on all the specimens obtainable, but it was evidently thin and, according to the figure of Deshayes, was not crenulated.

HORIZON AND LOCALITIES: Sables Moyens (Upper Eocenic). Acy-en-Multien and many other localities in the Paris Basin.

No. 20144, Columbia University collection.

REMARKS: The adult of this species corresponds in essential characteristics with the fifth volution of *Cerithium lamellosum* and with the second of *C. adansoni*, and although occurring at a higher horizon than *C. lamellosum*, it illustrates a more primitive type of development. It represents the persistence of a type of shell which was probably devel-

oped as far back in geologic time as the Triassic, since we have in Jurassic time a shell with rounded volutions and an ornament of three simple spirals, which was probably developed from a two-spiraled form just as the mutation *trispirale*, described below, arose from the type species by the development of another spiral on the shoulder.

Cerithium bicarinatum mut. **trispirale** n. mut.

Plate II, fig. 7.

1824. *Cerithium bicarinatum* DESHAYES, Desc. des coquilles foss. des environs de Paris, p. 356, pl. 53, fig. 6.

1866. *Cerithium bicarinatum* DESHAYES, Desc. des anim. sans vert. découverts dans le bassin de Paris, p. 180.

MEASUREMENTS: Length, 25 mm.; greatest diameter, 10.2 mm.; apical angle, 25°; sutural angle, 85°.

The development of the variety is precisely the same as that of the type species to the seventh volution, on which a faint third spiral is introduced above the two primary ones. This spiral grows rapidly until it equals in strength the lower primary spiral. The median spiral is slightly stronger than the others, so that the outline of the volution would be a regular curve if represented by a line touching the edges of the spirals. This type of ornamentation persists throughout the remainder of shell growth. The body volution has two strong spirals and three or more fine ones below the three primary spirals. The aperture is like that of the type species.

HORIZON AND LOCALITIES: Sables Moyens (Upper Eocenic). Acy-en-Multien and other localities in the Paris Basin.

No. 20145, Columbia University collection.

REMARKS: This mutation differs from the type species only in the presence of a third spiral, which becomes strong enough to change the outline of the volution. There is a perfect gradation between the species and its mutation, since specimens of the former are found in which the third spiral is barely distinguishable as a faint elevation on the adult whorls, and others in which this feature appears earlier and earlier in the ontogeny until the typical form of the mutation is developed. The mutation represents merely the next step in the evolution of this group.

Cerithium retardatum sp. nov.

Plate II, fig. 6.

MEASUREMENTS: Length, 27.2 mm.; greatest diameter, 1.5 mm.; apical angle, 24°; sutural angle, 86°.

The early stages of this species are described from a young individual of ten volutions. The protoconch of this specimen is missing, but the youngest volution preserved is .5 mm. in diameter and is probably the first volution beyond the protoconch. It is ornamented by a single spiral only, and no ribs are present. Another spiral is added above the first on the next volution, and on the third volution of those preserved, the two spirals become of nearly equal strength. Ribs first appear on the fourth volution and on the fifth, a fine third spiral appears above the two primaries. The three spirals are well developed on the seventh volution, and on the eighth the first intercalated spiral is introduced between the two lower primary ones. Another intercalated spiral soon appears between the two upper primary spirals, and the adult whorls have one spiral intercalated between each pair of primaries, with two fine spirals above and two below the three primary spirals. The body volution has two strong and six very fine, closely set spirals on its lower slope.

The aperture is similar to that of *C. bicarinatum,* being nearly circular, with shallow anterior canal. The callus of the inner lip is wider and the posterior ridge better developed than on *C. bicarinatum.* The outer lip is somewhat broken, but the lines of growth indicate that its lower margin grew more rapidly than the upper one.

HORIZON AND LOCALITIES: Sables Moyens (Upper Eocenic). Le Guépelle, Acy-en-Multien, Paris Basin.

No. 20146, Columbia University collection.

REMARKS: *Cerithium retardatum* represents a step in advance of *C. bicarinatum* mut. *trispirale* in the development of intercalated spirals. The three forms, *C. bicarinatum,* its mutation, *trispirale,* and *C. retardatum,* constitute a direct series in evolution. *C. bicarinatum* develops ribs and two equal primary spirals only. The mutation *trispirale* carries the development farther in the growth of a third primary spiral, and *C. retardatum* advances still farther in the introduction of intercalated spirals.

C. retardatum illustrates the law of recapitulation, for its fifth volution is like the adult of *C. bicarinatum,* and its seventh volution represents the adult of the mutation *trispirale.* At the same time the law of acceleration is illustrated by this shell, since the evolution represented by the entire life history of both *C. bicarinatum* and *C. bicarinatum* mut. *trispirale* is passed over in the first seven volutions of *C. retardatum.* But while *C. retardatum* is accelerated as compared with *C. bicarinatum,* it is retarded as compared with *C. æquispirale* and other shells occurring in the Upper Eocenic. It may be compared with the Upper Cretacic *C. albense* in the main line of evolution of the *C. tuberosum* group.

Cerithium sp. undt.

MEASUREMENTS: Length, 13.5 mm.; greatest diameter, 5.3 mm.; apical angle, 35°, changing to 26° on the last three volutions; sutural angle, 83.2°.

Two small specimens of nine volutions each are the only representatives of this species in the collections studied. They are probably young individuals, but it is impossible to identify young shells from the figures and descriptions as usually written.

The youngest volution preserved is .4 mm. in diameter and has one spiral only. The next volution is too much worn to show the ornamentation, but the third volution has two spirals crossed by ribs. The two spirals become of equal strength and, with the ribs, remain the only ornamentation until the sixth volution, when a fine spiral is introduced below the lower spiral. On the next volution a spiral is intercalated between the two primary ones, and on the eighth volution a fine spiral appears on the shoulder. The body volution retains the characteristic two strong spirals and has two fine spirals on the shoulder, with one intercalated between and one below the two primary spirals. The lower slope of the body volution has two strong spirals and several finer ones below the primary spirals. Spirals of the third order also appear on this lower slope.

The aperture is circular, with a shallow anterior canal. The callus of the inner lip is comparatively wide and has a distinct ridge near its posterior end. The outer lip is thin and not crenulated on the young shell.

HORIZON AND LOCALITY: Eocenic, Paris Basin. Precise horizon and locality unknown.

No. 20163, Columbia University collection.

REMARKS: This little shell is like *C. bicarinatum* to the sixth volution, after which it develops in a direction different from that of the two descendants of *C. bicarinatum* already described, namely, *C. bicarinatum* mut. *trispirale* and *C. retardatum*. This divergence is expressed in the acquisition of a third spiral on the lower slope of the whorl, instead of on the shoulder, as in the line of evolution just described. The spirals of the shoulder slope are introduced later, but always remain fine, and the shoulder persists to the last volution present on these forms, while it is lost on *C. bicarinatum* mut. *trispirale*. This species may be considered a descendant of *C. bicarinatum*, but it represents a different path of evolution from that, including *C. retardatum*.

2. *Vicinocerithium*

Vicinocerithium parallelum gen. et sp. nov.

Plate VII, figs. 4, 5; plate VIII, figs. 4, 5; plate IX, figs. 3, 4.

MEASUREMENTS: Length, 29 mm.; greatest diameter, 12 mm.; apical angle, 30.5°; sutural angle, 81.5°.

The protoconch of this species is not preserved. The youngest volution present bears three spirals, the lowest of which is the most prominent, and is separated by a wide interspace from the two upper spirals. On the next volution ribs appear, and the median spiral becomes stronger than the upper, but not quite so prominent as the lowest spiral. A slight ridge below the suture forms a fourth ill-defined spiral. On the third volution present the two lower spirals are equal in strength, and a fine spiral is intercalated between them. The third spiral has also become stronger, so that the outline of the volution is a regular curve. Two additional fine spirals appear just below the suture. The fourth and fifth volutions are essentially like the third, with an increase in the number of fine spirals. On the sixth volution the median primary spiral becomes stronger than the other two, and this tendency increases until, on the adult whorls, this spiral forms the margin of a sharply angled volution, with numerous fine spirals on the shoulder and the lower slope of the whorl. The uppermost primary spiral is reduced to the rank of a secondary spiral, and the lowest primary spiral, originally the strongest on the shell, is much reduced in relative size, though still stronger than the secondary spirals. This and another strong spiral just above the suture are crenulated, showing a tendency toward the formation of nodes, which on the latest portion of the body volution are fairly well developed. A third nodose spiral is present below those just described, and fine spirals are intercalated between all coarser ones on the lower slope of the body volution.

The aperture is nearly circular and the anterior canal is rather long and widely open. The outer lip is thin and the inner lip is covered by a strong callus.

HORIZON AND LOCALITY: Sables Moyens. Le Guépelle, Paris Basin. No. 20156, Columbia University collection.

REMARKS: This species has been considered identical with *Cerithium* (*Vicinocerithium*) *bouei* DESH., and if the adult characters alone are considered, they are hardly distinguishable, the only difference being that the present species has a somewhat higher spire and the shoulder is far-

ther from the horizontal. The development of the two shells is quite different, and for this reason they should rank as at least distinct species. By comparing figs. 4, 5 on plate VII, 4, 5 on plate VIII, 3, 4 on plate IX with figs. 6 on plate VII, 6 on plate VIII, 5, 6 on plate IX, it will be seen that *V. parallelum* acquires its sharp shoulder by developing its median primary spiral and retaining the lowest primary spiral in a subordinate position, while *V. bouei* develops its uppermost primary spiral to form the shoulder angle and the median spiral is reduced to the rank of a secondary spiral, and is finally indistinguishable from them.

The development of *V. parallelum* and *V. bouei* differs so widely from that of *Cerithium* that they should be referred to a distinct genus, as is here done. A full diagnosis of the genus awaits a more extended study of related species which should be included in the same genus. The two species are described here to illustrate the case of parallelism mentioned in the introduction.

Vicinocerithium bouei (*Deshayes*)

Plate VII, fig. 6; plate VIII, fig. 6; plate IX, figs. 5, 6.

1824. *Cerithium bouei* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 347, pl. 52, figs. 9-11.
1906. *Batillaria bouei* COSSMANN, Essais de Paléoconch. Comp., VII, 134.

MEASUREMENTS: Length, 22 mm.; greatest diameter, 9.5 mm.; apical angle, 32°; sutural angle, 81.5°.

A portion of the protoconch is preserved on one specimen. It is about .4 mm. in diameter and apparently has the form of the typical *Cerithium* protoconch. The next volution beyond the protoconch has apparently but one primary spiral, forming a shoulder angle just above the suture. The third volution has more fine spirals on the shoulder, and both ribs and intercalated spirals appear for the first time on the fifth volution. On the sixth volution two of the primary spirals above the spiral of the shoulder angle become stronger, until on the succeeding volution all three are of equal strength, making the outline of the volution an obtuse angle with sloping upper surface and vertical sides. On the next two volutions the uppermost of the three primary spirals becomes stronger, until it forms the margin of an exceedingly sharp shoulder angle. Later the median spiral becomes reduced to the size of a secondary spiral, the lowest primary spiral becomes irregularly undulating, and another undulating spiral of somewhat less strength is developed just above the suture. These changes produce in the adult stage a volution that is almost indistinguishable from that of *V. parallelum*.

The aperture of this species is like that of *V. parallelum,* except that the canal is somewhat shorter.

HORIZON AND LOCALITIES: Sables Moyens. Le Guépelle and many localities in the Paris Basin.

No. 20160, Columbia University collection.

REMARKS: *V. bouei* is referred by M. Cossmann to the genus *Batillaria,* but a comparison with the type of that genus, *B. zonale,* shows a wide difference in development, the latter species resembling *Cerithium* in its early stages. As will be seen by comparing fig. 6, plate VII, with figs. 2, 3, 4, plate III, *V. bouei* differs from *Cerithium* from the protoconch stage onward, and this difference entitles it to rank as a distinct genus, as noted above.

3. *Potamides*

Genus **Potamides** *Brongniart*

1810. *Potamida* BRONGNIART, Ann. du Mus. Nat. d'hist. naturelle, XV, 468.
1822. *Potamides* BRONGNIART, in Cuvier's Recherches sur les ossemens fossiles, II.
1906. *Potamides* COSSMANN, Essais de Paléoconch. Comp., VII, 103.

Genotype *Potamides lamarcki* BRONGNIART.

The genus *Potamides* is distinguished from *Cerithium* mainly in the slight development of the siphonal canal. In the type of the genus *P. lamarcki* this canal is short, widely open, and with its anterior margin slightly reflexed. This type of canal persists with little change from the middle Eocenic to recent time.

The early stages of *Potamides,* as pointed out in connection with the description of the genotype, are closely similar to those of typical *Cerithium,* but after having developed the *Cerithium*-like outline of the volution with two equal spirals crossed by ribs, species of the genus continue to emphasize the formation of nodes as their most characteristic surface feature, instead of accenting the spirals, as in *Cerithium.* In this paper only those species are included in the genus *Potamides* which have not only an aperture similar to the genotype, but also have young stages indicating a similar path of development.

Cerithium and *Potamides* are without doubt closely related genera, and *Potamides* is the more primitive in structure. The aperture of the young *Potamides* is almost destitute of canal, while the aperture of the young *Cerithium* is like that of *Potamides,* and it is reasonable to suppose that the order of evolution has been from forms without canal to those

with the slight canal of *Potamides,* and later to the well-developed canal of *Cerithium.* Hence the ancestor from which both genera are derived must have been more like *Potamides* than like *Cerithium,* although the type of *Potamides, P. lamarcki,* and other species of the genus occur at higher horizons than many well-developed species of *Cerithium.* They represent the persistence of a primitive type of structure throughout a long period of geologic time, while *Cerithium,* though descended from a common ancestor, represents a more rapid evolution of highly specialized forms.

Potamides lamarcki *Brongniart*

1810. *Potamides lamarcki* Brongniart, Ann. du Mus. Nat. d'hist. naturelle, XV, 468, pl. 22, fig. 5.
1824. *Cerithium microstoma* Deshayes, Desc. des coquilles foss. des environs de Paris, II, 412, pl. 59, figs. 32-34.
1866. *Cerithium lamarcki* Deshayes, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 177, pl. 80, figs. 25-28.
1906. *Potamides lamarcki* Cossmann, Essais de Paléoconch. Comp., VII, 103.

Measurements: Length, 22.8 mm.; greatest diameter, 6.6 mm.; apical angle, 19°; sutural angle, 88.5°.

The protoconch of this species is beautifully preserved on a small individual of seventeen volutions. The form is similar to that of *Cerithium adansoni,* and the surface is smooth and shining. It comprises about one and one-half volutions, after which two fine spirals of equal strength appear and remain the only ornamentation of the shell for three volutions. On the fifth volution the spirals are crossed by ribs, and for the next four volutions the shell has the characteristic ornamentation of the young *Cerithium*—that is, an angular outline formed by two equal spirals crossed by ribs. On the ninth volution a third spiral is added just below the suture, and all the spirals form nodes where crossed by the ribs. The median row of nodes lags slightly behind the others, so that the ribs are curved in crossing the volutions. The ornamentation of the adult consists of three strong nodose spirals which are rectangular in cross-section and a fine continuous spiral just above the suture. The ribs are faint or obsolete in the adult, and the entire surface of the shell is covered by extremely fine, closely set spirals, which are only visible with a strong lens. Some specimens show gerontic characters in the thickening of the shell and the loss of the nodes on the body volution. The lower slope of this volution bears three spirals in addition to those already mentioned.

The aperture is nearly circular. The callus of the inner lip is thin and spread out broadly over the lower surface of the body volution, and

the outer lip is thin and strongly sinuous. The anterior canal is very short, shallow and has a reflexed margin.

HORIZON AND LOCALITY: Oligocenic. Aurillac, Paris Basin.
No. 20153, Columbia University collection.

REMARKS: This species follows the same path of evolution as *Cerithium adansoni* for the first nine volutions, but is more retarded in the development of ribs than that species. After the ninth volution the shoulder is lost, and the species diverges from the *Cerithium* line of evolution. The adult has flattened volutions and an ornamentation of rows of nodes instead of the angular outline of the whorls and several orders of spirals characteristic of *Cerithium*.

As compared with Eocenic species of *Cerithium*—*C. æquispirale*, for example—*Potamides lamarcki* is more primitive in structure, having a less well-developed canal and simpler type of ornamentation, and it represents, as noted in connection with the genus, the persistence of a primitive form while more rapid evolution was taking place in related groups.

Potamides cordieri mut. **typum** n. mut.

1824. *Cerithium cordieri* var. a DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 338, pl. 52, fig. 8.

MEASUREMENTS: Length, 29.8 mm.; greatest diameter, 11.5 mm.; apical angle, 25°; sutural angle, 84.5°.

The youngest volution present is .6 mm. in diameter and is ornamented by ribs and two equal spirals. The same ornamentation continues for four volutions, and on the fifth a nodose spiral appears just below the suture. This spiral increases in strength and becomes more distinctly nodose until, on the eleventh of the volutions preserved, it is as strong as the two nodose spirals below it. At this stage the general outline of the volution is straight and parallel with the slope of the spire, and its surface is ornamented by three equal rows of nodes without ribs. The same ornamentation is continued until the fourteenth volution, when the loose coiling reveals a continuous spiral just above the suture. On the fifteenth volution present a fine, slightly nodose spiral appears between the two upper rows of nodes. The same kind of ornamentation continues throughout the remaining whorls. The body volution has three rows of strong nodes—one fine intercalated row and two strong continuous spirals below the ornamentation of nodes. On the later part of this volution the growth lines are crowded, the shell somewhat thickened and the nodes indistinct or obsolete.

The aperture is quadrangular, with short, widely open siphonal canal. The callus of the inner lip is thick and broad. The outer lip is strongly sinuous.

HORIZON AND LOCALITIES: Sables Moyens. La Chapelle, Le Guépelle and other localities in the Paris Basin.

No. 20153, Columbia University collection.

REMARKS: Were it not for the old-age features present on the later part of the body whorl, this variety might be taken for the young of the type species mentioned below, but the shell appears in all ways like a full-grown individual, with a length only about half that of *P. cordieri.*

The development of this form is closely similar to that of *P. lamarcki,* and the adult differs but slightly in general appearance. It is, however, larger, has a wider apical angle and lacks the extremely fine spirals covering the surface between the nodes as in *P. lamarcki.*

Potamides cordieri *Deshayes*

1824. *Cerithium cordieri* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 338, pl. 52, figs. 14, 15.

1866. *Cerithium cordieri* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 137.

1906. *Ptychopotamides cordieri* COSSMANN, Essais de Paléoconch. Comp. VII, 108.

MEASUREMENTS: Length, 60 mm.; greatest diameter, 20 mm.; apical angle, 23.5°; sutural angle, 90°.

The only specimen of this species available for study is broken at the apex, but enough remains to show that the development of this shell is like that of the mutation *typum* and remains the same in all ways except in the number of spirals on the last two or three volutions. *P. cordieri* differs from its mutation only in its greater size and in the fact that while *P. cordieri* mut. *typum* has only one row of fine nodes intercalated between the coarser ones, the type species has a similar row intercalated between the two lower and also below the lowest of the three rows of strong nodes. The intercalation of fine nodes in the remaining interspaces would naturally follow their introduction in one of them, so that the adult *P. cordieri* constitutes the next step in this line of evolution beyond that of *P. cordieri* mut. *typum.* For this reason it would have been more appropriate to consider the mutation *typum* the type species; but the name being already established for the larger specimens, it should not be changed.

HORIZON AND LOCALITIES: Sables Moyens. La Chapelle and other localities in the Paris Basin.

No. 20154, Columbia University collection.

REMARKS: *Potamides cordieri* and its mutation are referred by M. Cossmann to *Ptychopotamides,* a genus which is distinguished from *Potamides* by the presence of a columellar plication, but such a plication is certainly absent from all of the eleven specimens studied, and the close similarity in development between this form and *P. lamarcki* has led to the placing of the species in the genus *Potamides.*

Potamides involutum *Lamarck*

1804. *Cerithium involutum* LAMARCK, Ann. du Mus. Nat. d'hist. naturelle de Paris, III, 348.
1824. *Cerithium involutum* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 328, pl. 41, figs. 10-13.
1906. *Tympanotomus involutum* COSSMANN, Essais de Paléoconch. Comp., VII, 120.

MEASUREMENTS: Length, 30 mm.; greatest diameter, 10 mm.; apical angle, 25°; sutural angle, 87°.

The youngest volution seen on this species is .8 mm. in diameter. It has at this stage ribs and two equal spirals. The same ornamentation continues for three volutions, and on the fourth a third spiral is introduced above the two already existing. This spiral increases gradually in strength until, on the eighth volution, it is as strong as the two below it. At this stage the shoulder has disappeared, and the surface is ornamented by three equal rows of nodes and a fine continuous spiral just above the suture. On the later whorls, at a stage varying in different individuals, the nodes are lost, leaving the surface marked by continuous spirals only. Still later the two lower spirals also disappear, leaving a single spiral which forms the margin of a strong shoulder angle just below the suture. The extent of this smoothing of the shell varies greatly on different individuals, occupying three or more volutions, or the spirals, and even the nodes, may persist nearly to the end of the body volution. Specimens on which the smooth portion comprises several volutions have also a narrower angle of slope for the sides in this portion of the shell, indicating a flattening of the whorls parallel to the axis of coiling. The embracing of the whorls is greater than in the young portion of the shell, and on some specimens also a distinct canal is formed at the posterior margin of the aperture by this overlapping of a fold in the outer lip upon the preceding whorl.

The aperture is closely similar to that of *Potamides lamarcki.* The siphonal canal is short and widely open, the callus of the inner lip thick, and the margin of the outer lip strongly sinuous.

HORIZON AND LOCALITY: Calcaire grossier. Cuise-la-motte, Paris Basin. No. 20155, Columbia University collection.

REMARKS: The shells included under this name form a perfect gradational series from forms in which the loss of nodes appears only on the later part of the body volution to those in which both nodes and spirals are absent, if we include the forms figured by Deshayes, from nearly the whole surface. So perfect is the gradation in the collection studied that hardly two individuals are alike, and each may be considered a mutation, though for convenience they are described under one name.

The loss of ornamentation, the flattening of the whorls and the overlapping of the later whorls upon the earlier are all old-age features which indicate a progressive gerontism and approaching extinction in the branch of evolution which they represent.

The life history of this species is closely similar to that of *P. cordieri* mut. *typicum*, down to the stage when erontic features begin to appear. It differs from that species in having a wider apical angle, but the two species are doubtless closely related.

Potamides lapidum *Lamarck*

1804. *Cerithium lapidum* LAMARCK, Ann. du Mus. Nat. d'hist. naturelle de Paris, III, 350.

1824. *Cerithium lapidum* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 421, pl. 60, figs. 21-22.

1906. *Potamides lapidum* COSSMANN, Essais de Paléoconch. Comp., VII, 104, pl. 10, figs. 6-7.

MEASUREMENTS: Length, 31 mm.; greatest diameter, 9.5 mm.; apical angle, 18.5°; sutural angle, 88°.

The youngest volution studied is .8 mm. in diameter, and there are evidently several volutions missing above this. Its ornamentation consists of two very fine, equal, continuous spirals. On the next volution these spirals are crossed by very faintly developed, oblique ribs which are present with varying strength and frequency on the succeeding ten volutions. These ribs are never well developed, and on the adolescent and adult whorls they give place altogether to crowded lines of growth. On the later volutions the spirals also become indistinct, and the whorls have a rounded outline, with a surface roughened by the crowded lines of growth and faint traces of one or two spirals. On the young of some specimens the lower of the two spirals is more prominent than the upper, and the ribs in crossing give it a nodose appearance, but this ornamentation also disappears from the later whorls.

The aperture is circular, with a thickened callus on the inner lip, and the margin of the outer lip is sinuous. The siphonal canal is shallow and broad, with a strongly reflexed margin.

HORIZON AND LOCALITIES: Calcaire grossier. La Frileuse and many other localities in the Paris Basin.

No. 20157, Columbia University collection.

REMARKS: The highest development of ornamentation on this shell advances but little beyond the stage with two simple spirals represented by the second to the fourth volutions of *P. lamarcki,* and the development of the ribs is so feeble as to correspond with only the earlier part of the fifth volution of that species. *P. lapidum* is doubtless developed from the same ancestor as *P. lamarcki,* but since in the adult it becomes more smooth, instead of developing a higher degree of ornamentation in the direction of *P. lamarcki,* it probably represents a lateral branch from the main *Potamides* line of evolution.

4. *Potamidopsis*

Genus **Potamidopsis** *Munier-Chalmas*

1900. *Potamidopsis* MUNIER-CHALMAS, Congrès géol. Paris, V, Chideville. Liste générale, p. 375.

1906. *Potamidopsis* COSSMANN, Essais de Paléoconch. Comp., VII, 109.

Genotype *Cerithium tricarinatum* LAMARCK.

M. Cossmann distinguishes this genus from true *Cerithium* as follows:

Enfin *Potamidopsis* se distingue des vrais *Cerithinæ* par son canal court, par son labre non replié en travers du canal, et aussi par ses tours imbriqués. La séparation—qu'a proposée Munier-Chalmas, dans de simples listes de fossiles publiées à l'occasion du Congrès de 1900, sans aucune diagnose—est donc à retenir.

The earliest stages in the development of the genotype show that this shell is derived from the same stock as the true *Cerithium,* but it diverges from the main line of evolution so strongly and at such an early stage that it deserves to rank as a distinct genus. M. Cossmann describes *Potamidopsis* as a sub-genus of *Potamides,* but the group is more closely related to *Cerithium* than to *Potamides;* hence it should not rank as a sub-genus of the latter. It is also too distantly related to *Cerithium* to constitute a sub-genus of that group, and hence it is here ranked as an independent genus. To the distinguishing characters enumerated by M. Cossmann may be added the numerous volutions producing a very high spire; the close embracing of the whorls; the general outline of the volutions, not convex, but conforming to the slope of the spire; the high development of nodes and the absence of ribs on all except the nepionic volutions of the shell. The aperture also varies in its angular outline—

the broad and thick callus of the inner lip, with no trace of posterior tooth, and the short, oblique siphonal canal. The outer lip is often thickened, and its anterior portion grows more rapidly than the posterior part, making the outline of the margin strongly sinuous.

Potamidopsis tricarinata *Lamarck*

Plate VII, figs. 7, 8; plate VIII, figs. 7, 8; plate IX, figs. 7, 8.

1804. *Cerithium tricarinatum* LAMARCK, Ann. du Mus. Nat. d'hist. naturelle, III, 272, No. 4.

1824. *Cerithium tricarinatum* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 325, pl. 51, figs. 1, 8.

1866. *Cerithium tricarinatum* DESHAYES, Desc. des anim. sans vert. découverts dans le bassin de Paris, III, p. 123.

1902. *Potamides tricarinatum* COSSMANN, Catal. illust. des coquilles foss. de l'Éoc. des environs de Paris, IV, p. 69.

1903. *Tympanotomus tricarinatum* COSSMANN, Paleontologia Universalis, Cent. I, pl. 3, figs. 1, 2.

1906. *Potamidopsis tricarinatus* COSSMANN, Essais de Paléontol. Comp., VII, 109, pl. 11, figs. 5, 6.

MEASUREMENTS:[5] Length, 45 mm.; greatest diameter, 17 mm.; apical angle, 20°; sutural angle, 87°.

The early stages of the species are described from a young individual of fifteen volutions. The protoconch is missing, but the youngest volution preserved is probably the first beyond the protoconch, as it has a diameter of only .3 mm. It has an ornamentation of two equal spirals without ribs, and the same ornamentation persists on the next volution. Ribs appear on the third volution, which has an ornamentation exactly similar to the adult of *Cerithium bicarinatum*. On the fourth volution the lower spiral becomes stronger and the upper one weaker, a tendency which increases on the next three volutions until, on the seventh and eighth volutions, the upper spiral has entirely disappeared, and the ornamentation consists merely of a single strongly nodose spiral, forming a projecting shoulder angle just above the suture. The ninth volution has a sub-sutural spiral the nodes of which are connected with those of the shoulder angle by well-developed ribs. This type of ornamentation persists for seven volutions more, and on the fourteenth volution a fine spiral is intercalated between the two already existing. Comparing this young individual with an adult, it is found that the latter is more retarded in the growth of this fine spiral than the former. It does not

[5] The specimen measured is the one which seems to correspond most closely with the figures of the type given in the Paleontologia Universalis, centuria I, plate 3, figs. 1, 2.

appear on the adult individual until the sixteenth volution, after which it becomes stronger and soon breaks up into a row of fine nodes placed half way between the two rows already formed. The ribs become discontinuous, and the last seven whorls are ornamented by three rows of nodes, of which the lowest forms a projecting shoulder angle just above the suture, and the median row is very slightly finer than the upper one. On the later part of the body whorl all the nodes become indistinct or obsolete, where the crowding of the growth lines and thickening of the shell indicate old-age conditions.

The aperture is about equal in length and width and somewhat angular in outline. The callus of the inner lip is very thick and broad, its posterior part often spreading out for a considerable distance over the posterior part of the body whorl. There is no trace of posterior tooth, as in *Cerithium* sens. str. The outer lip is often greatly thickened, strongly flaring at the margin, and it overlaps more or less upon the preceding whorl. The thickening of the shell, the loss of ornamentation and the encroaching of the later part of the body whorl upon the preceding whorl are all old-age features which indicate that the species is approaching its extinction.

HORIZON AND LOCALITIES: Calcaire grossier, Sable Moyens. Grignon and many other localities in the Paris Basin.

No. 20122, Columbia University collection.

REMARKS: The young stages of this species furnish a clue to its development from a form resembling *Cerithium bicarinatum,* since its development for the first four volutions is closely parallel to the development of that species, and the fourth volution (counting the protoconch as one) is the counterpart of the adult *C. bicarinatum.* The species could not, however, have been developed from *C. bicarinatum* itself, since it occurs at an earlier horizon, but was probably developed from the pre-Jurassic ancestor of *C. bicarinatum* mentioned in connection with that species—the same ancestor which probably gave rise along a different path of evolution to *C. corallense* and its descendants, *C. æquispirale, C. tuberosum,* etcetera.

Potamidopsis tricarinata has developed many mutations by the accentuation or suppression of one or another of its surface features. Of these mutations, Lamarck has described one and given it the designation "*β*," and Deshayes has indicated five others by letters from "b" to "f," the letter "a" being used for the type species. The mutations occur at the same horizon and localities as the type, and, as might be expected, transitional forms exist between all of them.

Potamidopsis tricarinata mut. **baucis** mut. nov.

1804. *Cerithium tricarinatum* var. β LAMARCK, Ann. du Mus. Nat. d'hist naturelle, Paris, III, 272.

The author says of this species:

Dans la variété β, la carène supérieur de chaque tour est un peu plus éminente que celle du milieu.

The mutation is apparently more common than the type species, since it is rare to find specimens in which the two upper rows of nodes are equal. The upper row is slightly stronger, even in the type figured in Paleontologia Universalis, but the varietal name may be retained for those forms in which the difference is strongly developed.

No. 20121, Columbia University collection.

Potamidopsis tricarinata mut. **brontes** mut. nov.

1824. *Cerithium tricarinatum* var. b DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 325, pl. 51, fig. 2.

This mutation is distinguished by the strong carina which forms a projecting shelf around the whorls and by the fine nodes of the two upper spirals. The shells of this variety are usually larger than those of the typical form.

No. 20123, Columbia University collection.

Potamidopsis tricarinata mut. **cronus** mut. nov.

1824. *Cerithium tricarinatum* var. c DESHAYES, Desc. des coquilles foss. des environs de Paris, II, p. 325, pl. 51, figs. 3, 4.

The carina of this mutation is also very strong, but the nodes are more widely spaced and more prominent than in the mutation *brontes*. The median row of nodes is obsolete and the upper row is poorly developed.

Potamidopsis tricarinata mut. **doris** mut. nov.

1824. *Cerithium tricarinatum* var. d DESHAYES, Desc. des. coquilles foss. des environs de Paris, II, p. 326, pl. 51, fig. 6.

This mutation is similar to the last, but in this form it is the subsutural row of nodes which becomes obsolete.

Potamidopsis tricarinata mut. **eris** mut. nov.

1824. *Cerithium tricarinatum* var. e DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 326, pl. 51, figs. 4, 7.

On this species the carina is not prominent, and its nodes are nearly obsolete, leaving the margin but slightly wavy. The two upper rows of nodes are present.

Potamidopsis tricarinata mut. **fatua** mut. nov.

1824. *Cerithium tricarinatum* var. f DESHAYES, Desc. des coquilles foss. des environs de Paris, II, p. 326, pl. 51, fig. 9.

This is an extreme mutation, which is distinguished by the almost entire absence of nodes, in the adult stages, from both the carina and the two spirals above it. The variation is carried so far in this form that it would be described as a distinct species if the nodes had altogether disappeared.

Potamidopsis acus *Deshayes*

1866. *Cerithium acus* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 199, pl. 75, figs. 19, 20.

MEASUREMENTS (Deshayes): Length, 25 mm.; greatest diameter, 6 mm.

Deshayes records the discovery of a single specimen only of this species. According to his figures and description, it has a long, slender spire of twenty-five volutions. The adult is ornamented by two rows of nodes connected by ribs, the lower row being more prominent than the upper. A fine undulating spiral is present just above the suture.

The aperture is like that of *P. tricarinata*, except that it does not show gerontic characters in the thickening of the shell and loss of ornamentation seen on many specimens of the former species.

Deshayes calls attention to the similarity of this shell to the young *P. tricarinata*, and it might be considered the young of that species were it not that all the specimens of *P. tricarinata* studied, of 25 mm. in length or of twenty-five volutions, have passed beyond the stage represented by the last whorl of *P. acus* in the intercalation of a finely nodose spiral between those already existing. If *P. acus* is actually adult, as it appears to be, it represents a more primitive form than *P. tricarinata* and may well be the immediate ancestor of that species. This hypothesis would be confirmed if other specimens showing young stages similar to those of the very young *P. tricarinata* were discovered.

HORIZON AND LOCALITY: Calcaire grossier. Monchy, Paris Basin.

Potamidopsis mixta *Deshayes*

——. *Cerithium mixtum* Defrance, Nom. nud.

1824. *Cerithium mixtum* Deshayes, Desc. des coquilles foss. des environs de Paris, II, 324, pl. 45, figs. 6-11.

1866. *Cerithium mixtum* Deshayes, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 123.

1906. *Ptychopotamides mixtum* Cossmann, Essais de Paléoconch. Comp., VII, 108.

Measurements: Length of the eleven volutions preserved, 41 mm.; greatest diameter, 15 mm.; apical angle, 27.5°, changing to 21.8° on last three volutions; sutural angle, 80°.

The youngest volution preserved on the shell studied is 3 mm. in diameter; hence a considerable portion of the apex has been broken away. The first three volutions are much worn, destroying all the finer surface features, but the fourth has precisely the ornamentation of *P. tricarinata* mut. *brontes,* namely, a strong nodose carina near the base of the volution, a sub-sutural row of rather strong nodes and a median row of nodes much finer than either of the others. This remains the ornamentation of the shell until the third from the last volution, when the subsutural and the lowest row of nodes become equal in strength, finer and much crowded. A fourth, finely nodose carina is developed at the base of the volution and is partially concealed by the succeeding whorl. On the body volution the nodes of the upper row are small and in places so close together as to become confluent. Two nodose carinæ and several fine spirals are present on the lower slope of the body volution.

The aperture is similar to that of *P. tricarinata,* with an expanded callus on the inner lip and a comparatively long, twisted siphonal canal. A slight columellar plication defines the posterior margin of the canal. The outer lip is broken in the specimen at hand, but the figures of Deshayes, cited above, show it to be similar to that of *P. tricarinata.*

Horizon and localities: Sables Moyens. Anvers and other localities in the Paris Basin.

No. 20147, Columbia University collection.

Remarks: So far as can be determined, the life history of this species is like that of *P. tricarinata* until the last three volutions, when the ornamentation changes to that of three rows of crowded nodes, the uppermost being slightly more prominent than the lowest. It is probably a descendant of *P. tricarinata,* showing its divergence from its ancestor on the last three volutions only.

The columnellar plication which furnishes the reason for placing this

species in the genus *Ptychopotamides* is indistinct, and does not constitute a sufficient reason for separating the species from the group to which it is closely related in its development.

Potamidopsis tuberculosa *Lamarck*

1804. *Cerithium tuberculosum* LAMARCK, Ann. du Mus. Nat. d'hist. naturelle, III, 348.

1824. *Cerithium tuberculosum* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 48, figs. 1-5.

1866. *Cerithium tuberculosum* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 122.

1906. *Serratocerithium tuberculosum* COSSMANN, Essais de Paléoconch. Comp., VII, 75.

MEASUREMENTS: Length, 33 mm.; greatest diameter, 12.2 mm.; apical angle, 26°; sutural angle, 86.4°.

The early stages of this species are described from a young individual of fifteen volutions. The protoconch of the specimen is missing, and the first two volutions are too much worn to show the surface ornamentation, but the third volution present is ornamented by a sub-sutural spiral and a stronger spiral forming a shoulder angle just above the suture. Both spirals are rendered nodose and connected by ribs which are continuous across the volutions. This type of ornamentation persists for five volutions and is closely similar to the ornamentation of *P. tricarinata* at a slightly later stage. The nodes of the lower and upper rows gradually become equal in strength, and the shoulder disappears. On the sixth volution of those preserved a spiral is intercalated between the two rows of nodes already formed, and two volutions later this spiral is broken up into a row of very fine nodes. The ornamentation at this stage resembles that of *P. tricarinata* at the same stage, except that the lower row of nodes is more prominent on the latter species. At the eleventh volution the nodes of the sub-sutural row become more prominent and more widely spaced than those of the lowest row. This tendency increases until a shoulder angle composed of strong, transversely elongate nodes is formed just below the suture. This becomes the ornamentation of the adult shell, except that a fourth spiral which is partially exposed just above the suture also becomes wavy or faintly nodose. The body volution bears one nodose ridge in addition to those already described and several fine spirals on its lower slope.

The aperture is nearly circular. The callus of the inner lip is broad and thin. The outer lip is thin; its margin, growing more rapidly at

the anterior portion, gives it a sinuous outline. The siphonal canal is broad and deep, bordered by a strong ridge on its columellar side.

HORIZON AND LOCALITIES: Sables Moyens (Upper Eocenic). Widely distributed in the Paris Basin.

No. 20148, Columbia University collection.

REMARKS: The earliest volutions of this shell are missing, but the youngest preserved has an ornamentation similar to that of the ninth to the thirteenth volutions of *Potamidopsis tricarinata.* It adds an intercalated spiral as in the latter species, but it diverges from the line of evolution represented by *P. tricarinata* by forming its shoulder angle at the upper instead of the lower margin of the whorl. This species may be regarded as derived from the same ancestral stock as *P. tricarinata,* but it represents a divergent line of evolution.

M. Cossmann refers this species to *Serratocerithium,* a sub-genus founded mainly on characters of the aperture, but the aperture of *P. tuberculosa* does not appear to differ to a marked degree from that of *P. tricarinata.* The canal is slightly longer and the outer lip thinner and less flaring. The present reference of the species, being founded on descent as revealed by the ontogeny, necessarily arrives at a different result from one founded on adult characters alone.

Potamidopsis roissyi *Deshayes*

1824. *Cerithium roissyi* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 322, pl. 50, figs. 13-20.

1866. *Cerithium roissyi* DESHAYES, Desc. des anim. sans vert. découverts dans le bassin de Paris, p. 127.

1906. *Tympanotonus roissyi* COSSMANN, Essais de Paléoconch. Comp., VII, 120.

MEASUREMENTS: Length, 25.7 mm.; greatest diameter, 8 mm.; apical angle, 20°; sutural angle, 90°.

The protoconch is missing from the best specimen available, and it is probable that two or three more volutions are also broken away. The youngest volution present is .7 mm. in diameter, and it has exactly the ornamentation of *P. tricarinata* from the ninth to the thirteenth volutions. The same ornamentation continues for four volutions, after which the ribs disappear and the two rows of nodes become equal in strength and often alternate in position as compared across the whorl. On the sixth volution a fine spiral is intercalated at about the middle of the volution. This spiral soon breaks up into a row of extremely fine nodes. At about the same stage of growth the sub-sutural row of nodes becomes stronger than the others, a tendency which increases until the

adult condition is reached. The ornamentation of the adult consists of three rows of nodes of which the upper are larger and more widely spaced than the others, and the nodes of the median row are very fine. An irregularly nodose fine spiral is barely visible just above the suture. The body volution has two strong spirals below those already mentioned. On this volution the growth lines become very much crowded, and all the nodes become indistinct, especially toward the later part of the volution.

The aperture is about equal in length and breadth and is roughly quadrangular in outline. The callus of the inner lip is broad and thin. The siphonal canal is short, widely open and somewhat twisted. The outer lip is thin and has a strongly sinuous outline.

HORIZON AND LOCALITY: Sables Moyens superieur (Upper Eocenic). La Chapelle, Paris Basin.

No. 20149, Columbia University collection.

REMARKS: The ornamentation of this species closely resembles that of *P. tuberculosa,* both in its development and in the adult stage. The species differs from *P. tuberculosa* in its smaller size; narrower apical angle, which makes it a more slender shell; its shorter canal and more angular aperture.

This species bears the same relation to *P. tricarinata* as does *P. tuberculosa*—that is, it is derived from the same ancestor as both, but develops in the direction of *P. tuberculosa,* to which it is closely related.

Potamidopsis crassinoda sp. nov.

MEASUREMENTS: Length of specimen with apical whorls missing, 39.8 mm.; greatest diameter, 26.7 mm.; apical angle, 32°, changing to 23.8° on the sixth volution; sutural angle, 85°.

This species is distinguished from *Potamidopsis tuberculosa,* to which it is closely related, in being a larger and thicker shell and in having the nodes of the surface much larger and more prominent. This difference begins at an early stage of growth and continues throughout the life of the animal. The youngest volution preserved is 2.5 mm. in diameter, and several whorls have evidently been broken away above this. The first three volutions have an ornamentation of about the same strength and character as the adult of *P. tuberculosa,* but beyond this the large nodes characteristic of all the later volutions are developed. The nodes of the uppermost row are large, blunt cones; those of the lowest row, smaller and transversely elongate. The median nodes are very fine and on some specimens nearly obsolete. The base of the volution is produced into lobes, which sometimes overhang the succeeding volution.

The aperture is similar to that of *P. tuberculosa,* but the canal is longer and more strongly reflexed, and the callus of the inner lip is thicker and is not closely applied to the surface of the shell. The outer lip is thickened with crowding of the growth line and loss of ornamentation for some distance back of it.

HORIZON AND LOCALITY: Sables Moyens. Rosoy-en-multiens, Paris Basin. No. 20150, Columbia University collection.

REMARKS: This species has been regarded as a variety of *Potamidopsis tuberculosa,* but its much greater size, strongly marked surface features, and longer siphonal canal, as well as its more accelerated development, entitle it to rank as a distinct species. It is evidently derived from the same ancestor as *P. tuberculosa,* following the same path of evolution but strengthening all the features of the shell. The three species, *P. roissyi, P. tuberculosa* and *P. crassinoda,* possess the same type of ornamentation, and they form a series in which *P. roissyi* is at one extreme, characterized by small size, thin shell and delicacy of ornament, and *P. crassinoda,* at the other, characterized by thick shell, strong tubercles and wide apical angle.

Potamidopsis conjuncta *Deshayes*

1824. *Cerithium conjunctum* DESHAYES, Desc. des coquilles fossiles des environs de Paris, II, 387, pl. 73, figs. 1-4.

1866. *Cerithium conjunctum* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 123, pl. 80, figs. 9-16.

1906. *Tympanotonus conjunctus* COSSMANN, Essais de Paléoconch. Comp., VII, 120.

MEASUREMENTS: Length of specimen from which apex is broken, 29.4 mm.; greatest diameter, 10.8 mm.; apical angle, 28.2°, changing to 18.2° on the last three volutions; sutural angle, 86°.

The youngest volution available for study is 2 mm. in diameter, and several volutions have been broken away above it. The ornamentation is that of two rows of nodes, one near each suture, the lower row being the more prominent. The upper and lower nodes are connected by ribs. This ornamentation resembles that of *P. tricarinata* from the ninth to the thirteenth volutions. On the third volution present a fine spiral is intercalated between the two rows of nodes. This spiral soon becomes finely nodose, and the ornament of the adult is that of three rows of nodes of which the uppermost and lowest are large and of equal size, while the nodes of the median row are very small. The body volution has two strong spirals and several fine ones on its lower slope.

The aperture is roughly quadrangular. The callus of the inner lip is thick and expanded posteriorly. The siphonal canal is short, twisted and has a strong columellar ridge defining its posterior margin. The outer lip is broken in the specimens studied, but, according to the figures of Deshayes, cited above, it is thin and strongly sinuous.

HORIZON AND LOCALITY: Oligocenic. Jeures, Paris Basin.
No. 20151, Columbia University collection.

REMARKS: The development of this shell is closely similar to that of *P. tricarinata,* so far as can be determined from the specimens studied. The adult differs only in the fact that the lowest row of nodes equals the uppermost in prominence, instead of exceeding it. This causes the outline of the volution to be parallel with the slope of the spire, instead of forming a shoulder. *P. conjuncta* probably occupies about the same relation to *P. tricarinata* as does *P. tuberculosa,* diverging from the *tricarinata* line of evolution at about the same stage in its development, but in a different direction. The adult of *P. tricarinata* shows greater prominence of the lowest row of nodes; that of *P. tuberculosa* emphasizes the prominence of the sub-sutural row, and in *P. conjuncta* they are equal.

Potamidopsis trochleare *Lamarck*

1804. *Cerithium trochleare* LAMARCK, Ann. du Mus. d'hist. naturelle, III, 349.
1824. *Cerithium trochleare* DESHAYES, Desc. des coquilles foss. des environs de Paris, II, 388, pl. 55, figs. 10, 11.
1866. *Cerithium trochleare* DESHAYES, Desc. des animaux sans vert. découverts dans le bassin de Paris, III, 129, pl. 80, figs. 1-8.
1906. *Tympanotonus trochleare* COSSMANN, Essais de Paléoconch. Comp., VII, 118, pl. 11, fig. 19.

MEASUREMENTS: Length, 25 mm.; greatest diameter, 12 mm.; apical angle, 25.2°; sutural angle, 85°.

One of the specimens studied shows the protoconch. This is similar in form to the protoconch of *Cerithium adansoni* and comprises about one and one-half volutions. The volutions immediately succeeding the protoconch on this specimen are poorly preserved; but another specimen, whose youngest volution is .7 mm. in diameter, retains the surface features. This is the third volution, as shown by comparison with a complete individual. It is ornamented by two nodose spirals, of which the lower is the more prominent, and a third fine intercalated spiral. This is the ornamentation of the adult *P. tricarinata.* The median spiral persists for two volutions only, after which the shell has two rows of nodes only, with the lower more prominent than the upper. The latter stage

lasts for a variable number of volutions on different specimens, but usually from five to eight volutions. Beyond this the ribs disappear, and the shell is ornamented for the remainder of its growth by two extremely prominent continuous spirals with deep concave depressions between them. A third spiral, partly concealed by the embracing of the whorls, is shown on the body volution to be less prominent than the others.

The aperture is distinctly quadrangular. The callus of the inner lip is thick and rather narrow. The siphonal canal is short and deep. The outer lip is often thickened in large individuals, sinuous and folded into lobes to correspond with the spirals of the outer surface.

HORIZON AND LOCALITIES: Oligocenic. Morigny, Jeures and many other localities in the Paris Basin.

No. 20152, Columbia University collection.

REMARKS: The youngest volution of this species to show the surface has the ornamentation of the adult *P. tricarinata.* The first change to take place in this ornamentation is in the loss of the median spiral, which was the last feature to be acquired in the development of the latter species. The succeeding three or four volutions of *P. trochleare* correspond with a still younger stage of *P. tricarinata,* namely, that with two rows of nodes only. The adult *P. trochleare* has two continuous spirals, as in the earliest stages of *P. tricarinata.* The facts thus far stated seem to indicate a loss of characters by gerontism and the return to the primitive conditions of an ancestor, but that this is not the case is shown by a study of the intervening stages of *P. tricarinata.* Studying the development of that species in reverse order, the stage preceding that with two rows of nodes only is one in which the sub-sutural row of nodes is absent, and, earlier still, a fine spiral is present immediately above the shoulder spiral (plate VIII, fig. 7). This is not the same feature as the median row of nodes in the adult, although it occupies the same position, because it disappears and gives place to another character before the appearance of the adult median nodes. It is this spiral, however, which, on the fourth volution, is as strong as the spiral at the shoulder angle and forms the upper of the two continuous spirals on the second volution. In *P. trochleare,* on the contrary, it is the sub-sutural spiral which persists and forms the upper of the two strong spirals in the adult. The lower of the two corresponds with the spiral at the shoulder angle in *P. tricarinata.* These two spirals have not the character of primitive structures, but are on the contrary, extreme in their development. *P. trochleare* is a descendant of *P. tricarinata,* with its youngest stages like the adult of the

latter species. From this stage it progresses toward simplification of surface forms rather than complication of them, as in the species previously described. It illustrates the fact that progressive development does not always mean complication of structures, but may also travel in the direction of simplification of structures. Although *P. trochleare* does not add new types of ornamentation, it does emphasize strongly the one feature retained in the extreme prominence of its two continuous spirals.

Illustrations of progressive development resulting in more simple structures are found in other genera; for example, *Claviger matoni* GRAY has young stages in which the whorls are ornamented by four strong spirals crossed by numerous oblique ribs, changing abruptly to an ornamentation of two very prominent continuous spirals, but without other features to indicate gerontism as a cause for the loss of ornamentation.

Deshayes's figures of this species, cited above, indicate an extreme degree of variation, including forms with three spirals, or one spiral, or rows of strong nodes, and it is probable that several of these should be considered distinct species. In the absence of specimens showing these variations, they will not be considered here.

5. *Vulgocerithium*

Vulgocerithium minutum *de Serres*

1822. *Cerithium minutum* DE SERRES. Essai pour servir a l'histoire des anim. du midi de la France, p. 60.

1856. *Cerithium minutum* HÖRNES and PARTSCH, Abhand. der k. k. geol. Reichsanst., III, 390, pl. 41, figs. 8, 9.

MEASUREMENTS: Length, 25 mm.; greatest diameter, 9 mm.; apical angle, 33.5°, changing to 16° on the last four volutions; sutural angle, 83.5°.

The youngest volution preserved on the specimen studied is 1.2 mm. in diameter. It has a well-defined shoulder with two strong spirals, one finer intercalated spiral and four on the shoulder. On the next two volutions the sub-sutural spiral becomes broad, another spiral is added between the two primaries, and one appears on the lower slope of the whorl. On the succeeding volutions the sub-sutural spirals become elevated at intervals as a row of nodes, the lower slope of the volution becomes nearly continuous with its vertical sides and numerous intercalated spirals appear. The adult ornamentation is that of a sub-sutural row of nodes, a median row with nodes slightly more prominent than those of the upper row and ribs which are more or less continuous toward the upper suture but are represented by irregularly spaced nodes below the

median line. The shoulder on the last three volutions is nearly obsolete, being defined merely by the median row of low nodes.

The aperture is of the form usual in this group, with a narrow callus on the inner lip, a strong posterior tooth and a short anterior canal. The outer lip is thin and slightly crenulated.

HORIZON AND LOCALITY: Upper Oligocenic (Aquitanian). Saucats, France. No. 3123, Museum of Comparative Zoölogy.

REMARKS: This species continues into the Miocenic, but the specimens studied are from the Oligocenic. Except for its small size, the shell is closely similar to *V. vulgatum,* and it may well be the immediate ancestor of that species.

Vulgocerithium pupæforme *Basterot?*

1825. *Cerithium pupæforme* BASTEROT, Mémoire géol. sur les environs de Bordeaux, p. 58, pl. 3, fig. 18.
1906. *Dizoniopsis pupæforme* COSSMANN, Essais de Paléoconch. Comp., VII, 147, pl. XII, figs. 22-24.

MEASUREMENTS: Length, 12 mm.; greatest diameter, 4.8 mm.; apical angle, 36.5°, changing to 26° on the last three volutions; sutural angle, 76°.

The protoconch of this species is not preserved, but a volution .6 mm. in diameter probably represents about the second volution beyond it. This whorl is ornamented by two equal spirals, and on the next volution the spirals are crossed by ribs. On the third volution of those preserved a spiral is added between the two primary spirals and one just below the suture. On the later volutions numerous fine spirals appear until those of the third order may be recognized. On the body volution the shoulder is less prominent and the nodes formed by the crossing of the ribs and the sub-sutural spiral are larger, so that without a lens the surface appears to be ornamented by two rows of nodes, the lower of which is formed by the crossing of the ribs and the shoulder. The body volution has two or three strong spirals, with finer intercalated ones on its lower slope.

The aperture is elongate oval, with a broad and thick callus on the inner lip. The siphonal canal is long and slightly curved. The outer lip is thin and not expanded.

HORIZON AND LOCALITY: Oligocenic (Aquitanian). Saucats, near Bordeaux. No. 2521, Museum of Comparative Zoölogy.

REMARKS: The original description of *Cerithium pupæforme* has not been obtainable, and the reference to this species is somewhat doubtful.

The development of this shell, as well as its adult ornamentation, has all the characteristics of *Vulgocerithium*. It resembles *V. minitum* to such an extent that it was at first thought to be the young of that species, but it is more accelerated than *V. minutum*, acquiring its tertiary spirals at an early stage. It differs further from the latter species in having a narrower aperture and longer canal. The well-developed callus and nearly uniform size of all of the ten individuals studied seem to indicate that the specimens are fully adult.

F. CRETACIC SPECIES OF CERITHIUM

No actual specimens of true *Cerithium* from horizons earlier than the Aptien were available for study, and the following phylogeny worked out from the literature is subject to revision, if more material should be obtained.

Cerithium cornuelianum *d'Orbigny*

1842-1843. *Cerithium cornuelianum* D'ORBIGNY. Paléontol. Française, Terrains Crétacés, II, Gastéropodes, p. 361, pl. 228, figs. 11-13.
1906. *Atresius cornuelianum* COSSMANN, Essais de Paléoconch. Comp., VII, 195.

The original description is as follows:

DIMENSIONS: Ouverture de l'angle spiral, 27°; longeur totale, 27 millim.; largeur, 12 millim.; longeur du dernier tour, par rapport à l'ensemble 35/100; angle sutural, 89°.

Coquille allongée, turriculée. Spire formée d'un angle régulier, composée de tours convexes, ornés en travers, à la dernière révolution spirale, de dix côtes flexuenses, ondulées, non arrêtées, se correspondant obliquement d'un tour à l'autre. Sur ses côtes viennent se croiser de légers sillons longitudinaux très-inégaux. Bouche ovale, prolongée en avant et terminée par un sinus; labre très-échancré en arrière, saillant antérieurement.

HORIZON AND LOCALITY: Aptien. Grange-au-Ru, near the Varin bridge, commune de Wassy (Haute Marne).

REMARKS: This species has volutions of a rounded outline, ribs continuous across the whorl and numerous spirals of different orders. It is thus a simple shell, having the characteristics which might be expected in an early type of true *Cerithium*. A specimen in the Museum of Comparative Zoölogy does not show the young stages, but on the last three volutions two of the spirals are stronger than the others. This suggests the beginning of the development which becomes a characteristic feature of *Cerithium æquispirale* and later species of the genus.

A posterior tooth is not developed on the inner lip, but this would hardly be expected before the spirals have become strong on the body

volution, for the presence of such a tooth appears, in many cases, to be due to a strong spiral on the body volution, which projects into the aperture and is accented by the passage of the callus over it.

M. Cossmann refers this species to *Atresius,* but in the description of that genus, the beak is said to be large and bent backward and the spire to be ornamented by nodulose costæ, characteristics which do not appear on this species. It seems to bear little resemblance to the type of the genus *Atresius.*

Cerithium albense *d'Orbigny*

1842-1843. *Cerithium albense* D'ORBIGNY, Paléontol. Française, Terrains Crétacés, II, Gastéropodes, p. 355, pl. 227, figs. 10-12.

The original description is as follows:

DIMENSIONS: Ouverture de l'angle spiral, 20°; longeur totale, 13 millim.; diamètre, 4 millim.; longeur du dernier tour, par rapport à l'ensemble, 30/100.

Coquille très-allongée, aciculée. Spire formée d'un angle régulier, composée de tours convexes, séparés par des sutures, ornés, en long, de côtes inégales, dont quatre, plus grosses, plus saillantes, tranchantes, vont diminuant de grosseur des supérieures aux inférieures. Entre chacune de celles-ci existe une petite côte très-étroite; il y a encore, en travers, par révolution spirale, de onze ou douze côtes arrondies, droites, sur lesquelles passent les premières.

Le dernier tour a de plus une seule côte longitudinale. Bouche ovale, prolongée en canal, en avant. Labre mince, tranchant.

HORIZON AND LOCALITY: Neocomian. Marolles (Aube), France.

REMARKS: The figures of this species show a simple type of shell with rounded volutions, well-developed ribs and three strong spirals on each volution. A finer fourth spiral is also present just below the suture, and the shell is further ornamented by a single intercalated spiral between each pair of the coarser ones. The outer lip has the crenulated margin characteristic of *C. æquispirale* and later species of *Cerithium.*

This shell is simpler than *C. cornuelianum* in possessing two orders of spirals only, and, so far as can be determined without an examination of the shell, it seems to constitute an earlier member of the *Cerithium* line of evolution.

G. JURASSIC SPECIES OF CERITHIUM

Cerithium corallense *Buvignier*

1843. *Fusus corallensis* BUVIGNIER, Mémoire de la Soc. Philomatique de Verdun, p. 22, pl. 6, fig. 7.

1889. *Brachytrema corallensis* DE LORIOL, Abh. Sweiz. Paläont. Gesell., XVI, 65, pl. 9, figs. 1, 2.

1906. *Brachytrema corallensis* COSSMANN, Essais de Paléoconch. Comp., VII, p. 18.

The original description of this species is as follows:

Coquille turriculée, allongée, à côtes longitudinales, au nombre de cinq sur les tours supérieurs, mais plus nombreuses sur les autres; elles sont recoupées par des sillons transverses au nombre de trois sur chaque tour. Bouche ovale, anguleuse supérieurement, échancrure large, profonde et oblique.

HORIZON AND LOCALITY: Jurassic, Coral-rag. St. Michiel, France.

REMARKS: This species of *Cerithium* shows primitive characteristics in its simple ornamentation consisting of primary spirals and ribs only, its moderate degree of embracing of the whorls and its simple aperture, with short, straight canal. The points of intersection of the spirals and ribs are often elevated, giving the surface a nodose appearance, but the ornamentation is composed essentially of the ribs and three simple spirals only. In this respect the shell is more primitive then *C. albense* and must resemble the young of that species before the introduction of intercalated spirals.

Specimens of this species were not obtainable, but from the evidence furnished by the literature it seems to be an ancestral form of *Cerithium* and the earliest representative thus far obtained of the line of evolution terminating in *C. tuberosum*.

This species has been referred to the genus *Brachytrema*, but a comparison with the type of that genus, *B. buvignieri*, shows a wide contrast in form and ornamentation, the latter species having the low spire and wide apical angle of the genus *Trochus*, with the outer lip much expanded and the body volution longer than the remainder of the shell.

V. SUMMARY

Reviewing the facts already presented, it is found that, while no specimens of true *Cerithium* were obtained earlier than the Aptien, it appears from the literature that the Jurassic species, *Cerithium corallense*, may represent the earliest known species of the genus. This is a primitive type of shell of small size, with rounded whorls and having on its adult volutions three spirals crossed by ribs.

In studying the development of retarded species of *Cerithium*, it is found that the shell forms first a single spiral, with a second spiral added above the first. Later the two spirals become of equal strength and are crossed by ribs. This stage reappears constantly throughout the genus and its near relatives. The fact that it is so persistent a feature suggests that it probably formed the adult stage of an early Jurassic or Triassic ancestor of *Cerithium*, from which forms like *C. corallense* were devel-

oped by the addition of a third spiral above the two primary ones. Such a type of development is epitomized in three species of the upper Eocenic. *C. bicarinatum* has adult ornamentation like the supposed primitive ancestor of *C. corallense*—that is, two equal spirals crossed by ribs (plate IV, fig. 9). The immediate descendant of the former species is *C. bicarinatum* mut. *trispirale,* a form which corresponds with *C. corallense* in having a third spiral present above the two primary ones, producing a shell with rounded volutions and an ornamentation of three simple spirals crossed by ribs.

The lower Cretacic species, *C. albense,* shows an advance upon *C. corallense* in the introduction of intercalated spirals, and it has its parallel in the Eocenic species, *C. retardatum,* which differs from its immediate ancestor, *C. bicarinatum* mut. *trispirale,* only in the presence of intercalated spirals. *C. bicarinatum* is descended from an early ancestor of *Cerithium,* and is so retarded as to retain its ancestral characteristics nearly unchanged. Its descendants pass through rapidly, in one geological period, a path of evolution which has been traveled more slowly in the main line of evolution from early Jurassic, or possibly Triassic, to Cretacic time.

An advance upon the type of development shown in *C. albense* is seen in *C. cornuelianum,* of later Cretacic (Aptien) time. This shell has many intercalated spirals, and two of the primary spirals are stronger than the others, forming a slight projection around the median portion of the adult volutions. This projection, although similar in form, is not the developmental equivalent of the primary two-spiraled stage, for in the phylogeny of the genus it appears after the stage with three primary spirals and after the development of intercalated spirals. In recent, highly accelerated species of the genus, intercalated spirals appear so early in the ontogeny that the stage with three simple spirals is either omitted altogether or obscured by the fact that the third spiral on the shoulder never becomes as strong as the others. In such cases the stage just described seems to be continuous with the primitive two-spiraled stage, from which it differs morphologically only in the presence of intercalated spirals.

The greater abundance of Eocenic material in the collections studied furnishes an opportunity for determining the phylogeny with greater certainty than in the earlier horizons. At that time *C. æquispirale* represents the next stage in the phylogeny of the genus beyond *C. cornuelianum,* for on this specimen the two equal spirals are well developed and persist to the adult whorls, and spirals of several orders are easily recognizable. The young stages of *C. æquispirale* are unfortunately missing,

but they were doubtless simpler than the youngest stage preserved, and were probably not unlike the young specimens referred to *C. inabsolutum;* but if these specimens are correctly idenified, the adult differs from *C. æquispirale* in the direction of loss of fine spirals and of the shoulder. *C. lamellosum* carries this loss of ornament still farther, and the two constitute a lateral branch in the phylogeny of *Cerithium. C. calcitrapoides* represents another lateral branch, having its young stages like the adult *C. cornuelianum,* but its later stages have a shoulder with a sharp angle of the type seen on recent species of the genus.

As stated above, the European Miocenic and Pliocenic furnish no undoubted species of *Cerithium* sens. str., but in the Miocenic of Florida *C. chipolanum* seems, so far as can be determined from the description and figure, to belong to this genus and to represent a branch in which a comparatively low spire is developed. *C. chipolanum* is probably an American representative of an undescribed European form which was the ancestor of the somewhat low-spired recent species, such as *C. adansoni, C. echinatum,* etcetera.

The Pliocenic *C. callisoma* has the high spire characteristic of the type of the genus *C. tuberosum,* and it, too, probably had its European parallel, which was the ancestor of *C. tuberosum* and other high-spired related forms. The abundance of material in the collections of recent shells reveals a great flowering out of the genus in recent time, and however different the appearance of the adult shells, all reveal their common ancestry by a similarity in their young stages, as described above and indicated on plate I.

Among the genera closely related to *Cerithium, Vulgocerithium* is perhaps the nearest, developing as it does at an early stage the two strong spirals with intercalated spirals, and diverging from the main line of evolution only in the greater development of nodes and in the absence of a sharp shoulder angle in the adult. Species of this genus seem to undergo little change from Oligocenic to recent time, and all the species described are similar in general appearance and differ from one another only in details.

The genus *Potamides* is closely related to *Cerithium.* The type of the genus *P. lamarcki* develops the bicarinate ornamentation in the same manner as in *C. retardatum* (plate III, figs. 9, 10, and plate IV, fig. 9) or other retarded or primitive species of *Cerithium,* but retains each stage for a greater portion of the spire, or, in other words, its early ontogeny is like that of *Cerithium,* but more retarded. The adult expresses its divergence from *Cerithium* by developing nodes as the chief feature of its ornamentation. As pointed out above, *Potamides* is a more primitive genus than *Cerithium* in its slightly developed canal, in the sim-

plicity of its ornamentation and in its retarded ontogeny. It is probably developed from the same bicarinate ancestor from which *Cerithium* arose, but includes primitive types which persist throughout several periods of geological time. Eocenic species of *Potamides* form, like *Vulgocerithium*, a compact group the members of which do not diverge strongly, even in the adult stages.

The genus *Tympanotonus* is founded upon *Murex fuscatus* LINNÉ, a species formerly referred to *Potamides*, and this shell has the typical *Potamides* young stages, forming the peculiar ornamentation of the adult by developing its median row of nodes into large spines. The genus should be restricted to those forms which are like *Potamides* in the young and only show divergence in the neanic or adult stages. As thus restricted, the genus is a direct descendant from *Potamides*.

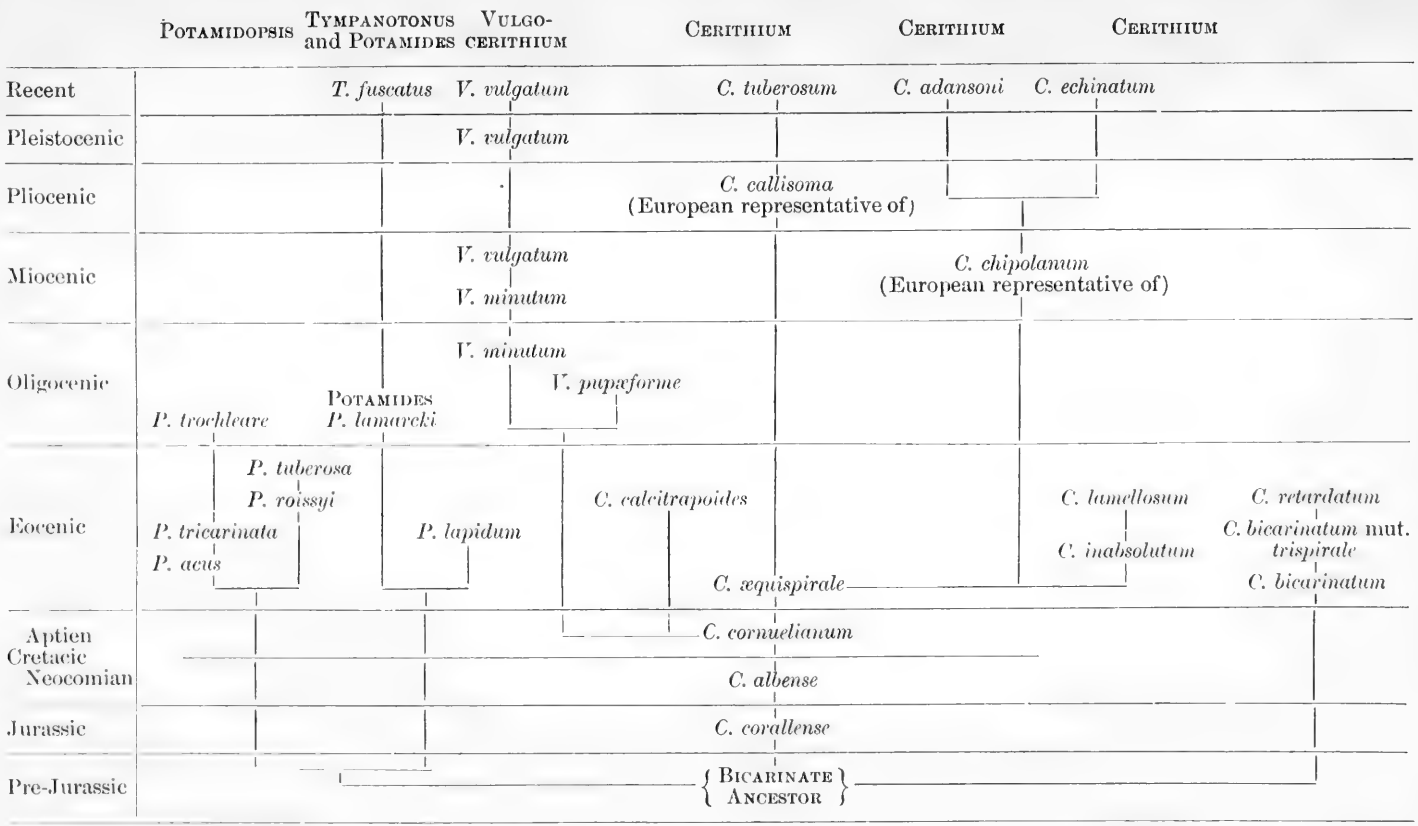
The genus *Potamidopsis*, having for its genotype *Cerithium tricarinatum* LAMARCK, is also closely related to *Cerithium*, as shown by the development of the genotype. This species forms a bicarinate ornamentation in the same manner as both *Cerithium* and *Potamides* (compare plate VII, figs. 7, 8, with plate III, figs. 9, 10, and plate IV, fig. 9), but it is more accelerated than *Potamides*. Beyond this stage, *Potamidopsis* diverges strongly from *Cerithium* in forming its shoulder angle just above the suture and in having its surface ornamented by rows of nodes. The genus as a whole is less accelerated than *Cerithium*.

As a probable ancestor of *P. tricarinata* we have *P. acus*, whose adult stages resemble the ninth to the thirteenth volutions of *P. tricarinata*, and from this species we have developed *P. roissyi* and *P. tuberculosa*, whose development is parallel to that of *P. tricarinata* up to the *P. acus* stage. After this stage these forms diverge from *P. tricarinata* by developing the uppermost instead of the lowest row of nodes.

The ancestor of *Cerithium* immediately preceding the Jurassic species described probably possessed a bicarinate ornamentation crossed by ribs and a very slightly developed canal. The young stages probably had rounded whorls, with one spiral at first and later two continuous spirals. The collections thus far studied do not furnish sufficient evidence for a statement as to the canalless form from which this primitive ancestor of the genus was derived.

Cerithium is a genus which shows a strong tendency to vary, as shown by the great diversity of forms present in the Eocenic and still greater variety in recent time; but, notwithstanding the wide differences in adults, relationship may be traced by similarity in the young stages, pointing out the path of evolution which all have traveled.

Table to Show the Phylogeny of Certain Cerithiidæ



LITERATURE.

ADAMS, C. B.: Catalogue of Panama Shells. 1852.

ADANSON, M.: Histoire Naturelle du Sénégal. Avec le Relation abrigée d'une Voyage faite en ce pays, pendant les années 1749-53. Paris. 1757.

VON ALTH, A.: Die Versteinerungen des Nizniower Kalksteines. Beiträge zur Paläontologie und Geologie österreich-ungarns und des Orients, I, 1 and 2 Theil, Heft III and IV. 1882.

D'ARCHIAC, ET HAIME, JULES: Descriptions des animaux fossiles du groupe nummulitique de l'Inde. 1853.

ARNOLD, RALPH: New and Characteristic Species of Fossil Mollusks from the Oil-bearing Tertiary Formations of Southern California. Smithsonian Miscellaneous Collections, XXXII, pp. 525-546. June, 1907.

ASCHER, ELSE: Die Gastropoden, Bivalven und Brachiopoden der Grodischter Schichten. Beiträge zur Paläontologie und Geologie österreich-ungarns und des Orients, Bd. XIX. 1906.

BARROIS, CHARLES: Mémoire sur le Terrain Crétacé des Ardennes et des régions voisines.

DE BASTEROT, M. B.: Description des coquilles fossiles des environs de Bordeaux. Univalves. Mémoire de la Société d'histoire naturelle de Paris, 11, pp. 17-100, pl. 1-7. 1825.

BAYLE: Note géologique sur les provinces d'Ouran. Bulletin de la Société géologique, XI. 1854.

BELLARDI, LUIGI E MICHELOTTI, GIOVANNI: Saggio orittografico sulla classi dei gastropodi fossili dei terreni Terziarii de Piemonte. Torino.

Exts. Mémoire della Reale Accademia delle Science di Torino, Série II, Tom. III. 1840.

BEYRICH, E.: Die Conchylien des norddeutschen Tertiärgebirges. Zeitschrift d. Deutsch. Geolog. Gesellschaft, Bd. V. 1852.

DE BLAINVILLE: Dictionnaire des sciences naturelles. Mollusks. 1820.

——: Fauna Française. Mollusks. 1825.

BÖHM, JOHANNES: Die Gasteropoden des Marmolatakalkes. Palæontographica, XLII. 1895.

——: Die Kreidebildungen des Fürbergs und Sulzbergs bei Seigsdorf in Oberbayern. Palæontographica, XXXIII. 1891-1892.

BROCCHI, DI G.: Conchiologia fossile subappennina, II, Milano. 1814.

BROILI, FERDINAND: Die Fauna der Pachycardientuffe des Seiser Alp. Scaphopoden und Gastropoden. Palæontographica, LIV. 1907-1908.

BRONGNIART, ALEXANDRE: Mémoire sur les terrains d'eau douce. Annales du Muséum National d'histoire naturelle, XV. 1810.

BRONN, H. G.: Index palæontologicus. 1848.

——: Italiens Tertiärgebilde. 1831.

BROWN, THOMAS: Illustrations of the Fossil Conchology of Great Britain and Ireland. Nos. I-IX. 1834-1838.

BRUGUIÈRE: Histoire naturelle des Vers. Encyclopédie Méthodique, Tome I, pt. 2, pp. 345-758. 1792.

BUVIGNIER: Mémoire sur quelques fossiles nouveau des departments de la Meuse et des Ardennes. Mémoire de la Société Philomatique de Verdun. 1843.

CHENU, J. G.: Manuel de Conchyliologie, I, pp. 279-284. 1859.

COLUMNÆ FABII: De aquatilibus aliisque nonnullis animalibus. Roma. 1616.

COSSMANN, MAURICE: Contribution à la Paléontologie Française des Terrains Jurassique Mém. de la société géologique de France, No. 14, V and VI. Pls. XVI-XX. 1895.

——: Catalogue illustré des coquilles fossiles de l'Éocene des environs de Paris, Appendice No. 3. 1902. *Ibid.* Quatrième fascicule.

COSSMANN, MAURICE, ET PISSARO, G.: Faune Éocénique du Cotentin, 1903. I, II.

Bulletin de la Société Géologique de Normandie, XXII, pour 1902, publié October, 1903.

COSSMAN, MAURICE: Observations sur Quelques Coquilles Crétaciques recueillies en France. 1896-1903.

——: Essais de Paléoconchologie Comparée. Septième livraison. Juillet, 1906.

DAINELLI, G.: Il Miocene inferiore del Monte Promina in Dalmazia. Palæontologia Italica, VII, 235-285, pll. 29-33. 1901.

——: La fauna eocenica di Bribir in Dalmazia. Palæontographica Italica, XI, pt. II, 1-91, pll. 1, 2. 1905.

DALL, WM. HEALY: Contribution to the Tertiary Fauna of Florida, with especial reference to the Miocene Silex-beds of Tampa, and the Pliocene beds of the Caloosahatchie River. Trans. Wagner Free Institute of Science of Philadelphia, III, pt. 1, August, 1890; pt. II, December, 1892.

——: On the Synonymic History of the Genera *Clava* Martyn and *Cerithium* Bruguière. Proc. Academy Natural Science Philadelphia, August, 1907. Issued September 28, 1907.

DAUTZENBERG & DOLLFUS: Mollusca. Roussillon I. 1882-1885.

DEFRANCE: Dictionnaire des Sciences Naturelles, VII. 1817.

DENINGER, KARL: Die Gastropoden der Sächsischen Kreideformation, 4 Tafeln. Beiträge zur Paläontologie und Geologie Österreich-ungarns und des Orients, XVIII, 1-35. 1905.

DESHAYES, G.-P.: Description des coquilles fossiles des environs de Paris, II. 1824.

——: Expédition scientifique de Morée, III. 1832.

——: Description des Animaux sans Vertébres découverts dans le bassin de Paris. Tome troisième. 1866.

DILLWYN, LEWIS WESTON: A descriptive catalogue of recent shells arranged according to the Linnean System. 1817.

DUBOIS DE MONTPÉREUX: Conchyliologie fossile et aperçu géognostique des formations du plateau Volhyni-Podolien, Berlin. 1831.

DUJARDIN: Mémoire sur les Couches du Sol en Touraine. Mémoire Geog., II. 1837.

EICHWALD, E.: Naturhistorische Skizze von Lithauen, Volhynien und Podolien. 1830.

——: Lethæa Rossica. 1853.

ÉTALLON: Étude paléontologique sur le Jura graylois. Mémoires de la Société d'Emulation du Doubs. Troisième série, VIII. 1862.

FISCHER, PAUL: Manuel de Conchyliologie. 1887.

GEINITZ, HANNS BRUNO: Das Elbthalgebirge in Sachsen. Palæontographica, XX, pt. 1, 1872; pt. 2, 1872-75.

GOLDFUSS, AUGUST: Petrefacta Germaniæ, pt. III (2d edition). 1863.

GRATELOUP: 1er Mémoire de la Conchyliologie fossile du bassin de l'Adour. Actes de la Société Linn. de Bordeaux. 1836.

——: Conchyliologie fossile des Terrains Tertiares au Bassin dé l'Adour, Environs de Dax. 1840.

GREGORIO, ANTONIO DE: Sulla Fauna delle argille scagliose di Sicilia (Oligocene-Eocene) e sul Miocene di Nicosia. 1881.

GREPPIN, ED.: Description géologique du Jura bernois. Materiaux pour la carte géologique de la Suisse, 8me livr. 1870.

——: Études sur les mollusques des couches coralligènes d'Oberbuchsitten. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XX

——: Description des fossiles du Bajocien Supérieur des environs de Bâle. (1893). 1894.
Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XXV. 1898.

HARRIS, G. D.: Neocene Mollusca of Texas. Bulletin Amer. Pal. I, No. 3. December 2, 1895.

——: The Midway Stage. Bulletin Amer. Pal. I, No. 4. June 11, 1896.

HARRIS, G. F.: The Australasian Tertiary Mollusca. British Museum Catalogue of Tertiary Mollusca, pt. 1. 1897.

HARRIS, GEO. F., and BURROWS, HENRY W.: The Eocene and Oligocene beds of the Paris Basin. Geologists' Association, London. April 3, 1891.

HEILPRIN, ANGELO: Explorations on the West Coast of Florida and in the Okeechobee Wilderness. Transactions Wagner Free Institute of Science, Philadelphia, I. May, 1887.

HOLZAPFEL, E.: Die Mollusken der Aachener Kreide. Palæontographica, XXXIV. 1888.

HOMBRON ET JACQUES: Voyage Astrolabe Zoologique, V. 1833.

HÖRNES, MORITZ UND PARTSCH, PAUL: Die Fossilen Mollusken des Tertiär-Beckens von Wien. Abhandlungen der kaiserlich-königlichen geologischen Reichsanstalt, Band III. 1856.

HÖRNES, RUDOLF: Neue Cerithien aus der Formengruppe der *Clava bidentata* (Defr.) Grateloup von Oisnitz in Mittelsteirmark. Sitzungsberichte der mathematische-naturwissinschaftlichen Klasse der kaiserlichen Akademie der Wissenschaften. Band CX, Abh. I, Heft I, pp. 315-344. 1901.

HÖRNES, R. UND AUINGER, M.: Die Gastropoden der Meeresablagerungen der ersten und zweiten miocänen Mediterränstufes. Vienna, 1879-92.

HUDLESTON, WILFRID H.: A Monograph of the Inferior Oölite Gasteropoda. Pt. 1. The Palæontographical Society Monographs. 1887-1896.

HYATT, ALPHEUS: Genesis of the Arietidæ. Smithsonian Contributions to Knowledge, No. 673. 1889.

KAUNHOWEN, F.: Die Gastropoden der Maestrichter Kreide. Palæontologische Abhandlungen, Band 8 (Neue folge Band 4). 1898-1901.

KIENER: Species general et Iconographie des Coquilles vivants. 1834-1880.

KISSLING, E.: Die Fauna des Mittel-Oligocäns im Berner-Jura. Abhandlungen der schweizerischen paläontologischen Gesellschaft, XXII. 1895.

KLIPSTEIN, A. VON: Mittheilungen aus dem Gebietete der Geologie und Palæontologie Band I. Beiträge zur geol. Kenntniss der östl. Alpen. 1843.

KOBELT, WILH.: Die Gattung Cerithium in Systematisches Conchylien Cabinet von Martini und Chemnitz, Band I, Abtheilung 26. 1898.

KOENEN, A. VON: Die Gastropoda Holostomata und Tectibranchiata, Cephalopoda und Pteropoda des Norddeutschen Miocän. Neues Jahrb. für Mineral. Beilage Band II, zweites Heft, 1882.

——: Das Marine Mittel-Oligocän Norddeutschlands und sein Mollusken-Fauna. Palæontographica, XVI, pp. 53-128. 1867-68.

KOKEN, E.: Die Gastropoden der Trias Hallstaat. Abhandlungen d. k. k. geol. Reichsanstalt Wien, 18, Heft 4, 1897.

LAMARCK: Prodrome nouv. class. 1799.

——: Système des animaux sans vertébres. 1801.

——: Suite des mémoires sur les fossiles des environs de Paris. Annales du Muséum National d'histoire naturelle de Paris, t. III. 1804.

LINK, H. F.: Beschreibung der Rostock Sammlung. 1807.

LINNÉ, CAROLI: Systema Naturæ, Tomus I. 1767.

LORIOL, P. DE: Monographie Paléontologique des couches de la zone à *Ammonites tenuilobatus* (Badener Schichten) d'Oberbuchsitten et de Wangen (Soleure). Mémoires de la Société Paléontologique Suisse, VII. 1881.

——: Études sur les Mollusques des couches coralligènes de Valfin (Jura). Mémoires de la Société Paléontologique Suisse, XIV. 1887.

——: Études sur les mollusques des couches coralligènes inférieurs du Jura Bernois, Pt. I. Abhandlungen der Schweizerischen Paläontologischen Gesellschaft, XVI. 1889.

——: Description des Mollusques et Brachiopodes des Couches Sequaniennes. Mémoires de la Société Paléontologique Suisse, XX. 1893.

——: Études sur les Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XXIII. 1896.

——: Études sur les Mollusques et Brachiopodes de l'Oxfordien inférieur ou zone à *Ammonites renggeri* du Jura Bernois. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XXVI. 1899.

——: Étude sur les Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen du Jura Bernois. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XXVIII. 1901.

LORIOL, P. DE, ROYER, E., TOMBECK, H.: Description géologique et paléontologique des étages jurassique supérieurs de la Haute-Marne. Mémoires de la Société Linnéenne de Normandie, 1869-72, XVI, 1872.

MAILLARD, GUSTAVE: Invertébres du Purbeckien du Jara. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XI. 1884.

MAILLARD ET A. LOCARD: Monographie des Mollusques Tertiaires terrestres et fluviatiles de la Suisse. Abhandlungen der Schweizerischen paläontologischen Gesellschaft, XIX (1892). 1893.

MARTIN, G. C.: Maryland Geological Survey Miocene (Mollusca), pp. 131-270. 1904.

MARTIN, K.: Die Tertiarschichten auf Java. Palæontologische Theil. 1879.

MARTYN, THOMAS: The Universal Conchologist. London. 1784.

MAURY, CARLOTTA J.: A Comparison of the Oligocene of Western Europe and the Southern United States. Bulletin Amer. Pal. III, No. 15. June 16, 1902.

MELLEVILLE, M.: Mémoire sur les Sables tertiares inférieurs du bassin de Paris, avec la description de 78 espèces de coquilles fossiles inédites de ce terrain, pls. I-X. Annales des Sciences Géologiques. 1843.

MONTFORT, D. DE: Conchyliologie Systématique II. 1810.

MÜNSTER, GR. ZU: Beiträge zur Petrefactenkunde, IV Heft. Beyreuth. 1841.

MURCHISON, R. I., DE VERNEUIL, KEYSERLING, ALEX.: Géologie de la Russie d'Europe et des Montagnes de l'Oural, II, Pt. 3 Paléontologie. 1845.

NEWTON, R. B.: Systematic List of British Oligocene and Miocene Mollusca. 1891.

NOETLING, F.: Die Fauna der baltischen Cenomän-Geschiebe. 199 Taf. XVI-XXIII. Palæontologische Abhandlungen, II. 1884-1885.

——: Fauna of the Upper Cretaceous (Maestrichtien) beds of the Mari Hills. Memoir of the Geological Survey of India, ser. XVI, vol. 1, Part III. 1902.

NYST, P. H.: Description des Coquilles fossiles des Terraines tertiare de la Belgique. 1843.

OLIVI: Zoologia adriatica. 1792.

OPPENHEIM, PAUL: Die Eocänfauna des Monte Postale bei Bolca im Veronesischen. September, 1896. Tafeln XII-XIX. Palæontographica XLIII. 1896-1897.

——: Die Priabonaschichten und ihre Fauna, mit 21 Tafeln und zahlreichen Figuren in Text. Palæontographica XLVII. 1900-1901.

——: Ueber einige alttertiäre Faunen der österreichisch-ungarischen Monarchie. Tafeln XI-XIX, pp. 185-277. Beit. Päl. und Geol. Österreich-ungarns und des Orients, Bd. XIII. 1901.

D'ORBIGNY, ALCIDE: Paléontologie Française. Description des Mollusques et Rayonnés Fossiles. Terrains Crétacés Gastéropodes, XII. 1842-1843.

——: Prodrome. 1850.

PARTSCH, PAUL: Neue Aufst. der Petrefaktenkunde. Sammlung des k. k. Mineralog. Cab. in Wien. 1842.

PEASE, WILLIAM HARPER: Descriptions of New Species of Marine Gasteropoda inhabiting Polynesia. American Journal of Conchology, V, pp. 64-87. 1870.

PHILIPPI, R. A.: Enumeratio Molluscorum Siciliæ, I, 1836; II, 1844.

——: Tertiärversteinerungen des nordwestlichen Deutschlands. 1843.

——: Abbildungen und Beschreibungen neuer oder wenig gekannter Conchylien, III. 1851.

——: Verzeichniss der in der Gegend von Magdeburg aufgefundenen Tertiärversteinerungen. Palæontographica, I, pp. 42-90. 1851.

——: Die tertiären und quartiären Versteinerungen Chiles. Leipsic. 1887.

PUSCH: Polens Paläontologie. 1837.

QUENSTEDT, FRIEDRICH AUGUST: Petrefaktenkunde Deutschlands. 1st Abteilung, siebenter band. Gasteropoden. 1881-1884.

REEVE, LOVELL AUGUSTUS: Conchologia Iconica, or Illustrations of the Shells of Molluscous Animals, XV. 1866.

RISSO: Histoire naturelle des environs de Nice et des Alpes maritime, IV. 1826.

REHBINDER, B.: Fauna und alter der Cretaceischen Sandstein in die Umgebung des Salzsees Baskuntschak. Mémoires des comité géologique de Russie, XVII. 1902.

ROISSY: Histoire naturelle des Mollusques, VI. 1805.

ROMANOWSKI, G.: Geologische und paläontologische Uebersicht des nordwestlichen Thian-Schan und des südöstlichen Theiles der Niederung von Turan. 1880.

SANDBERGER: Untersuchen über das Mainzer Tertiärbecken. 1853.

SCHLOSSER, MAX: Die Fauna des Kelkeimer Diceras-Kalkes. Palæontographica, XXVIII. 1881.

SERRES, MARCEL DE: Essai pour servir à l'histoire des animaux du midi de la France. 1822.

SHERBORN, C. DAVIES, and WOODWARD, B. B.: On the Dates of the "Encyclopédie Méthodique" (Zoölogy). Proceedings Zoöl. Society London, pp. 582-584. 1893.

SISMONDA, E.: Synopsis méthodique animaux invertébres Ped. foss. 1847.

SOWERBY, G. B.: Thesaurus Conchyliorum, or Monographs of Genera of Shells. Edited by G. B. Sowerby, II. 1855.

SPEYER, OSCAR: Die Conchylien der Casseler Tertiärbildungen. Palæontographica, XVI. 1866-1869; XIX, 1871.

STANTON, TIMOTHY, W.: The Colorado Formation and its Invertebrate Fauna. Bulletin U. S. Geological Survey, Number 106. 1893.

STOLICZKA, FERD.: Gastropoda of the Cretaceous Rocks of Southern India. Memoirs of the Geological Survey of India, ser. I, vol. II. 1868.

STRUCKMANN, C.: Neue Beiträge zur Kenntniss des oberen Jura und der Wealdenbildungen der Umgegend von Hannover s. 3 Taf., I-V. Paläontologische Abhandlungen, Erster Band. 1882-1883.

STURANG, RUDOLF: Gastropoden des Rothen Meeres. Expedition S. M. Schiff "Pola" in das Rothe Meer. 1895-96; 1897-98. Denkschriften der kaiserlichen Akademie der Wissenschaften. Band 74. 1904.

TROSCHEL, F. H.: Das Gebiss der Schnecken, zur Begründen einer naturlichen Classification, I. 1856; II, 1878.

TRYON, GEORGE W.: Manual of Conchology, IX. 1887.

VINASSA DE REGNY, P. E.: Synopsis dei molluschi terziari delle Alpi venete. Palæontographica Italica, I, pp. 211-275, pls. XVI-XVIII, 1896 (for 1895), pp. 149-184, pls. XXI-XXII, 1897 (for 1896).

WANNER, J.: Die Fauna der obersten weissen Kreide der libyschen Wüste. Palæontographica, XXX, pt. 2. 1902.

WEERTH, O.: Die Fauna des Neocomsandsteins im Teutoburger Wald s. 3 Taf., I-XI. Palæontologische Abhandlungen. Band II. 1884-1885.

WHIDBORNE, G. F.: A Monograph of the Devonian Fauna of the South of England (1891). The Palæontographical Society, London, I. 1889-1892.

WOLFF, WILHELM: Die Fauna der südbayerischen Oligocänmolasse. February, 1897. Palæontographica, XLVIII. 1896-1897.

WOOD, SEARLES V.: Monograph of the Crag Mollusca. Palæontographical Society Monographs, London. 1848.

WOOD, WILLIAM: Index testaceologicus, or a Catalogue of Shells, British and Foreign. 1818-1828.

ZEKELI, FRIEDRICH: Die Gastropoden der Gosaugsbilde. Abhandlungen der k. k. Wien-Geol. Reichsanstalt, I Band. 1852.

VON ZITTEL, K. A.: Die Gasteropoden der Stramberger Schichten. Palæontographica. Beiträge zur Naturgeschichte der Vorwelt. Supplement. 1873.

PLATE I

SURFACE FEATURES OF CERITHIUM AND VULGOCERITHIUM

Diagram to illustrate the development of five surface features on eleven recent species of *Cerithium* and *Vulgocerithium vulgatum*.

The numbers at the left of the plate indicate the numbers of the volutions, the protoconch being numbered 1.

—— = primary spirals.

| = ribs.

\ | > } = outline of volution.

═══ = spirals of secondary and higher orders.

. = nodes.

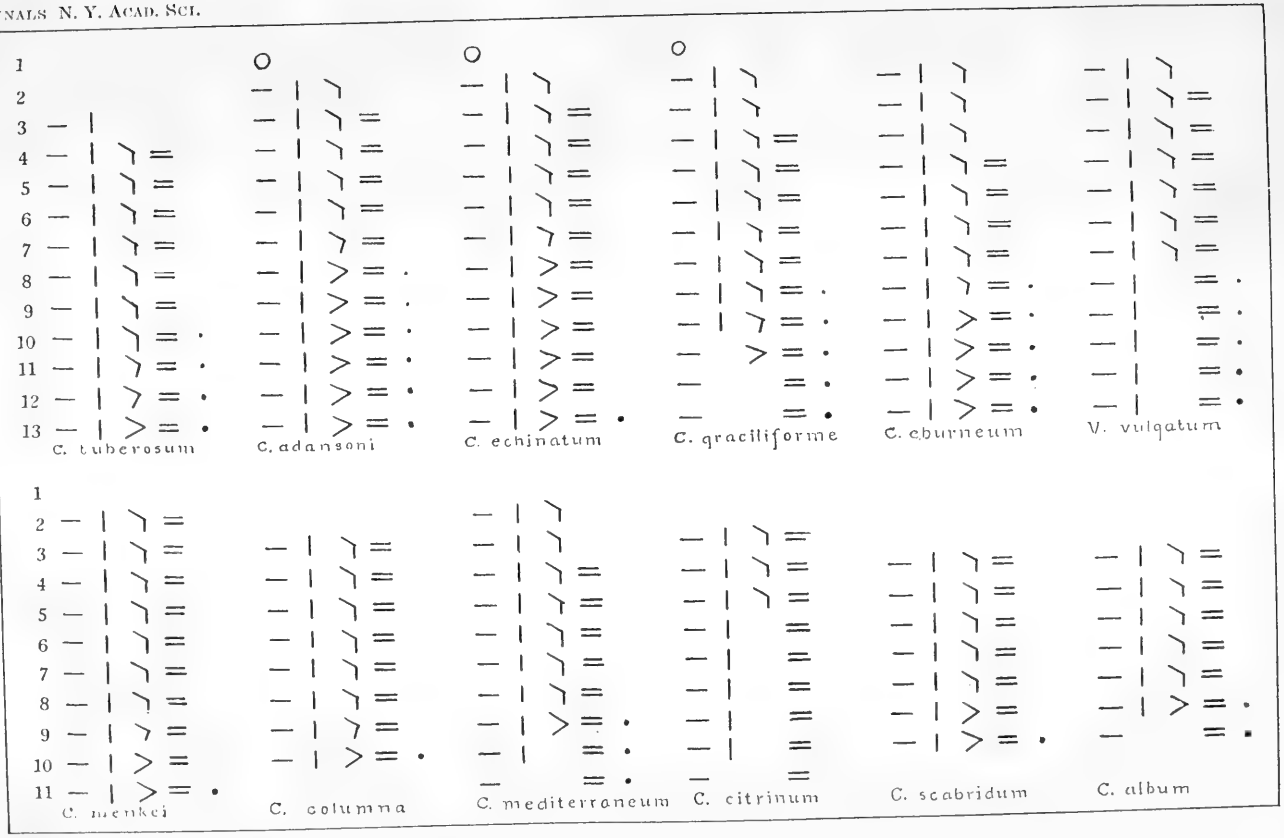

C. tuberosum
C. adansoni
C. echinatum
C. graciliforme
C. eburneum
V. vulgatum
C. menkei
C. columna
C. mediterraneum
C. citrinum
C. scabridum
C. album

PLATE II

FIG. 1. *Vicinocerithium bouei* (DESHAYES). × 2.

FIG. 2. *Vicinocerithium parallelum* sp. nov. × 2.

FIG. 3. *Cerithium adansoni* BRUGUIÈRE, a young individual. × 1⅓.

FIG. 4. *Cerithium tuberosum* COLUMNÆ. × 1⅓.

FIG. 5. *Cerithium æquispirale* sp. nov. × 2.

FIG. 6. *Cerithium retardatum* sp. nov. × 2.

FIG. 7. *Cerithium bicarinatum* mut. *trispiralis* mut. nov. × 2.

FIG. 8. *Cerithium bicarinatum* DESHAYES. × 2.

The figures are from photographs, retouched by the author.

The figures are from photographs retouched by the author.

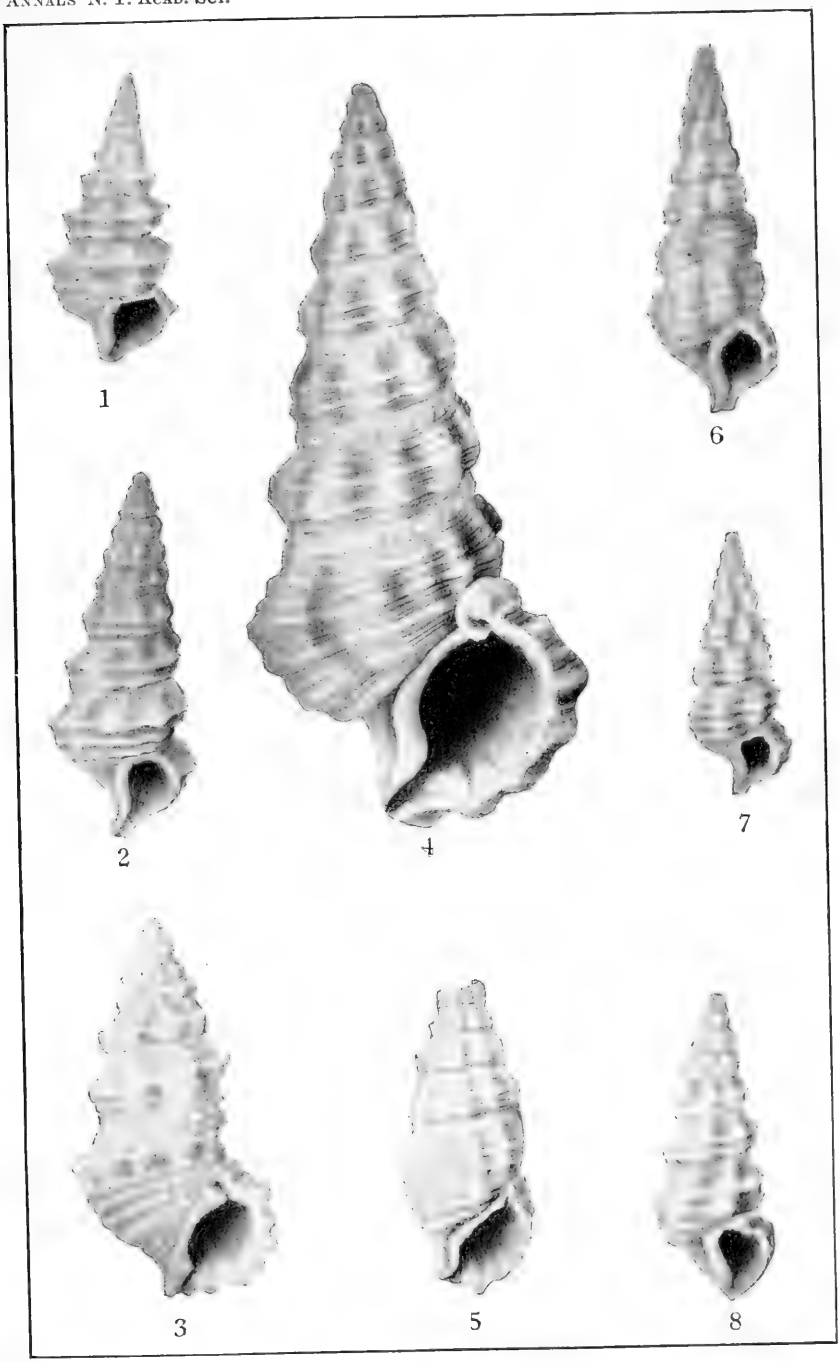

1
2
4
6
7
3
5
8

PLATE III

ONTOGENY OF SIX SPECIES OF CERITHIUM

Numbers at the left of the plate indicate the numbers of the volutions. Dotted lines indicate gradual transition from one volution to the next figured. The amount of enlargement is given on the plate; actual measurement of the portion of the shell figured is given below. All the figures on Plates III to IX are from original drawings by the author.

FIG. 1. *Cerithium tuberosum*, fourth volution. 1.6 × .3 mm.
FIG. 2. *Cerithium adansoni*, protoconch. .6 × .4 mm.
FIG. 3. *Cerithium adansoni*, second volution. .8 × .3 mm.
FIG. 4. *Cerithium adansoni*, third volution. 1.1 × .5 mm.
FIG. 5. *Cerithium? nodulosum*, fourth volution. 1.9 × 1 mm.
FIG. 6. *Pseudovertagus aluco*, fourth volution. 2.2 × 1.1 mm.
FIG. 7. *Cerithium lamellosum*, protoconch and first volution. .5 × .7 mm.
FIG. 8. *Cerithium lamellosum*, third volution. .7 × .32 mm.
FIG. 9. *Cerithium retardatum*, second volution. .5 × .25 mm.
FIG. 10. *Cerithium retardatum*, third volution. .75 × .37 mm.

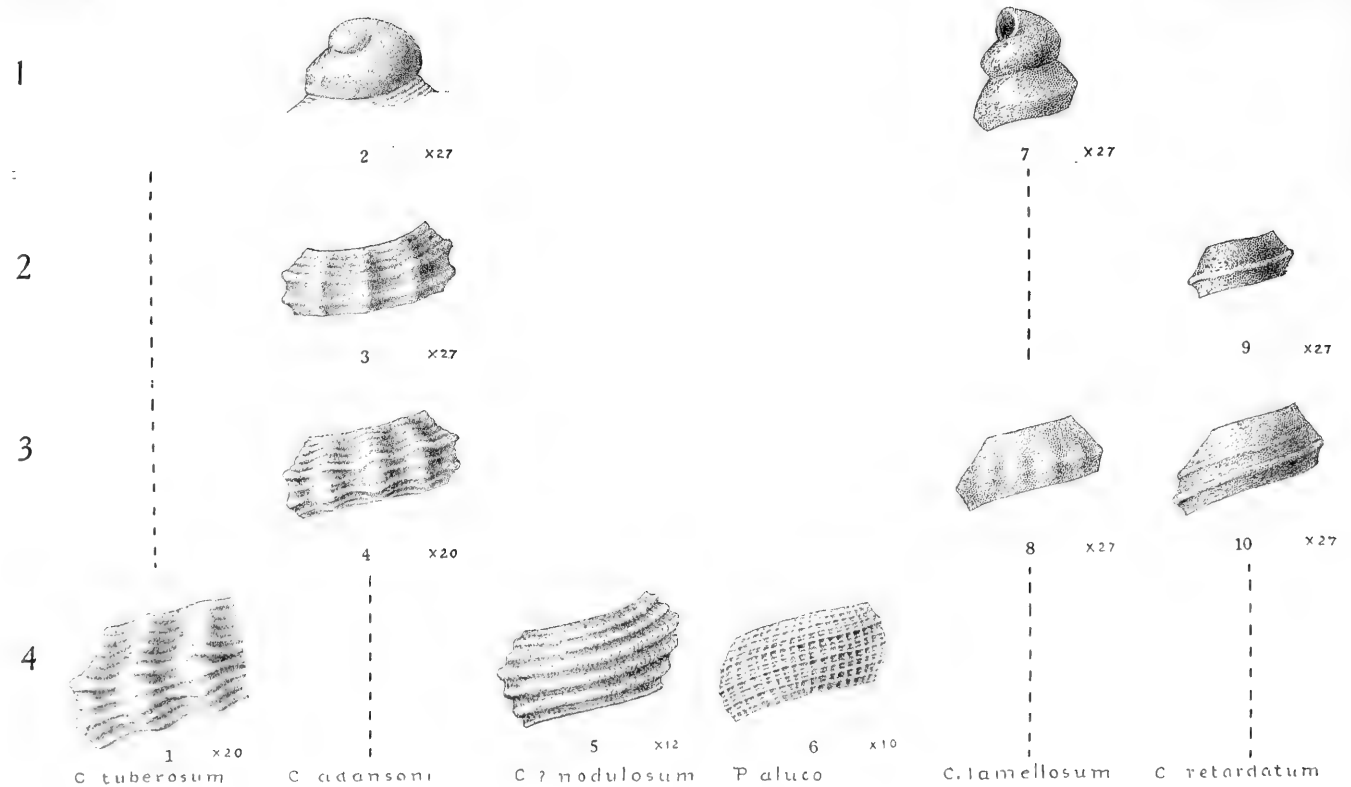

1
2
3
4
2 x27
3 x27
4 x20
1 x20
5 x12
6 x10
7 x27
9 x27
8 x27
10 x27
C tuberosum
C adansoni
C ? nodulosum
P aluco
C. lamellosum
C retardatum

PLATE IV

ONTOGENY OF SIX SPECIES OF CERITHIUM (continued)

FIG. 1. *Cerithium tuberosum*, eighth volution. 4.6 × 2.2 mm.

FIG. 2. *Cerithium adansoni*, fifth volution. 3.5 × 1.5 mm.

FIG. 3. *Cerithium adansoni*, eighth volution. 9 × 3.4 mm.

FIG. 4. *Cerithium? nodulosum*, sixth volution. 6 × 3 mm.

FIG. 5. *Cerithium? nodulosum*, eighth volution. 6 × 5 mm. Later whorls of this shell are not figured, as they are too large to show details when reduced to the scale of this plate.

FIG. 6. *Pseudovertagus aluco*, seventh volution. 5.2 × 2.3 mm.

FIG. 7. *Pseudovertagus aluco*, eighth volution. 7 × 3 mm.

FIG. 8. *Cerithium lamellosum*, fifth volution. 1.2 × .5 mm.

FIG. 9. *Cerithium retardatum*, fifth volution. 1.2 × .5 mm.

FIG. 10. *Cerithium retardatum*, seventh volution. 2 × 1 mm.

PLATE IX

Fig. 1. *Cerithium laboriosum*, eighth volution. 4.6 × 2.2 mm.

Fig. 2. *Cerithium adunosum*, fifth volution. 3.5 × 1.5 mm.

Fig. 3. *Cerithium adunosum*, eighth volution. 8 × 3.1 mm.

Fig. 4. *Cerithium? modulosum*, sixth volution. 6 × 3 mm.

Fig. 5. *Cerithium* [illegible]

this shell are not figured, as they are too large to show details when reduced to the scale of this plate.

Fig. 6. *Pseudocerithium ulmo*, seventh volution. 5.2 × 2.3 mm.

Fig. 7. *Pseudocerithium ulmo*, eighth volution. 7 × 3 mm.

Fig. 8. *Cerithium lamellosum*, fifth volution. 1.2 × .5 mm.

Fig. 9. *Cerithium retiradiatum*, fifth volution. 1.2 × .5 mm.

Fig. 10. *Cerithium retiradiatum*, seventh volution. 2 × 1 mm.

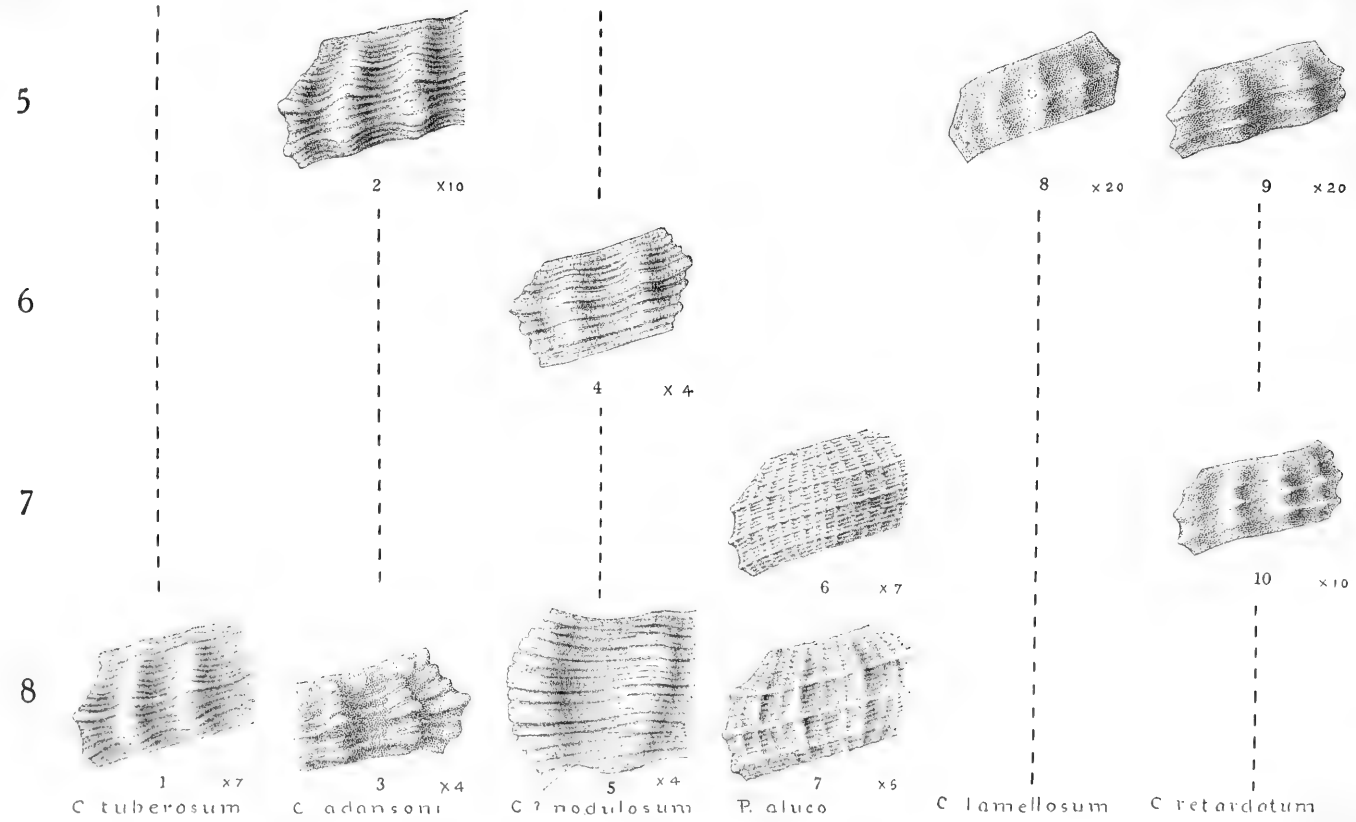

5
6
7
8
2 X10
4 X 4
8 X 20
9 X 20
6 X 7
10 X 10
1 X 7
3 X 4
5 X 4
7 X 5
C tuberosum
C adamsoni
C ? nodulosum
P. aluco
C lamellosum
C retardotum

PLATE V

ONTOGENY OF SIX SPECIES OF CERITHIUM (continued)

FIG. 1. *Cerithium adansoni*, ninth volution. 12 × 7 mm.
FIG. 2. *Cerithium adansoni*, aperture. 16 × 12 mm.
FIG. 3. *Cerithium æquispirale*, ninth volution. 2.5 × 1.4 mm.
FIG. 4. *Cerithium æquispirale*, twelfth volution. 4.4 × 8.5 mm.
FIG. 5. *Pseudovertagus aluco*, tenth volution. 10 × 4.5 mm.
FIG. 6. *Pseudovertagus aluco*, eleventh volution. 16 × 7 mm.
FIG. 7. *Cerithium lamellosum*, ninth volution. 3.4 × 1.5 mm.
FIG. 8. *Cerithium lamellosum*, eleventh volution. 6 × 3.5 mm.
FIG. 9. *Cerithium retardatum*, ninth volution. 3.8 × 1.8 mm.

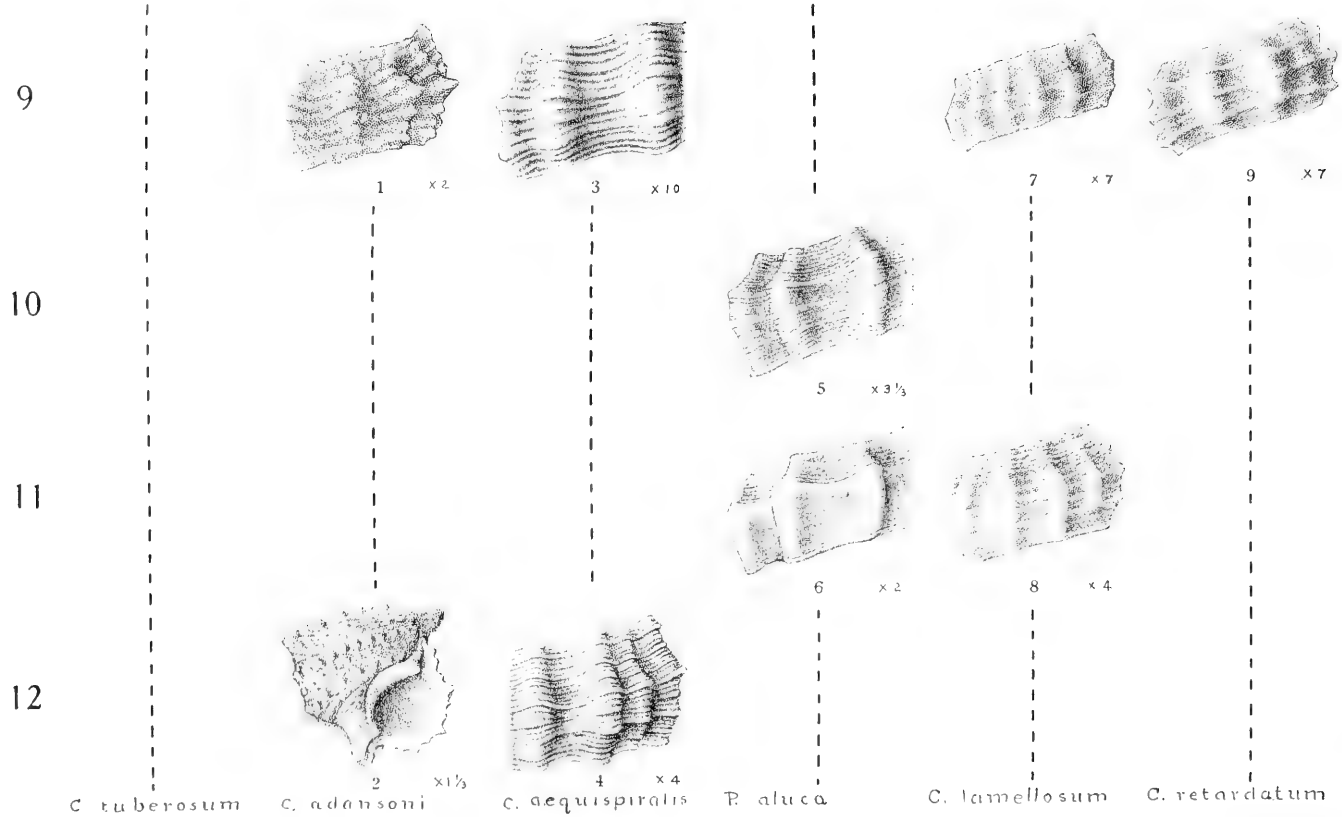
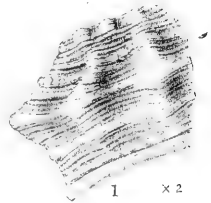

9
10
11
12
1 ×2
3 ×10
7 ×7
9 ×7
5 ×3⅓
6 ×2
8 ×4
2 ×1⅓
4 ×4
C. tuberosum
C. adansoni
C. aequispiralis
P. aluca
C. lamellosum
C. retardatum

PLATE VI

ONTOGENY OF SIX SPECIES OF CERITHIUM (continued)

FIG. 1. *Cerithium tuberosum*, thirteenth volution. 12 × 11.5 mm.
FIG. 2. *Cerithium tuberosum*, fourteenth volution. 24 × 29 mm.
FIG. 3. *Cerithium æquispirale*, fourteenth volution. 9.5 × 9.2 mm.
FIG. 4. *Pseudovertagus aluco*, thirteenth volution. 19 × 11 mm.
FIG. 5. *Pseudovertagus aluco*, fourteenth volution. 22 × 20 mm.
FIG. 6. *Cerithium lamellosum*, aperture. 12 × 11 mm.
FIG. 7. *Cerithium retardatum*, fourteenth volution. 8.5 × 4 mm.
FIG. 8. *Cerithium retardatum*, aperture. 7 × 9 mm.

13



1 ×2

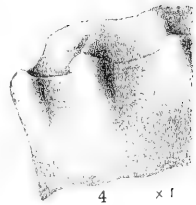
14

×1.

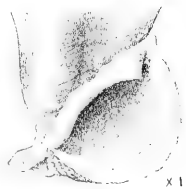
2

×2 2/3

3



4 ×1

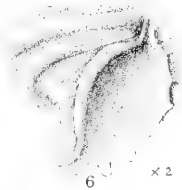


×1

5

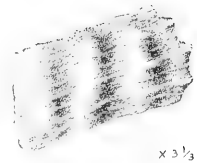
15

16



×2

6



×3 1/3

7

×2 2/3

8

C. tuberosum

C. aequispiralis Pfeiffer

C. lamellosum

C. retardatum

PLATE VII

ONTOGENY OF CERITHIIDÆ

FIG. 1. *Cerithium callisoma*, third volution. .8 × .3 mm.
FIG. 2. *Cerithium menkei*, second volution. .2 × .6 mm.
FIG. 3. *Cerithium menkei*, fourth volution. 1.8 × .8 mm.
FIG. 4. *Vicinocerithium parallelum*, second volution. 1.2 × .5 mm.
FIG. 5. *Vicinocerithium parallelum*, third volution. .2 × .8 mm.
FIG. 6. *Vicinocerithium bouci*, fourth volution. 1.4 × .6 mm.
FIG. 7. *Potamidopsis tricarinata*, second volution. .4 × .19 mm.
FIG. 8. *Potamidopsis tricarinata*, third volution. .6 × .3 mm.
FIG. 9. *Potamidopsis trochleare*, fractured protoconch. .4 × .3 mm.
FIG. 10. *Potamidopsis trochleare*, fourth volution. 1 × .4 mm.

PLATE VII

CYSTOIDEA OF CHRISTIANIA

FIG. 1. *Cerithium calliconus*, third volution. .8 × .3 mm.

FIG. 2. *Cerithium mendici*, second volution. .2 × .6 mm.

FIG. 3. *Cerithium mendici*, fourth volution. 1.8 × .8 mm.

FIG. 4. *Vicinocerithium puruflexum*, second volution. 1.2 × .5 mm.

FIG. 5. *Vicinocerithium puruflexum*, third volution. .2 × .8 mm.

FIG. [illegible]

FIG. 7. *Potamidopsis tricarinata*, second volution. .4 × .10 mm.

FIG. 8. *Potamidopsis tricarinata*, third volution. .6 × .3 mm.

FIG. 9. *Potamidopsis trochlearc*, fractured protoconch. .4 × .3 mm.

FIG. 10. *Potamidopsis trochlearc*, fourth volution. 1 × .4 mm.

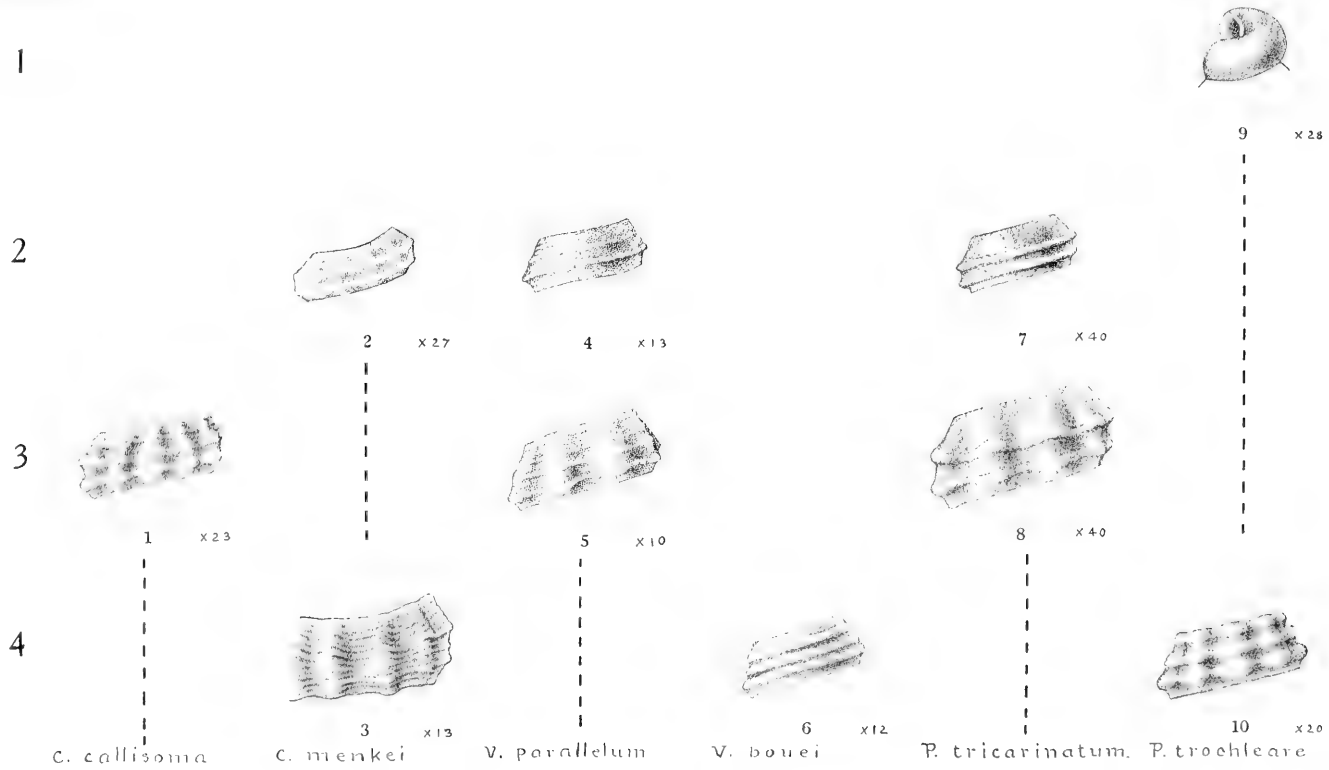

1
2
3
4
1 x23
2 x27
3 x13
4 x13
5 x10
6 x12
7 x40
8 x40
9 x28
10 x20
C. callisoma
C. menkei
V. parallelum
V. bouei
P. tricarinatum.
P. trochleare

PLATE VIII

ONTOGENY OF CERITHIIDÆ (continued)

FIG. 1. *Cerithium callisoma*, sixth volution. 1.8 × .8 mm.
FIG. 2. *Cerithium callisoma*, eighth volution. 2.6 × 1 mm.
FIG. 3. *Cerithium menkei*, fifth volution. 1.8 × 1 mm.
FIG. 4. *Vicinocerithium parallelum*, fifth volution. 2.4 × 1 mm.
FIG. 5. *Vicinocerithium parallelum*, seventh volution. 3 × 2 mm.
FIG. 6. *Vicinocerithium bouei*, eighth volution. 2.8 × 1.4 mm.
FIG. 7. *Potamidopsis tricarinata*, sixth volution. 1.4 × .6 mm.
FIG. 8. *Potamidopsis tricarinata*, tenth volution. 2.7 × 1 mm.
FIG. 9. *Potamidopsis trochleare*, sixth volution. 1.3 × .5 mm.
FIG. 10. *Potamidopsis trochleare*, twelfth volution. 11.8 × 7.5 mm.

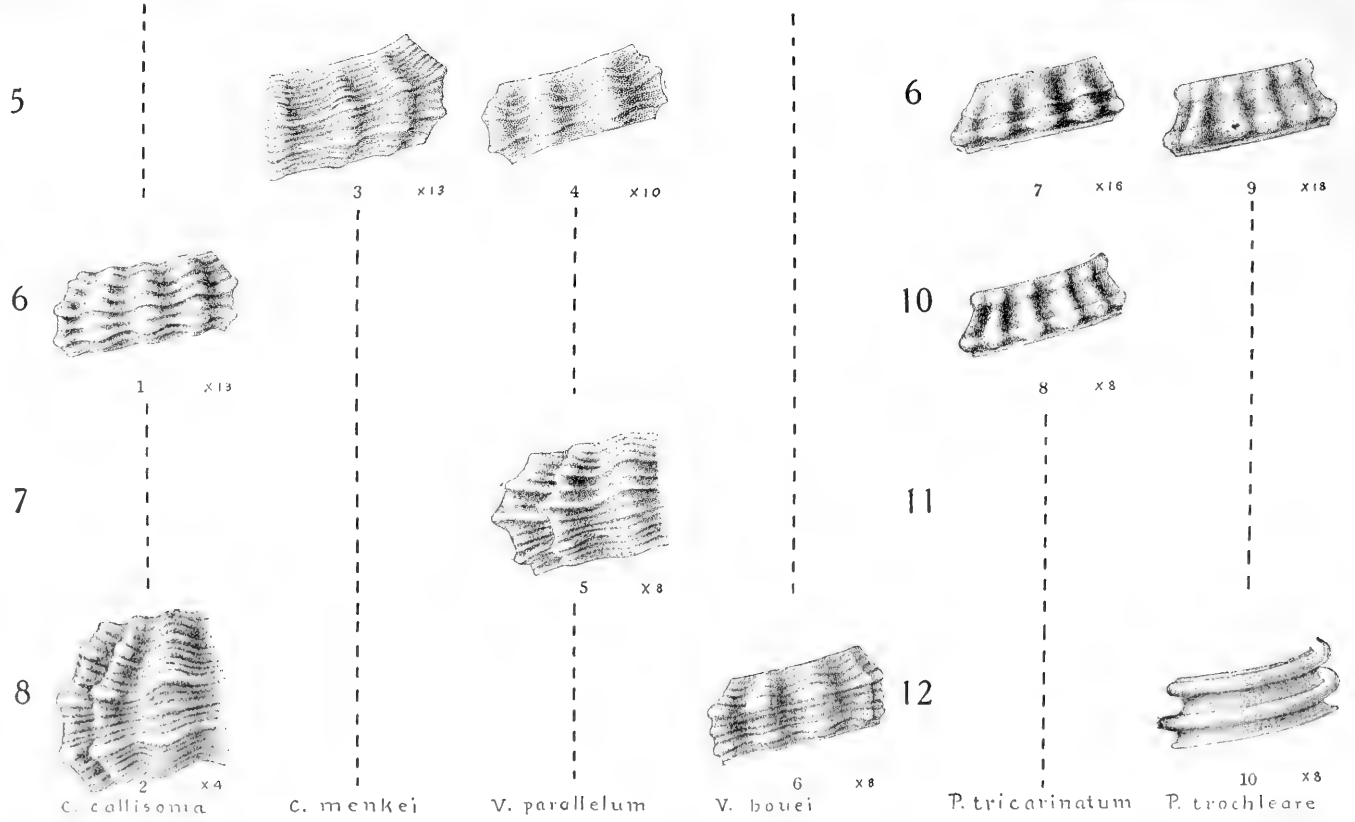

5
6
7
8
1 x13
2 x4
3 x13
4 x10
5 x8
6 x8
6
10
11
12
7 x16
9 x18
8 x8
10 x8
C. callisoma
C. menkei
V. parallelum
V. bouei
P. tricarinatum
P. trochleare

PLATE IX

ONTOGENY OF CERITHIIDÆ (continued)

FIG. 1. ***Cerithium callisoma***, tenth volution. 7.3 × 7 mm.

FIG. 2. ***Cerithium menkei***, tenth volution. 13 × 11.5 mm.

FIG. 3. ***Vicinocerithium parallelum***, twelfth volution. 6 × 4 mm.

FIG. 4. ***Vicinocerithium parallelum***, aperture. 9.8 × 8 mm.

FIG. 5. ***Vicinocerithium bouei***, twelfth volution. 3 × 2 mm.

FIG. 6. ***Vicinocerithium bouei***, aperture. 8.5 × 6.5 mm.

FIG. 7. ***Potamidopsis tricarinata***, twenty-third volution. 12 × 5 mm.

FIG. 8. ***Potamidopsis tricarinata***, twenty-fourth volution. 19 × 11 mm.

FIG. 9. ***Potamidopsis trochleare***, aperture. 11.8 × 7.5 mm.

PLATE IX

ORTOSPIRA OF CENTRITES (continued)

FIG. 1. *Centrites callosus*, tenth volution. 7.3 × ? mm.

FIG. 2. *Centrites mexicus*, tenth volution. 13 × 11.5 mm.

FIG. 3. *Trichocentrites* [illegible]

FIG. 4. *Trichocentrites* [illegible]

FIG. 5. *Trichocentrites bonei*, twelfth volution. 3 × 2 mm.

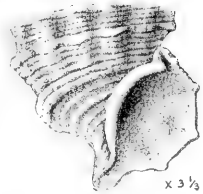
FIG. 6. *Trichocentrites bonei*, aperture. 8.5 × 6.5 mm.

FIG. 7. *Polyamidopsis* [illegible]

FIG. 8. *Polyamidopsis* [illegible]

FIG. 9. *Polyamidopsis troelsleyi*, aperture. 11.8 × 7.5 mm.

10



1 x 3⅓

2 x 1⅔

11

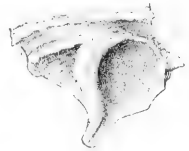
12

3 x 4

5 x 4

13

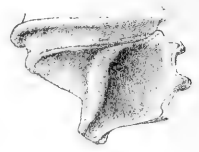
4 x 2



6 x 2⅔

C. callisoma C. menkei V. parallelum V. bouei

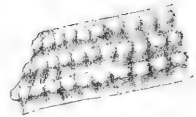
21



9 x 2

22

23

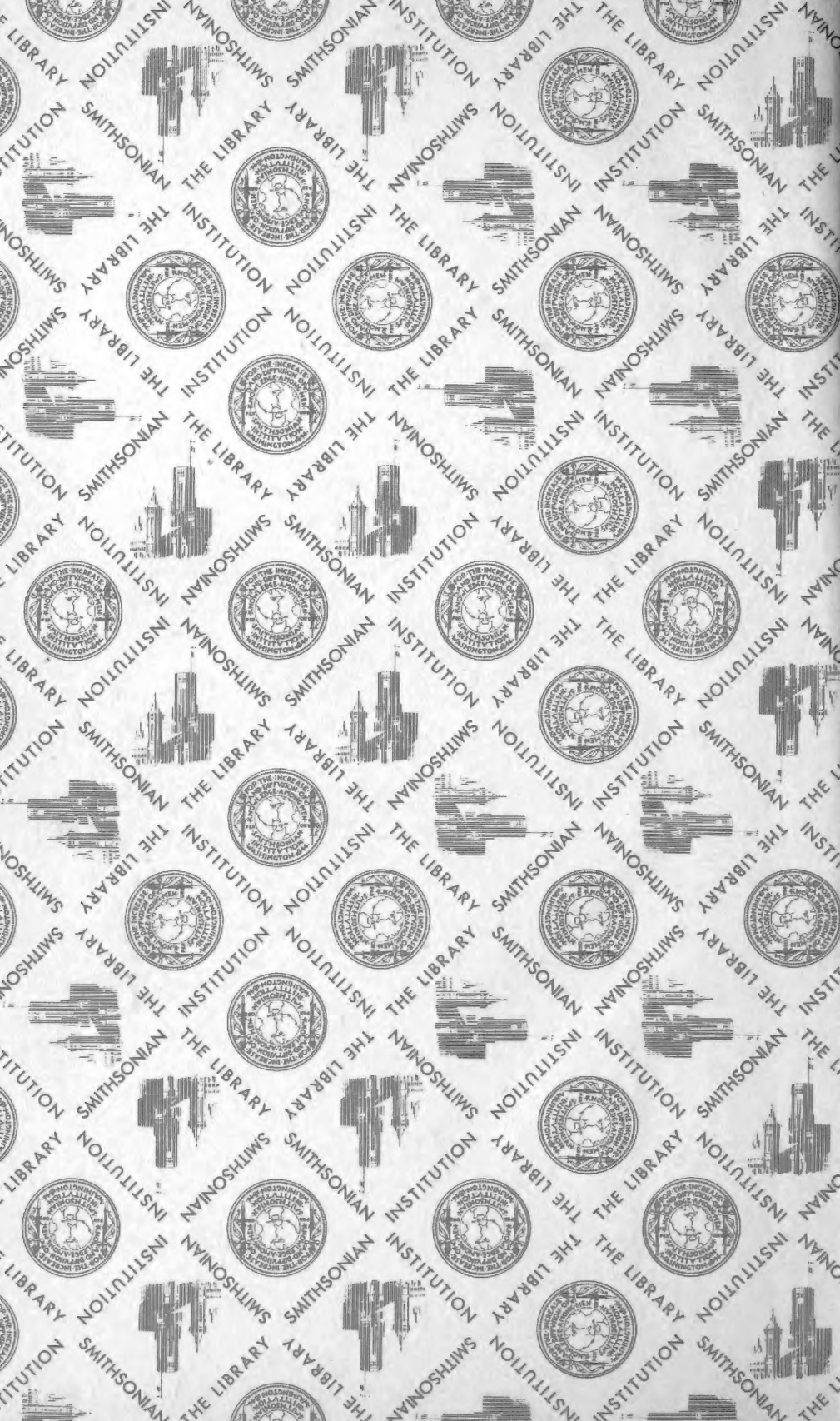


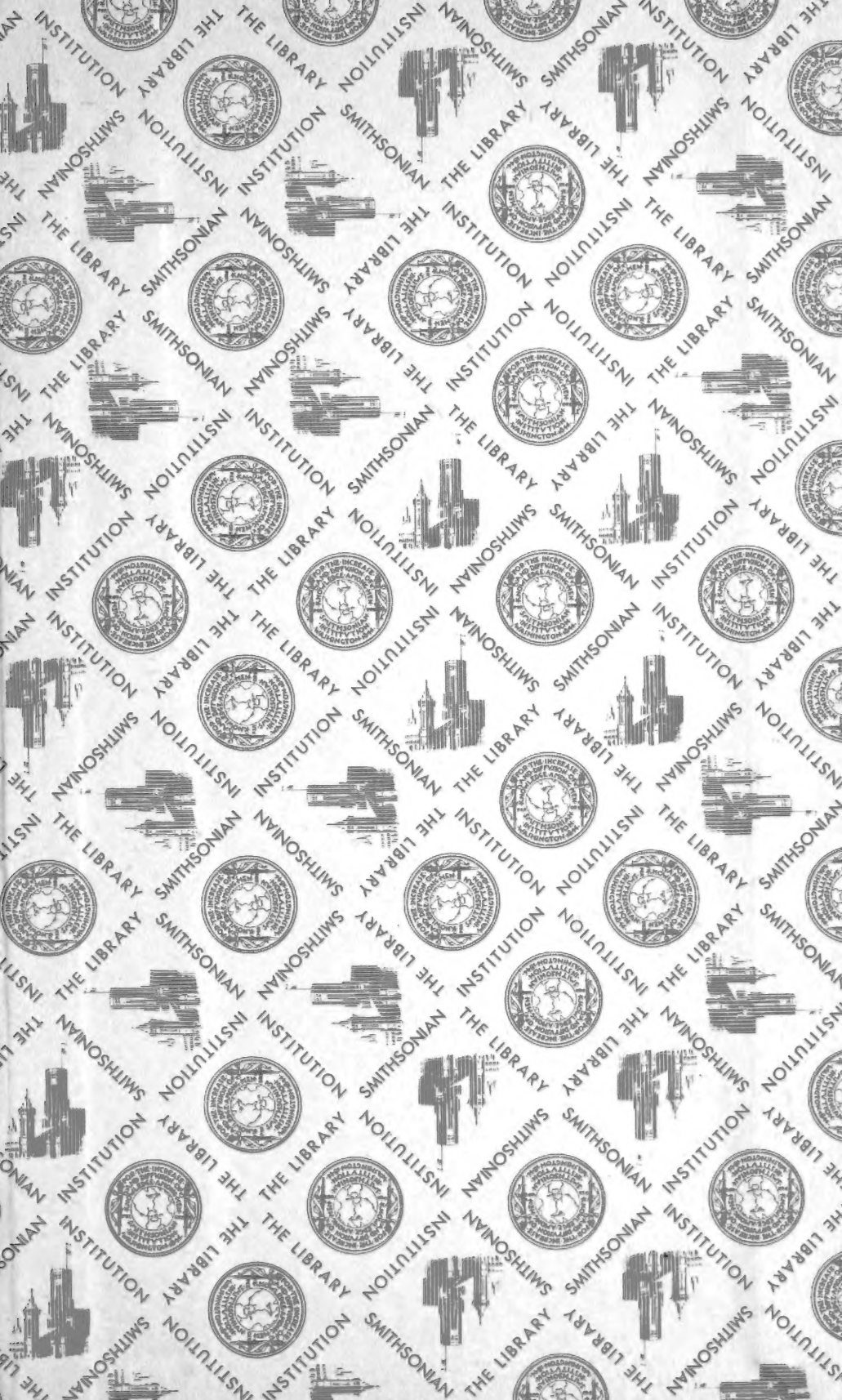
7 x 2

24

8 x 1⅓

P. tricarinatum P. trochleare.


SMITHSONIAN INSTITUTION THE LIBRARY


SMITHSONIAN INSTITUTION THE LIBRARY