

ON THE GENERA OF VENERIDÆ REPRESENTED IN THE
CRETACEOUS AND OLDER TERTIARY DEPOSITS.

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PLATE VI.

I. INTRODUCTORY REMARKS.

HAVING being led to study the shells of the recent species of the family Veneridæ, with the view of revising the many generic and subgeneric groups which have been proposed by various writers, and of constructing more satisfactory definitions of them than exist in any current textbooks, I found that it was necessary to include the fossil representatives of the family within the scope of my review.

The family doubtless originated during the course of Jurassic time, but it is doubtful whether any representatives of it exist among the Jurassic faunas of England or of Northern France. Several genera, however, make their appearance in the Lower Cretaceous rocks of both countries, and a still greater variety of forms is found in the Eocene series.

It would be interesting to ascertain whether the Veneridæ developed from one centre, or along two different lines of descent; the possibility of the latter mode of origin being suggested by the great difference which is observable among the Cretaceous representatives. *Dosiniopsis*, for instance, by its possession of posterior lateral teeth is unquestionably a link between *Cyprina* and *Dosinia*, while the Tapesine genus *Baroda*, by its elongate shape and by the simplicity of its hinge-teeth, seems to have had a very different origin.

With regard to the later Tertiary species (of Pliocene and Pleistocene age), most of them can be referred without difficulty to recent genera, but some of the Eocene and Cretaceous species exhibit differences which make it necessary to regard them as distinct genera or subgenera, while at the same time they illustrate the lines along which the recent genera have developed.

In this paper I shall concern myself with those species of Cretaceous, Eocene, and Oligocene age which occur within the limits of the Anglo-Parisian region, i.e. in the South of England and the North of France. In our own country palæontologists have hitherto been content to catalogue the British species under the names of *Venus* and *Cytherea* (or *Meretrix*), and up to about 1885 French palæontologists were content with the same generic nomenclature, except that Deshayes had described two species of *Tapes*, several supposed *Venerupis*, and a shell to which he gave the generic name of *Psathura*. In 1886, however, the Veneridæ of the Parisian Eocene were the subject of careful study and description by M. Maurice Cossmann, who recognized eleven different genera, of which number three were new, and he also divided his genus *Cytherea* into five sections or subgenera, and his *Venus* into three.¹

¹ Ann. Soc. Roy. Mal. Belg., tom. xxi, p. 104.

Still more recently Dr. W. H. Dall has investigated the American recent and Tertiary species, and has published a synopsis of the family Veneridæ,¹ in which he has redescribed and defined all the recent and fossil genera. This synopsis is unquestionably the most complete account of the family which has yet been published, and gives new information about some of the generic groups; but it has special reference to American species, and is not an entirely reliable guide with regard to European fossils. He also makes many alterations in the nomenclature, some of which have not gained acceptance in this country.

By British conchologists the Veneridæ have certainly been much neglected, for no one has published any adequate account of the recent genera since the appearance of Messrs. Adams' "Genera of Recent Mollusca" in 1858, nor has any critical revision of the fossil representatives been attempted.

My attention was called to the need of such revision by Mr. H. Woods, who, knowing of my interest in the Veneridæ, sent me some of the specimens which he then had under examination for description in his "Monograph of the Cretaceous Lamellibranchia." I then, for the first time, realized the peculiar characters of certain Cretaceous species, and perceived how greatly most of them differed from any recent shells. Subsequently it became evident that it would be very desirable to compare the Cretaceous and Eocene species, and I put myself in communication with M. Cossmann, who was kind enough to send me specimens from the Parisian Eocene to illustrate the subgeneric groups which he had proposed in 1886.

By kind permission of Dr. Teall I have had the advantage of studying the excellent series of Eocene and Oligocene Veneridæ in the possession of the Geological Survey at the Museum of Practical Geology; through the kindness of Mr. H. Woods I have also been able to examine the fine specimens in the Sedgwick Museum at Cambridge, and I have to thank Mr. Woods for other assistance and for advice given during correspondence on the subject.

The following is a list of the genera and subgenera which have been recognized as occurring in the Cretaceous and Eocene deposits, or have been proposed for species found therein, including some which are now indicated for the first time:—

<i>Dosiniopsis</i> , Conrad.	<i>Clementia</i> , Gray.
<i>Callista</i> , Mörch.	<i>Cyprimeria</i> , Conrad.
<i>Chionella</i> , Cossmann.	<i>Cyclorisma</i> , Dall.
<i>Aphrodina</i> , Conrad.	<i>Psathura</i> , Deshayes.
<i>Dollfusia</i> , Cossmann.	<i>Venerella</i> , Cossmann.
<i>Tivelina</i> , Cossmann.	<i>Mercimonia</i> , Dall.
<i>Pitaria</i> , Roemer.	<i>Chione</i> , Megerle.
<i>Atopodonta</i> , Cossmann.	<i>Textivenus</i> , Cossmann.
<i>Circe</i> , Schumacher.	<i>Veneritapes</i> , Cossmann.
<i>Gouldia</i> , Adams.	<i>Tapes</i> , Roemer.
<i>Sunetta</i> , Link.	<i>Baroda</i> , Stoliczka.
(?) <i>Ptychomya</i> , Agassiz.	

¹ Proc. U.S. Nat. Mus., vol. xxvi (1902), pp. 335-412; see also Trans. Wagner Free Inst. Sc., vol. iii, pt. 6 (1903), "Tertiary Fauna of Florida."

I propose to give some account of all these genera, and to mention the species which have been or can be referred to them. I have not, however, been able to see the Edwards Collection in the British Museum, and cannot therefore include all the species which were named by Edwards, but many of which have never yet been described. Again, there are many fossil shells which were called *Venus* or *Cytherea* by the older writers, but which are now known to belong to other genera; consequently it will be useful in the first place to give a list of the species which have thus been eliminated from the Veneridæ, and need not be considered in the present paper. These are the following:—

- Venus angulata*, Fleming (a *Cyprina*).
- V. fenestrata*, Forbes (a *Cardita*).
- V. lineolata*, Sow. (a *Cyprina*).
- V. Nysti*, Br. & Corn. (an *Eriphyla*).
- V. lucina*, Br. & Corn. (an *Eriphyla*).
- V. striato-costata*, Forbes (an *Astarte*).
- V. submersa*, Sow. (type lost, possibly a *Cyprina*).
- V. tenera*, Sow. (a *Lucina*).
- V. truncata*, Sow. (a *Cyprina*).
- V. pectenifera*, Sow. (an *Anisocardia*).
- Cytherea scutellaria*, Lam. (a *Cyprina*).

II. DESCRIPTION OF GENERA AND SUBGENERA.

1. DOSINIOPSIS, Conrad. Pl. VI, Fig. 1.

This genus was founded in 1864,¹ the type being a Lower Eocene fossil to which Conrad gave the name of *D. Meeki*. The original description was very inadequate, the presence of a posterior lateral tooth not being noticed, and only a left valve being figured. He does, however, mention *Cytherea lenticularis*, Rogers, as a closely allied species from which *D. Meeki* differs in being "proportionally more elevated and convex."

It was not till 1901 that Conrad's type was well figured by Messrs. Clark & Martin,² who consider it to be merely a variety of the previously described *D. lenticularis* of Rogers. They adopt the genus *Dosiniopsis*, but do not give any definition of it; and they regard *D. lenticularis* as the type, but do not give any fresh description of it, merely quoting that of Rogers. They state that *D. lenticularis* "is a moderately thin shell with a weak hinge, while the form described by Conrad is a heavy shell with a broad solid hinge. Every possible gradation between the extremes has been observed."

From the figures given by Messrs. Clarke & Martin it is seen that the older and thicker shells (*D. Meeki*) are as tall as they are broad, while the thinner form (*D. lenticularis*) is broader than it is high. Although no mention of the posterior lateral tooth is made in the text, it is shown very clearly in the figures, and it is of course more conspicuous in the shells which have a thick hinge-plate than in those with a weak one.

¹ Proc. Acad. Nat. Sci. Philad., 1863, p. 212.

² Maryland Geological Survey: "The Eocene Deposits of Maryland," p. 171, pl. xxxv.

M. Maurice Cossmann had recognized the existence of species of *Dosiniopsis* in the Lower Eocene of France as far back as 1885,¹ but he only gives a translation of Conrad's description of the type, and then remarks: "The form of the sinus, the crenulation of the nymph, and the (elongate) lateral tooth appear to me to justify the creation of a genus and consequently the adoption of Conrad's." No mention is made of a posterior lateral tooth.

Dr. W. H. Dall seems to have been the first to recognize the existence of posterior lateral teeth in *Dosiniopsis*.² He gave a complete fresh generic description, and mentions "the distinct posterior right lateral which fits into an excavated socket in the left valve"; then adding: "This is the only genus of the family with a distinctly developed posterior lateral tooth, and if it were not for the number of cardinals and the presence of a pallial sinus it might be referred to *Cyprina*." Dr. Dall, however, does not seem to have been aware of Messrs. Clark & Martin's observations (as above quoted), for he takes *D. Meeki* as the type, and his generic description includes the word 'heavy' as applied to the shell, and the words 'strong' and 'stout' applied to the lateral teeth. It seems desirable, therefore, to give an amended description of this genus, and I have drawn up the following, after examination of English and French species, and inspection of the excellent figures of the type form in the "Eocene Deposits of Maryland."

DOSINIOPSIS, Conrad, 1864.

Types—*Cytherea lenticularis*, Rogers, and var. *Meeki*, Conrad. Shell suborbicular or rounded-oval; concentrically striated. Lunule slightly impressed, but often indistinctly circumscribed; escutcheon not defined. Hinge generally strong, cardinal teeth three in each valve, all separate and entire except the right posterior, which is bifid; a posterior lateral in each valve, that of the right, being the stronger; an anterior lateral in the left valve, elongate, parallel to shell border, more or less rugose, and fitting into a corrugated pit in the right valve. Nymphs of both valves finely granulated. Margins of valves smooth. Pallial sinus ascending, not very deep, rounded or angular.

To *Dosiniopsis* I refer the Cretaceous shells hitherto known as *Cytherea caperata*, Sow., and *C. subrotunda*, Sow., both from the Selbornian Sands of Blackdown. There are three species in the Lower Eocene of the Paris Basin, and I think that all of them also occur in our Thanet Sands and London Clay; these are *D. orbicularis*, Edw., *D. fallax* (Desh.), and *D. bellovacina* (Desh.). A fourth species has been named by Edwards *D. pseudorbicularis*, but has not yet been figured.

2. DOSINIA, Scopoli, and SINODIA, n.subgen. Pl. VI, Fig. 2.

During my examination of the Cretaceous and Eocene Veneridæ I have been struck with the Dosinioid aspect of many of the shells,

¹ Ann. Soc. Malac. Belg., vol. xxi (1886), p. 125.

² "Synopsis of the Family Veneridæ": Proc. U.S. Nat. Mus., vol. xxvi (1902), p. 342.

and at the same time by the fact that none of them could actually be referred to the genus *Dosinia* as usually defined. I was thus led to study the recent forms of that genus more particularly, and found that, while the great majority of species agree with the definition given in conchological manuals, there are a few species which do not. Of these the most striking and abnormal is *D. trigona* (Reeve), which differs in the following respects:—

The shell is not orbicular, but ovately and bluntly trigonal, the fore-part of the shell being well developed, so that the umbones are subcentral. It is not compressed, but decidedly ventricose. The lunule is not impressed, but large and superficial. There is no escutcheon. The hinge differs in correlation with the anterior development of the shell, the anterior lateral being strong, erect, and distant from the anterior cardinal; similarly, in the right valve there is a deep and distant pit for its reception. The postero-dorsal margin of both valves is grooved for a long distance to receive the bevelled edge of the opposite valve. The pallial sinus is not elongate, but rather short, wide, and rounded.

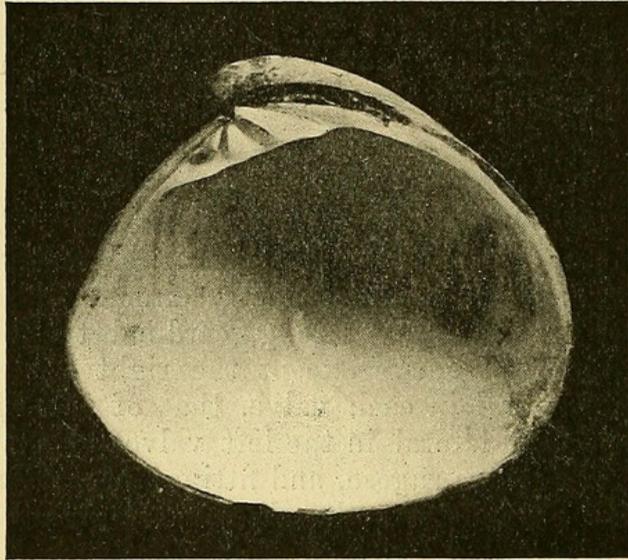


FIG. 1.—*Dosinia* (*Sinodia*) *trigona* (Reeve). Slightly enlarged.

There are some other species which resemble *D. trigona* to a greater or less extent: these are *D. tripla*, Roem.; *D. derupta*, Roem.; *D. sphaericula*, Roem.; and to a less degree *D. excisa*, Chem., and *D. subtrigona*, Sow., which are more nearly orbicular.

Now if the well-known Oligocene shell which goes by the name of *Cytherea incrassata* be carefully examined, it will be seen that it resembles *D. trigona* in all the points above mentioned, and that it further resembles *Dosinia* in the thickness of the shell and in the massive hinge-plate, in the occasional rugosity of the anterior lateral tooth, in the manner in which the right posterior cardinal springs from the end of the incurved anterior margin, and also in the long narrow pedal scar which runs under the hinge-plate below the two anterior teeth of the left valve.

For some time I was inclined to agree with M. Cossmann in considering *C. incrassata* to be a *Pitaria*, but a more careful study of a large number of interiors and a comparison with *C. Lyelli* from the Hamstead Beds have convinced me that both species are more nearly related to *Dosinia*. *C. Lyelli* is, in fact, still more *Dosinia*-like than *C. incrassata*, having a very small lateral tooth and a very shallow pit, while in the right valve the anterior cardinal is directed forward as in so many species of *Dosinia*.

I am consequently of opinion that these shells are ancestors of *Dosinia*, and that *D. trigona* and its congeners are direct descendants of the ancestral form which have persisted to the present day. Seeing also that they differ in so many ways from *Dosinia* proper, it seems desirable that they should be separated as a distinct subgenus under a new name. For this I propose *Sinodia*, which is an anagram of *Dosinia*, and for the type I take *D. trigona* (Reeve) (see Fig. 1), hoping that the animal may soon be examined to see if it also differs from that of *Dosinia*.

So far as I can ascertain, no true *Dosinia* has yet been discovered either in Cretaceous or Eocene strata, the *D. cretacea* of Zittel (1864) being either a *Cyprimeria* or a *Cyclorisma*, and the '*Dosinia* sp.' of Holzapfel (1889) being only so named from the resemblance in external shape. A true *Dosinia* has, however, been described from the Oligocene of Florida by Dr. Dall.

If my view be correct, the typical orbicular form of *Dosinia*, with its deeply impressed lunule, is a specialized and comparatively recent type, not appearing in Western Europe until the Miocene epoch, while *Sinodia* was specially prevalent in Oligocene time, and was probably developed from *Pitaria*, which certainly existed in early Eocene times. I find this latter view is in accord with the opinion expressed by Stoliczka,¹ who suggested a connection between *Dosinia* and *Caryatis* (i.e. *Pitaria*) through the species *D. trigona* and *D. sphaericula*. Moreover, in most *Pitaria*, in the Eocene *Atopodonta*, and in the cognate *Callocardia*, the teeth are arranged in a manner which resembles that described by Bernard as occurring at a certain stage in the development of the hinge, the special point being that the right anterior cardinal and the front half of the bifid posterior cardinal are connected by a curved lamina which forms an arch over the median tooth.

The characters of the *Sinodia* group have practically been given above in distinguishing it from *Dosinia*, but it may be useful to indicate the points in which it differs from *Pitaria* or the latter from it. *Pitaria* is generally of a more regularly oval shape; it has a larger lateral pit in the right valve with more or less well developed lateral teeth above and below; the anterior cardinal is always parallel to the median, but is connected with the posterior in the manner above-mentioned. The pallial sinus is so variable that no distinctive character can be based upon it.

¹ "Cretaceous Fauna of Southern India," vol. iii, Pelecypoda: Pal. Indica, 1871, p. 155.

There is an Eocene species which may belong to *Sinodia*, but not having seen specimens of it I cannot yet be sure of its affinities. This is *C. despecta*, Desh., which is described by him as an oval shell, thick and solid, becoming subtriangular with age, and the figure shows that the umbones are subcentral. The hinge-plate is broad and thick, and the anterior lateral is small and conical, fitting into a small round depression in the right valve. If this turns out to be really a *Sinodia* it will be the earliest species of the group.

3. CALLISTA, Mörch, *non* Poli.

This genus has been accepted by most recent authors as derived from Poli (1791), but is rejected by Dr. Dall on the ground that Poli was not a binomial author. It is true that Poli had a double system of nomenclature, i.e. one set of names for the animal and another for the shell, but each was binomial. His method of nomenclature has been described and discussed by me in a previous paper,¹ in which it was shown that Poli's name *Callista* was applied to the animal only, and that in mentioning the various species of shells he used the Linnæan names, both of genus and species. Consequently I do not think the name *Callista* can be derived from Poli.

By some later writers, however, the name has been used in a conchological sense. Thus Leach in 1852 and Mörch in 1853 both applied it to groups of the Linnæan genus *Venus*, but neither of them specified a type. So far as I can ascertain, the earliest designation of a type for *Callista* (as a genus of shells) was made by F. B. Meek² in 1876, who adopted *Venus chione*, Linn., and as this species formed one of Mörch's *Callista* group the name with the type *C. chione* may be dated from Mörch's use of it.

Callista has an oval shell, smooth, or concentrically grooved, but in the recent forms always having minute radial discontinuous ingrained striæ beneath the vernicose periostracum, especially on the posterior slope. The hinge has three cardinal teeth in each valve; in the right valve the anterior and median cardinals are close together and have flat opposing faces, while in the left the corresponding teeth are united at the top and diverge like the sides of an obliquely written A; moreover, the median is always the thicker. In the left valve there is a single prominent anterior lateral; in the right an isolated pit for its reception, bordered by a small tooth below and a smaller one above. The pallial sinus is ample, horizontal, and pointed in front.

The genus is represented in Cretaceous rocks, but none of the species agree altogether with the above description, so that a distinct section or subgenus will have to be created for them.

In the Eocene series there are species which undoubtedly belong to the typical group of *Callista*, though some are referable to a special section of it. These latter were described under the name of *Callista* (as a section of *Cytherea*, Lam.) by M. Cossmann in 1886 (op. cit.,

¹ Proc. Malac. Soc., vol. viii, p. 99 (1908).

² "Cret. and Tert. Fossils of the Upper Missouri": Rep. U.S. Geol. Surv. Terr., vol. ix.

p. 113), but they really belong to the section *Macrocallista* of Meek (op. cit., 1876, p. 177). *C. lævigata* (Desh.) (Pl. VI, Fig. 5), at any rate, is referable to this section, while *C. proxima* and *C. suberycinoides* are similar in shape and in hinge-characters; but I have not seen specimens of *C. Heberti* (Desh.), the hinge of which, as figured by Deshayes, seems to resemble that of *Pitaria*.

Three other Eocene species of *Callista* were separated by M. Cossmann under the name of *Chionella*, and though he recognized their resemblance to *Cytherea chione* in shape and in surface-characters, he appears to have regarded them as more closely related to *Pitaria* than to other sections of the old genus *Cytherea*. In this view I find myself unable to concur, for I cannot see that they differ in any essential particular from recent forms of the *C. chione* group. Dr. W. H. Dall came to the same conclusion in 1902,¹ and as he did not recognize the name *Callista* he adopted *Chionella* as applicable to the whole of the large group of recent shells, which includes *C. chione*, though he was obliged to make it a section of a genus *Macrocallista* (Meek). I see no reason for this method of procedure, but regard the name *Chionella* as merely a synonym of the *Callista* of Mörch and of Meek.

I am indebted to M. Cossmann for sending me specimens of his type species of *Chionella* (*Ch. ovalina*, Desh.), and these I have carefully compared with young specimens of *Callista chione* and other species of the genus. The hinge of *C. ovalina* is identical with that of *Callista*, and the only point in which the shell differs from the generic type is the rounded and slightly ascending pallial sinus, a character which is common to many of the Eocene Veneridæ, and is not sufficient to warrant even sectional separation.

There remain, however, some other contemporaneous species which have the hinge of *Callista*, but differ in the surface sculpture of the shell, this consisting either of fine concentric striæ like those of *Pitaria* or else of sharp concentric ribs like those of *Hysteroconcha* (*Venus dione*, Linn.), and in neither case showing any trace of the minute radial markings of *Callista*. By M. Cossmann these species were distributed under several of his sections, without sufficient regard to the details of the hinge. I propose to separate them under the name of *Calpitaria*, to indicate its connection with both *Callista* and *Pitaria*, and would define the group as follows, taking *C. sulcataria*, Desh., as the type.

CALPITARIA, n. subgen.

Shell ovate, fairly convex, concentrically striated or sharply ribbed. Cardinal teeth like those of *Callista*, anterior and median cardinals of left valve united at the top and barely reaching to the shell-border, anterior pit in right valve deep, and generally separate, but sometimes having a narrow thread-like channel which passes in front of the anterior cardinal. Pallial sinus generally short, and always rounded, varying in direction from horizontal to ascending.

¹ Synopsis in op. cit., p. 351; see also Wagner, Free Inst. of Science, vol. iii, p. 1252 (Philadelphia, 1903).

This subgenus is certainly intermediate between *Callista* and *Pitaria*, and its existence makes it difficult to regard these two larger groups as separate genera. How many Eocene species will have to be referred to *Calpitarina* I cannot yet say, but think the following belong to it: *C. ambigua*, Desh., *C. Saincenyensis*, Desh., *C. Suessoniensis*, Desh. (= *tenuistriata*, Sow.), *C. fastidiosa*, Desh., and *C. elegans*, Lam.

CALLISTINA, n.sect.

One of the earliest representatives of the *Callista* group is the well-known '*Cytherea plana*,' Sow., from the so-called 'Greensand' of Blackdown. This has the cardinal teeth of *Callista*, but the left anterior lateral is a long narrow ridge, grooved or corrugated on the sides, and fitting into a shallow corrugated pit in the right valve, which pit occupies only a small area in the flat anterior part of the hinge-plate. This part of the plate, in fact, resembles *Dosinia* more than *Callista*. The surface of the shell is smooth, and as a rule, nothing but concentric lines of growth are visible, but a specimen in the Sedgwick Museum shows some irregular radial striæ like those of *Callista*. The pallial sinus is ascending and subangular in *C. plana*, but in some other species it is rounded. *C. subplana*, d'Orb., and *C. polymorpha*, Zittel, belong to the same group, for which I propose the name *Callistina*, with *C. plana*, Sow., as the type.

4. APHRODINA, Conrad (genus or subgenus). Pl. VI, Fig. 4.

This name was given to an American Cretaceous shell which Conrad had previously described as *Meretrix tippiana*. Though he had only a single left valve before him at the time, Conrad made this the type of a new genus,¹ which he described as follows:—"Generic character.—Shell rounded or suboval, striated or sulcated; hinge in the left valve with three diverging cardinal teeth, the anterior tooth as thick as the middle or thicker, and a straight compressed transversely rugose lateral tooth parallel with the margin of the shell above it; pallial sinus deep and similar to that in *Caryatis*, Roemer."

The figure given by Conrad shows that the anterior cardinal curves forward so as to point directly to the anterior lateral; also that the pallial sinus is wide, deep, and subangular. The type has quite recently been figured and described by Mr. Stuart Weller,² but he calls the shell *Meretrix tippiana*, without saying anything of Conrad's proposed genus, and his description of it is short. Moreover, he states that the right valve has only two cardinal teeth, which must be either a misprint or a mistake, for Dr. Dall describes it as having three cardinals in each valve, as indeed the structure of the left valve would lead us to expect (Synopsis cit., p. 355).

The generic affinities of this shell do not seem to be properly understood even in America, and in Europe it has practically been ignored.

¹ Amer. Journ. Conch., vol. iv (1869), p. 246, pl. xviii, fig. 5.

² "Report on the Cret. Palæont. of New Jersey": Geol. Survey of N.J., vol. iv of Pal. Series, pl. lxxviii, figs. 1 and 2 (1907).

Meek, in 1876,¹ appears to have correctly appreciated its general characters, for he adopted it as forming a subgenus in a large *Callista* genus, and places it after *Caryatis* (= *Pitaria*). Dr. Dall, on the other hand, separates it entirely from *Callista*, and puts it as a subgenus of the *Venus puerpura* group, which he chooses to call *Cytherea* (Bolten, non Lam.); he gives no reason for this grouping, but in all probability the point which weighed with him was the direction of the anterior cardinal, for the hinge of the *V. puerpura* group is certainly similar in that respect.

Now it is interesting to find that shells of exactly the same general facies as Conrad's *Aphrodina tippiana* occur in European Eocene beds, and that M. Cossmann had separated them from the other *Cythereas* of the Parisian Eocene, when he revised the group in 1886 (op. cit.). For these species he retained the name *Cytherea* (sensu stricto), and the first on his list was *C. nitidula*, Lam., with which species the *C. lucida* of Sowerby is identical. From examination of many specimens of the latter I am able to recognize the left valves as answering in every respect to the description of *Aphrodina*, and it follows that in these Eocene shells we have the material for a complete description of Conrad's genus or subgenus. I have therefore drawn up the subjoined definition of it:—

Shell oval, somewhat expanded anteriorly, surface smooth or finely striate; lunule slightly impressed, lanceolate and circumscribed; escutcheon not defined. Hinge with three divergent cardinals in each valve; in the left the posterior one is slightly bifid, the anterior is thick, flattened in front, and curved forward; in the right the posterior is broadly bifid, and the anterior small, slender, and directed forward. The strong elongate anterior lateral of the left is received by a pit between two small elongate teeth in the right valve. The nymphs are corrugated in *A. nitidula*, but are said to be smooth in *A. tippiana*. The pallial sinus is large and deep, more or less ascending, and rounded at the end.

In general shape, in the character of the lunule, and in some particulars of the hinge, *Aphrodina* shows a close resemblance to *Callista*. It differs, however, in the direction of the anterior cardinals, in the feeble median, and in the grooved posterior cardinal of the left valve. Moreover, I have not been able to detect any trace of radial striation even in well-preserved Eocene specimens.

With regard to the rugosity of the anterior lateral, this is hardly discernible in *A. nitidula*, so that I do not regard it as a group character, but as a primitive character in the Cretaceous shell (*A. tippiana*). On the whole, therefore, I think *Aphrodina* should be classed as a subgenus of *Callista*.

Other Eocene species referable to *Aphrodina* are *C. tranquilla*, Desh., and *C. nitida*, Desh. *C. corbulina* also probably belongs to it, but *C. despecta* and *C. Saincenyensis* certainly cannot be included.

¹ Rep. U.S. Geol. Surv. Terr., vol. ix, p. 177.

5. PITARIA, Roemer, emend. Dall. Pl. VI, Fig. 3.

This group was founded by Roemer in 1857 under the name 'Pitar' (after Adanson), but in 1862 he proposed to substitute the name *Caryatis*; this, however, is preoccupied in Lepidoptera (Hubner, 1816), and Dr. Dall has very properly pointed out that Roemer's original name should be adopted and Latinized into *Pitaria*, just as the 'Dosin' of Adanson was converted into *Dosinia*.

The type of this group is *Venus tumens*, Gmelin, and the species belonging to it were included by Gray in his genus *Dione* (1847), which name is also preoccupied by Hubner. The division was recognized by Cossmann in 1886 under the name of *Caryatis*, as represented by many species in the Eocene of France.

Pitaria has an oval shell which is smooth or finely striate; the lunule is circumscribed and superficial, not impressed. The hinge has already been partly described, but it may be added that the median and anterior cardinals of the left valve are united at the top, and are separated from the shell-border by a sulcus or channel, into which fits the arch formed by the union of the anterior and posterior teeth of the right valve. The strength of the bridge in the right valve and the consequent breadth of the corresponding channel in the left valve vary considerably both in recent and fossil species. Lastly, the anterior cardinal of the right is short and is undercut by a channel connecting the anterior lateral pit with the socket between the anterior and median cardinals. The pallial sinus is variable, sometimes small and sometimes deep, sometimes pointed and in others rounded, but generally ascending.

Species referable to *Pitaria* are believed to occur in Cretaceous rocks, but I have not been able to recognize any among those from English Cretaceous deposits. Many species from the Lower Cretaceous of France are still only known from casts, and consequently they cannot be referred to their proper genera. *Venus Orbigniana*, Forbes, may possibly be a *Pitaria*, but neither Mr. Woods nor I have been able to obtain sight of a specimen that shows the interior. Stoliczka supposed that *V. Rotomagensis*, d'Orb., was a *Pitaria*, and he may be right, but again we have not yet succeeded in seeing one which shows the hinge of either valve.

Many species of *Pitaria* occur in the Eocene, the commonest and best known being *P. Parisiensis*, Desh., and *P. obliqua*, Desh., though both have always been catalogued in this country as '*Cytherea*.' *Cyth. incurvata* (Edw. MS.) is also a well-characterized species of *Pitaria*, remarkable for its transverse elongation and for its prominent recurved umbones. *C. transversa*, Sow., *C. Bartonensis* (Edw. MS.), and *C. striatula*, Desh., also seem to belong to *Pitaria*.

6. ATOPODONTA, Cossmann.

This name was proposed by M. Cossmann in 1886 (op. cit., p. 110) for two small shells occurring in the Parisian Eocene, the first and type being *Venus conformis*, Desh., and the second *A. tapina*, Cossm. (then first described).

M. Cossmann gives full descriptions both of the genus and of the two species, but he does not seem to have rightly understood the composition of the hinge. He says, "the cardinal plate is thick and excavated (*échancrée*), without an anterior pit, bearing four teeth in the left valve and three in the right"; he proceeds to describe the peculiar arrangement of these teeth, and appears to regard all of them as cardinals. In this I think he is mistaken; it seems to me that the front tooth of the left valve, which is described as being small and pointed, must really be a diminutive anterior lateral, like that of *Cyth. Lyelli*, or the recent *Venus verrucosa*. In these shells the corresponding pit in the right valve is often so small and shallow as to be nearly obsolete, and I assume this to be the case in *Atopodonta*.

In the left valve what seem to be the anterior and median cardinals are united at the top and are separated from the shell-margin by a sulcus (as in *Pitaria*); behind these there is a simple and normal posterior cardinal. In the right valve there are two teeth of a reversed V-shape, one above the other, and behind these is a long narrow grooved posterior tooth. This is also comparable to the arrangement in *Pitaria* and *Callocardia*, but represents an earlier stage of development. The lower Λ is the primitive element of the median tooth, the upper one represents the bent lamina which would become the anterior cardinal and the bridge uniting it to the posterior tooth.

Dr. Dall appears to have perceived the true structure of the *Atopodonta* hinge, for in his Synopsis (op. cit., p. 353) he briefly dismisses the name as a synonym of *Callocardia*. In such dismissal, however, I think he goes too far, for though the two agree in the absence of a pallial sinus, the teeth-connections are in a different stage; moreover, in *Callocardia* the anterior lateral is strong, elongate, and sharp, fitting into a distinct pit in the right valve. The two shells are also very different in shape and in thickness of substance. It will, therefore, be convenient to retain *Atopodonta* as a distinct type, though for the present it may be regarded as a subgenus of *Callocardia*.

7. TIVELINA, COSSMANN. Pl. VI, Fig. 6.

This is a group of small shells separated from other species of *Cytherea* by M. Cossmann in 1886, but very inadequately defined. The following is a translation of his descriptive remarks:—"I group in this section, under a new name, shells which are thin, triangular, more transversely elongated than the true *Tivela*, more or less clearly grooved (*sillonnées*), with a large lanceolate lunule, a short sinus, and a hinge distinct from *Callista*. Contrary to what holds in the preceding groups, the shape of *Tivelina*, even in one and the same species, varies considerably."¹ The first species and the one which he regards as the type is *Cyth. tellinaria*, Lam.

From the name selected and from his reference to *Tivela* it would seem that M. Cossmann regarded *Tivelina* as in some way related to that genus, yet he gave no other indications of such

¹ Ann. Soc. Roy. Malac. Belg., vol. xxi, p. 119.

relationship. Probably the points which he had in mind were the somewhat triangular shape and the short pallial sinus, but there is no resemblance in the hinge-characters. Of them he only says that the hinge is distinct from that of *Callista* without specifying the exact points of difference.

Fischer¹ did not express any opinion on the precise relationship of *Tivelina*, merely stating that *Chionella* and *Tivelina* were names proposed for some fossil groups of *Meretrix*, and giving the following brief description of the latter: "Forme subtrigone; surface lisse; un pli sinueux en arrière." The sinuous fold, however, does not exist in all the species referred by M. Cossmann to *Tivelina*.

Dr. Dall, in 1902, placed the group as a subgenus of *Pitaria*, giving only a brief account of it, and stating the hinge to be "as in *Pitaria*." In his later memoir, however (op. cit., 1903, p. 1265), he says "hinge as in *Chionella*," but still retains the group as a subgenus of *Pitaria*, an arrangement with which I cannot agree. In any case it seems desirable to print a more complete and diagnostic description of *Tivelina*, and as M. Cossmann has kindly supplied me with specimens of eight of the principal species, I have carefully examined and compared these in order to express the distinctive characters which are common to all.

Shell oval, compressed, anteriorly expanded and posteriorly attenuated, frequently showing a shallow fold or depression which slightly sinuates the ventral border. Surface smooth or finely striated. Umbones small. Lunule long, lanceolate, and defined by incised lines, but never impressed, and sometimes the area is gibbous. Hinge-plate weak and narrow, elongated anteriorly and attenuated posteriorly, so that the cardinal area is short. The teeth resemble those of *Callista*, but are small and weak; in the left valve are three divergent cardinals, the middle being thickest, and a prominent triangular anterior lateral; in the right a narrow feebly-grooved posterior, while the median and anterior cardinals are short and nearly parallel, and in front are two narrow anterior laterals bordering a deep, narrow, elongate pit. The pallial sinus is always short and rounded.

On the whole it appears to me that *Tivelina* is more nearly allied to *Callista* than to any other genus. It differs, however, in the absence of radial striæ, in the umbones being small and nearer the middle line of the shell, in the curiously short and narrow hinge-plate, and in the narrowness of the right posterior cardinal; also in the small rounded pallial sinus. Whether these characters are of generic importance or not it is difficult to say, but they seem of rather more diagnostic value than those which distinguish *Pitaria* from *Callista*.

MERETRISSE, n. subgen. Pl. VI, Fig. 7.

Although the genus *Meretrix*, as restricted by Gray and Deshayes, and typified by *Meretrix morphina*, does not seem to have come into

¹ Manuel de Conchyliologie, 1887, p. 1080.

existence before the Miocene period, it is interesting to find that two little shells of Oligocene age approach very closely to those which are grouped under that name. They were regarded by M. Cossmann as species of *Tivelina*, but they differ in several respects from the typical forms of that group, and are unquestionably a link between *Tivelina* and *Meretrix*, so that they might be placed as a subgenus of either. Since they have hitherto been referred to *Tivelina* I retain them in that genus, but give them the distinctive name of *Meretrissa* to indicate their affinities.

The shells I refer to are *Cytherea depressa*, Desh., and *C. Stampinensis*, Desh. Deshayes' figures of the latter species are not good, and M. Cossmann informs me that the specimens from Pierrefitte, described by Stan. Meunier¹ under the name of *C. dubia*, are really identical with Deshayes' *Stampinensis*; I am also indebted to him for examples of both *depressa* from Jeures and of *Stampinensis* from Pierrefitte, thus enabling me to compare them with the species of *Tivelina* which he had previously sent me.

These shells are very small, *depressa* being only 8 mm. in transverse width and 7 mm. in height, while *Stampinensis* varies somewhat, but is often only 7 by 6 mm. They are subtrigonal, approximately equilateral, and have a smooth outer surface marked only by lines of growth.

From *Tivelina* they differ in being much shorter transversely, and consequently more equilateral and trigonal; the teeth are more widely and equally divergent, the right anterior cardinal sloping forward so as to point toward the pit of the anterior lateral; in the left valve the anterior lateral is longer and comes closer to the anterior cardinal. Again, the right posterior cardinal is not bifid, but entire or only slightly grooved as in some recent species of *Meretrix*; while the median teeth of both valves show a tendency to become bifid.

From *Meretrix* they differ in their very small size, in the approximation of the lateral to the cardinal teeth, and in having a distinct pallial sinus. *M. depressa*, which may be taken as the type, is rather a thin shell, with a weak hinge, and is thus very different from the solid recent forms of *Meretrix*; *M. Stampinensis* is rather stronger, but the hinge-plate is still weak and narrow. In the latter the sinus is small and placed high up by the adductor scar; in *depressa* it is rather deeper, but does not reach the middle of the shell; in both it is obtusely rounded.

8. DOLLFUSIA, COSSMANN.

This was proposed as a genus in 1886, but as it was based on a single right valve, and no other specimens have been found, it is impossible to be sure whether this valve is a normal one or a malformation of some other shell.

In the first place it is very small, only 6 mm. in length; secondly, it differs in shape from all other known members of the Veneridæ,

¹ Nouv. Arch. du Muséum, 1880, p. 243, pl. xiii, figs. 17, 18; see also Cossmann and Lambert, Mém. Soc. Géol. France, 1884, p. 82, pl. i, fig. 18.

being quadrangular or trapezoidal, with opposed subcentral umbones. M. Cossmann summed up its characters in the following terms: "The hinge is almost identical with that of *Dosinia*, but the short, open, rounded sinus is rather that of some *Tivelina*. By its shape one would take this shell for a species of the family Cardiidæ, but from that it is completely separated by its sinus and its hinge" (op. cit., p. 128).

With regard to the hinge, as shown in M. Cossmann's figure, I cannot see that it has any special resemblance to that of *Dosinia*;¹ still less can I see any likeness between its dentition and that of *Tivela*, near which Fischer placed it,² being apparently under the erroneous impression that there were two posterior cardinals instead of a single bifid one. The general arrangement of the teeth is similar to that of *Callista* and *Tivelina*, the anterior and median cardinals being close and nearly parallel, while the posterior is divergent and bifid; the somewhat different look of the hinge being really due to the shortening of the hinge-plate as a consequence of the peculiar shape of the shell. The short pallial sinus also resembles that of *Tivelina*, and is very different from the forms of sinus found in the genus *Dosinia*.

So far, therefore, as it is possible to form an opinion from the characters of a single valve and from a figure only, *Dollfusia* seems to me more closely related to *Tivelina* than to any other group of Veneridæ, and it may especially be compared with *T. sphenarium*.

9. CIRCE, Schumacher.

No shells referable to the typical group of the genus *Circe* have yet been found either in Cretaceous or Eocene deposits, those from the Gosau Beds which were described by Zittel in 1864 as *Circe* having since been transferred to *Cyprimeria*, while the shells referred to *Circe* by M. Cossmann in 1886 belong to its subgenera.

In the Oligocene, however, there is a shell which certainly seems to belong to the typical section of the genus, as exemplified by *C. litterata*, Linn. This was described as *Cyth. variabilis* by Stan. Meunier in 1880,³ and was recognized as a *Circe* by M. Cossmann⁴ in 1891. It is found at Étampes, south of Paris. The shell varies considerably in shape, from broadly oval to suborbicular. The external surface is concentrically grooved. The hinge exhibits the characteristic three straight and slightly divergent cardinal teeth of *Circe* proper, the anterior one being vertical and the other two oblique. The pallial line is slightly sinuated.

Of the four Eocene species referred to this genus in 1886 by M. Cossmann (op. cit., p. 126), *C. vetula*, Desh., and *C. Goodallioides*, Cossm., seem to belong to the section *Circenita* of Jousseau, which

¹ Having written to M. Cossmann on this point, I am glad to find that he does not now maintain its affinity with *Dosinia*.

² Manuel de Conchyliologie, 1887, p. 1079.

³ Nouv. Arch. du Muséum, ser. II, p. 242, pl. xiii, figs. 15, 16.

⁴ "Revue de la faune du terr. Olig. d'Étampes": Journ. de Conch., 1891, p. 274.

has convex valves (not compressed), and no defined escutcheon nor sunken ligament.

On the other hand, *C. circularis*, Desh., and *C. pusilla*, Desh., seem referable to the subgenus *Gouldia*, as exemplified in our recent *G. minima*. *Gouldia* differs from other sections of the genus in the wide divergence of the teeth, the anterior cardinal of the right valve sloping forward so as to point to the middle of the anterior lateral pit; another peculiarity is the union of the anterior adductor and the pedal scars, which in all other forms of *Circe* are separate from one another. In specimens of *C. pusilla* with which M. Cossmann has kindly supplied me, the pedal scar does seem to merge into that of the adductor; the shell is so minute that it is difficult to be sure, but I cannot see any separate scar. The teeth are certainly those of *Gouldia*.

Another species of *Circe* was afterwards described by M. Cossmann under the name of *C. Dumasi*, from the Middle Eocene of Bois Gouët in the Loire Inférieure,¹ and as he has also been kind enough to send me specimens of this I am able to say that it undoubtedly belongs to *Circenita*, and that it possesses the small round separate pedal scar which characterizes all members of the genus except *Gouldia*.

10. PTYCHOMYA, Agassiz.

This shell has been referred to different families by different authors. By Agassiz (1842) it was classed near *Mya*; by d'Orbigny (1844) it was described as a *Crassatella*; and it was referred to the same family both by Pictet and Campiche (1866) and by Stoliczka (1871); but Dames in 1873 gave reasons for regarding it as nearly related to the recent *Crista* (a subgenus of *Circe*). Fischer (1887) seems to have concurred in this view, but was evidently doubtful about the existence of an anterior pit in the right valve, and so far as I can ascertain no one has yet seen the hinge of a left valve.

By the kindness of Mr. Woods I have been able to examine the specimen from which his figure of the hinge of the right valve was drawn.² As might be inferred from the figure, it is not clear from this specimen that there were really three cardinal teeth; only two of them are quite distinct, these being a small anterior and a thick median; a posterior tooth may have been present, but, if so, it was fused with the nymph and has been broken off, all that remains being a broad flat plate below the deeply inset trough which held the ligament. The anterior portion of the shell is also broken, but enough remains to show that the area in front of the cardinals was small and that the border of the hinge-plate ran nearly straight to the anterior side, forming a ridge with a small hollow or trough above it. This may have received an anterior lateral tooth, if one existed in the left valve.

The shell agrees with *Crista* in being very thick, in bearing strong

¹ Bull. Soc. Sci. Nat. de l'Ouest.

² "Cretaceous Lamellibranchia": Pal. Soc. Mon., vol. ii, pl. xxvii, figs. 24-6.

radiating ribs, of which some are divaricate, in having apparently three divergent cardinal teeth and possibly an anterior lateral, in the entire absence of any escutcheon, and in the deeply sunk ligament; also in the crenulation of the valve margins, and in the absence of a pallial sinus. It differs from *Crista* in not having the large anterior expansion of the hinge-plate bearing the lateral teeth, in not having a distinct posterior cardinal separated by a groove from the nymph, and lastly in the divaricate ribs being on the anterior side, while in *Crista* they are on the postero-dorsal side; on that side of *Ptychomya* there is only a series of short tubercular ridges.

On the whole I incline to think that the resemblances outweigh the differences, but until the existence of an anterior lateral tooth is established the affinity with *Crista* must remain doubtful.

11. *SUNETTA* and subgenus *MEROËNA*. Pl. VI, Fig. 8.

The existence of the genus *Sunetta* as far back as early Eocene time was first pointed out by M. Cossmann in 1886, who referred four species occurring in the Parisian Eocene to this group, though *S. multisulcata* is probably only a variety of *S. semisulcata*, Lam. He does not, however, seem to have noticed that these early forms differ from all recent species in having smooth inner margins instead of crenulated edges. Moreover, the dorsal border of the Eocene shells is not so deeply inflected, so that the ligament is not so deeply sunk, and the upper angle of the escutcheon is more obtuse. The hinge is similar to that of the recent species, except that the posterior cardinal of the right valve is deeply grooved, whereas in recent species it is narrow and entire, or very feebly grooved. Lastly, the Eocene shells are much less inequilateral, the umbones being subcentral and the shell subtrigonal.

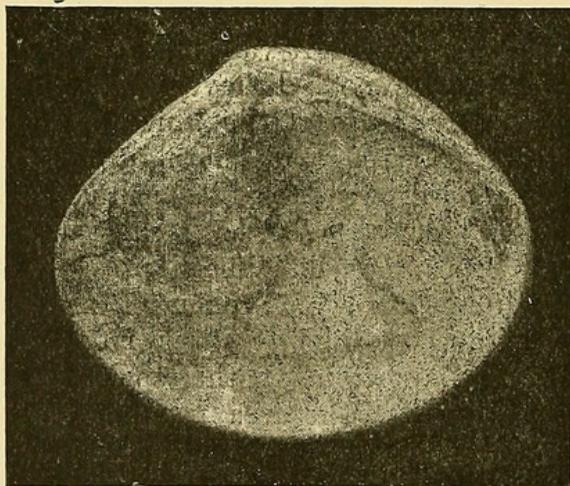


FIG. 2.—*Sunetta (Meroëna) trigonula*, Desh. Ovate variety; from a specimen in the British Museum.

These differences are certainly of sufficient importance to deserve recognition, and are all of them more important than the smoothness of the outer surface and more rounded shape, for which Jousseume has proposed to separate one or two recent species under the name of

Sunettina. I propose, therefore, to distinguish these Eocene shells by the name of *Meroëna*, and consider that they should rank as a subgenus. In reality, of course, they are ancestors of our modern assemblage of species known as *Sunetta*, and they represent a stage in its evolution from a more generalized form.

The name *Meroëna* is derived from Schumacher's name for the genus (*Meroë*), and as type I take the first on M. Cossmann's list (*S. trigonula*, Desh., see Fig. 2), which is a common shell in our Barton Beds, as well as in the equivalent deposits of the Paris Basin. The other two species are *M. semisulcata*, Lam., and *M. polita*, Lam., with which M. Cossmann unites *Cyth. separata*, Desh. Another species, has, however, been recently described by him, which forms an interesting link between *Meroëna* and typical *Sunetta*, for in shape, dentition, and sharpness of the dorsal angle it comes near to some recent forms, but has the smooth inner margins of *Meroëna*. This species is *S. Caillaudi* from the Middle Eocene of Bois Gouët (Loire Inférieure).

12. CYPRIMERIA, Conrad, 1864.

This genus was founded on a right valve of the American Cretaceous shell previously known as *Cytherea excavata*, Morton, and was described¹ as having (in that valve) a bifid oblique posterior cardinal and two oblique anterior teeth, "with an intermediate pit for the reception of the tooth in the opposite valve." By this, Conrad evidently meant that between the posterior and median teeth there is a wide space into which a broad left median tooth would fit.

As the generic characters of *Cyprimeria* are not correctly given either in Fischer's "Manuel de Conchyliologie" or in Eastman's edition of Zittel's Palæontology, Conrad's description of the right valve may be supplemented by the following:—The left valve has three separate and divergent teeth, the median being thick, triangular, and bifid, the others narrow and entire. There are no lateral teeth, and the anterior cardinal is parallel to the lunular border. The pallial line is only slightly indented below the posterior muscular scar. In shape the shell is orbicular and compressed.

The genus *Cyprimeria* is supposed to be essentially Cretaceous, and since species have been found in France, Germany, Bohemia, India, and North America, it is rather surprising that none have yet been discovered in British Cretaceous rocks. But, although the genus has only yet been recognized in deposits of Cretaceous age, there is, of course, no reason why it should not have survived into Eocene time, and in the Eocene of the Paris Basin there is a shell described by Lamarck as *Venus obliqua*, which seems to be referable to *Cyprimeria*, notwithstanding its small size.

V. obliqua has recently been well figured by M. Cossmann in his "Iconographie Complète des Fossiles Eocènes des Environs de Paris" (1906), pl. ix, fig. 48b (three views), the interiors of both valves being shown. From these figures it can be seen that the hinge-teeth

¹ Proc. Acad. Nat. Sci. Philadelphia, 1864, p. 212.

agree with those of *Cyprimeria*, as do also the other features of the shell, which, however, is very small, its length from side to side being only $9\frac{1}{2}$ mm., and its height $9\frac{1}{4}$, so that it is nearly orbicular. The only other point of difference is in the posterior tooth of the right valve, which, though bifid, is narrow, while in *Cyprimeria* it is more broadly bifurcate. It occurs in the Sables de Cuise (Yprésien) and in the Calcaire Grossier (Lutétien).

This shell was regarded by M. Cossmann in 1886 as a species of '*Mercenaria*' (now *Mercimonia*, see p. 169), and as no change was made in his later monograph I wrote to enquire whether he was aware of the resemblance of *Venus obliqua* to *Cyprimeria*. In reply, he admits that *V. obliqua* has some special characters, but he still considers that it belongs to the same group as *Mercimonia Bernayi* and *M. cythereæformis*, "malgré de légères différences dans la charnière."

M. Cossmann, however, was at the same time kind enough to send me a specimen of each valve of *V. obliqua*, and an examination of these valves only confirms the opinion I had formed from his photographic figures. The differences of the hinge seem to me much more than slight: thus in the left valve of *Mercimonia* the median tooth is entire, and of nearly equal thickness from end to end, differing much from the bifid triangular tooth of *V. obliqua*; in the right valve of *Mercimonia* the posterior is broader and more deeply cleft, and the other teeth are not directed so far forward, while in both valves there is a concave extension of the hinge-plate in front of the anterior teeth.

When it is remembered that *V. obliqua* agrees with *Cyprimeria* in being compressed and suborbicular in shape, and in having a nearly entire pallial line, I think that most conchologists will agree with me that it should be placed under that genus, especially if it is compared with such a form as *Cyprimeria discus*. I only regret that M. Cossmann cannot yet bring himself to share this opinion.

13. CYCLORISMA, Dall. Pl. VI, Fig. 9.

This group was first separated from *Cyprimeria* by Conrad in 1875, who proposed to call it *Cyclothyris*,¹ but this name having been appropriated by McCoy for a Brachiopod in 1844, Dr. Dall altered it to *Cyclorisma*.² The type is *C. carolinensis*, Conrad.

Up to 1875 many species of *Cyclorisma* had been described as *Cyprimeria* (notably by Stoliczka), because both in general shape and in the dentition they agree with that genus, but the type of *Cyprimeria* (*C. excavata*, Morton) has no pallial sinus, and it was solely on this ground that *Cyclorisma* was separated from it.

The size and shape of the pallial sinus in *Cyclorisma* vary considerably, and we find similar variations in some other early groups of Veneridæ, such as *Tivelina* and *Mercimonia*; consequently we must be on our guard against attributing too much importance to the sinuation of the pallial line, and to the length of the siphons which is connoted by it. If, therefore, this is the sole difference between the

¹ In Kerr's Report for 1875, Geol. Survey of N. Carolina, vol. i, App. I, p. 8.

² Proc. U.S. Nat. Mus., vol. xxvi (1902), p. 357.

two groups I should agree with Dr. Dall in ranking *Cyclorisma* as merely a subgenus (or even a section) of *Cyprimeria*.

It appears, however, that *Cyclorisma* varies considerably in shape, the typical form, as well as many of the Indian species, being nearly orbicular; others, like the British Cretaceous shell which has hitherto been known as *Venus vectensis*, Forbes, are suborbicular, and lastly we have the allied species *Venus faba*, Sow., which has the essential hinge-characters of *Cyclorisma*, but resembles a *Tapes* in shape.

I cannot find that any adequate description of the hinge of *Cyclorisma* has yet been published. The following has been drawn up partly from the figures of Stoliczka, but mainly from an examination of specimens of *C. vectensis* preserved in the Sedgwick Museum at Cambridge. There are three cardinal teeth in each valve, the posterior of the right being always deeply bifid, and the left median being sometimes bifid. There is no anterior lateral, but the hinge-plate is prolonged anteriorly, and forms a more or less concave space in front of the anterior cardinal very like that in the hinge of *Clementia*.

In the right valve the two anterior teeth are nearly parallel, and are directed forward, so that sometimes the anterior seems to end in the concavity, while the median runs into the rim of the hinge-plate. The posterior tooth is not merely bifid, but is actually double, consisting of two separate laminae, one of which curves forward to meet the top of the anterior tooth (as in *Pitaria*), while the hinder one runs in a nearly straight but oblique line across the hinge-plate. In some species this division of the posterior cardinal is so complete that the hinge seems to consist of four separate teeth; even Stoliczka was thus deceived, for he describes the hinge of the right valve as consisting of "two diverging pairs of thin laminar cardinal teeth, each pair originating from one point, and thus preserving the character of a single bifid tooth."¹ In the left valve the anterior and median teeth are united at the top and form a Λ -shaped tooth which barely reaches the margin of the shell; the posterior tooth is entire, not very long, and is slightly curved so as to reach down to the inner margin of the hinge-plate (as in *Dosinia* and some species of *Pitaria*).

The hinge of *C. faba* only differs from the above in regard to the relative strength of the left anterior and median teeth. In *vectensis* the median is the thicker, and may have been grooved; in *faba* both teeth are entire and equally strong.

No true *Cyclorisma* seems to have survived the Cretaceous period, at any rate in Western Europe, but some of the Eocene shells, now known by the name of *Mercimonia*, resemble *Cyclorisma* in the bifid structure of the posterior cardinal and in the anterior concavity of the hinge-plate.

14. CLEMENTIA, Gray, and FLAVENTIA, n.subgen. Pl. VI, Fig. 10.

A species of *Clementia* exists in the higher part of the Parisian Eocene series, and was described by M. Cossmann in 1886 (op. cit.,

¹ "Cret. Fauna of South India": Pal. Indica, 1871, vol. iii, p. 157.

p. 115) under the name of *C. Deshayesi*. It agrees in all essential characters with the recent typical species (*C. papyracea*, Gray), and has a similar thin fragile shell.

Nothing like a true *Clementia* has yet been found in beds of Cretaceous age, but the species which has hitherto been known by the name of *Venus ovalis*, Sow., offers many points of resemblance. In shape and general aspect *V. ovalis* resembles a *Callista*; indeed, the resemblance to *Callistina plana* is so great, not only in shape, but in the arrangement of the cardinal teeth, that unless the anterior part of the hinge-plate was exposed, the shell might easily be mistaken for a small specimen of *C. plana*. The place of the anterior lateral and its corresponding pit is taken by a concave space of elongate triangular form, similar to that on the hinge-plate of *Clementia*. The pallial sinus is deep, ascending, and rounded.

The only other genus with which it can be compared is *Cyclorisma*, but the position of the teeth is quite sufficient to distinguish them, for in *C. ovalis* the anterior and median cardinals cross the hinge-plate nearly vertically, instead of being directed obliquely forward as in *Cyclorisma*, while the posterior, though bifid, is not the double tooth of *Cyclorisma*.

From *Clementia* it differs, not only in the greater thickness of the shell, and consequently of the hinge-plate, but also in the form of the right posterior cardinal, which in *Clementia* is a short, straight, narrowly bifid tooth, consisting of two equal united laminae; while in *V. ovalis* this tooth consists of two diverging laminae, the hinder of which is much longer than the other; it is, in fact, exactly like the posterior tooth of *Callistina plana*. Lastly, *V. ovalis* has a circumscribed lunule.

In other respects the shell agrees with *Clementia*, and I am certainly of opinion that it may be regarded as the ancestor of this genus, but the differences are such that I think it should rank as a subgenus, and consequently should have a distinctive group-name. As the best specimens come from the Blackdown Beds, and are often of a golden-yellow colour, the name may be taken as indicative of that colour, and also as being formed on the same model as *Clementia*.

I think it very probable that some other Cretaceous species will have to be associated with *V. ovalis*, such as the *Tapes faba* of Holzapfel (*non* Sow.), from the Gosau Beds, as well as some French Lower Cretaceous species, but these latter cannot yet be determined, because their hinges are at present unknown. Again, a recent shell from the west coast of America has been referred to *Clementia* by Dr. Dall,¹ under the name of *Cl. solida*, the single right valve known being described as "large and solid for the genus"; but the teeth of this unique valve are neither like those of other *Clementia* nor those of *Flaventia*, so that, till other specimens have been found, its precise affinities can hardly be discussed.

Finally, there is the remarkable shell which was named *Psathura* by Deshayes, and of which only two valves are yet known. This only

¹ Proc. U.S. Nat. Mus., vol. xxvi (1902), p. 401, pl. xiv, fig. 4.

differs from *Clementia* in the absence of any pallial sinus, and if we bear in mind the great variability of the sinus in the *Cyprimeria-Cyclorisma* group (see p. 166), the absence of a sinus will not prevent our regarding *Psathura* as a subgenus of *Clementia*. If this broader view of the genus *Clementia* be accepted, its definition must be modified so as to include *Flaventia* and *Psathura* as subgenera. This can be done as follows:—

Shell transversely oval, inequilateral, convex, concentrically striated or undulated, without defined escutcheon and without lunule (except in *Flaventia*); pallial line deeply sinuated (except in *Psathura*); hinge bearing three cardinal teeth in each valve; in the right the anterior and median are nearly vertical, the posterior oblique and bifid; in the left there are three diverging teeth.

Clementia (sensu stricto).—Shell thin, fragile, white. Pallial sinus deep, ascending, rounded. Right posterior tooth short, straight, and narrow, consisting of two parallel laminae; the left median thicker than the others.

Flaventia.—Shell fairly strong, with a defined lunule. Right posterior tooth long and deeply bifid, the two laminae being of unequal length.

Psathura.—Shell thin and fragile. Hinge like *Clementia*, the right posterior very short, left valve with three equal and entire teeth. Pallial line entire.

15. MERCIMONIA, Dall. Pl. VI, Fig. 11.

This is a group of small shells which have hitherto only been found in the Eocene of the Paris Basin. They were included in the '*Venus*' of Deshayes, and were referred to *Mercenaria* by M. Cossmann in 1886, but were distinguished by Dr. Dall in 1902 under the name of *Mercimonia* (op. cit., p. 361), *Venus Bernayi*, Cossm., being taken as the type.

Mercimonia differs from *Mercenaria* and *Chione* in several respects, and notably in having smooth inner margins. Dr. Dall regards it as a section of *Katelsysia*, which he located as a subgenus of his *Marcia* group. There is certainly much resemblance between *Mercimonia* and *Marcia*, but I can see little between the former and *Katelsysia*, which I should not place in the same genus, because it has two grooved or bifid teeth in each valve, and is more nearly akin to *Tapes* and *Hemitapes*.

It is a question whether *Venus exalbida*, Dillw., is the rightful type of *Marcia*, but this is the shell with which *Mercimonia* may be best compared, and it is briefly described by Dall as a *Venus* (i.e. *Mercenaria*) "without hinge rugosities, radial sculpture, or marginal crenation." *Mercimonia*, however, possesses some special characters of its own, and for the present I prefer to let it stand by itself as a separate genus, until its affinities are better understood and the '*Marcia*' question has been satisfactorily settled.

M. Cossmann gave no general description of *Mercimonia*, though he described *M. Bernayi* in detail, and Dr. Dall's definition was only

a brief one, so I have judged it well to frame a fuller account from M. Cossmann's description of *M. Bernayi*, and from specimens of *M. cytheræformis*, Desh., which he has kindly sent me.

Group characters.—Shell oval, equally rounded at each end, tumid, with prominent umbones, which are inclined forwards, and slightly recurved, so that the front view of the closed valves is cordiform. The lunule is large, and feebly defined by a faint line. Escutcheon not defined.

The hinge-plate is thick, and the teeth are fairly strong; there are three in each valve, divergent and unequal; the right posterior is curved and strongly bifid throughout its length; in the left the anterior and median are united at top and do not quite reach the shell-border, and both are entire (not grooved). The anterior part of the hinge-plate forms a small concavity under the lunule. The pedal scar is merged in that of the anterior adductor. The hinge-plate and teeth have, in fact, quite as great a resemblance to that of *Venus lamellata* as to that of *V. exalbida*.

Such being the characters of the type species and of several others, namely, *cytheræformis*, Desh., *inopinata*, Desh., and *delicatula*, Desh., it becomes a question whether some of the other species referred to *Mercimonia* by M. Cossmann can remain in it. Thus, two of the species, *V. solida*, Desh., and *V. secunda*, Desh., differ in being much more oblique and in having no anterior concavity, the right anterior tooth being very small and placed directly under the lunule. *M. fallaciosa*, again, is a thin shell with a very small anterior cavity.

Four other species differ still more widely, for in them the right posterior cardinal is entire (not bifid), and is widely separated from the other teeth, the hinder part of the hinge-plate being excavated and abbreviated. They appear to me to belong to the group which M. Cossmann called *Venerella*, and I shall refer to them again under that head.

It will be noticed that in the above description no mention is made of the pallial sinus, the reason being that it is curiously variable; thus, in the type species there is hardly any sinus, *inopinata* has a small but distinct triangular sinus, *cytheræformis* has a deeper triangular one, and in *fallaciosa* it is deep, but horizontal and rounded. It is clear, therefore, that the sinus presents no constant character, and that the siphons of *Mercimonia* must have varied in length to a remarkable extent.

16. CHIONE, Megerle.

This genus is represented by a single species in the Oligocene of Pierrefitte in the district of Etampes. It was first figured and described as *Venus Loewyi* by Stan. Meunier in 1880,¹ and again by Messrs. Cossmann & Lambert in 1884.² It was recognized as a *Chione* by M. Cossmann in 1887, and is the earliest known member of the typical group of this genus in Europe.

¹ Nouv. Arch. du Muséum, ser. II, p. 241, pl. xiii, figs. 11, 12.

² Mém. Soc. Géol. de France, ser. III, vol. III, p. 79, pl. I, fig. 22.

It is a fairly large shell, varying in transverse length from 32 to 46 mm. (i.e. up to $1\frac{3}{4}$ inch). It is oval in shape, with a thick shell, and a strong hinge-plate, bearing three stout widely-divergent teeth, the anterior one being close under and parallel to the lunular border. The pallial sinus is short and evenly rounded. The valve-margins are crenulated. The surface-sculpture has the combined radial and concentric elements of *Chione*, the concentric ribs being the more conspicuous. It resembles such recent species as *C. pectorina* or *C. asperrima*, except in the relative dominance of the concentric ribs.

Textivenus, Cossmann.—Two small Eocene shells were separated under this name by M. Cossmann in 1886, on account of their remarkable surface-sculpture. This consists of fine divaricate raised thread-like ridges, which cross one another in trellis-fashion on the ventral portion of the valves. I place these shells under *Chione*, because they agree with species of that genus in all essential characters, excepting only in the crenulation of the inner margins, which are smooth; but the outer layer of the shell with its raised pattern projects slightly beyond the inner layer, and forms a narrow frilled or festooned border.

The type of this subgenus is *Venus texta*, Lam., and it differs from *Mercimonia* in having an impressed lunule, and an escutcheon bordered by a ridge where the sculpture ceases. The teeth are more widely divergent, and the left median has a tendency to become bifid. The pallial sinus is fairly deep and angular or subangular.

17. BARODA, Stoliczka, and VENERELLA, Cossm. Pl. VI, Fig. 12.

The type of this genus was described by d'Orbigny under the name of *Venus fragilis*,¹ and was separated by Stoliczka in 1871 under the name of *Baroda*, two other species from the Cretaceous rocks of India being at the same time described. The group is placed both by Fischer and Dall as a subgenus of *Tapes*, but the characters of the hinge seem to remove it so far from *Tapes* proper that it is more convenient to regard it as a distinct genus, especially as I find a close relationship between it and *Venerella*, in spite of the difference in shape.

In *Baroda* the arrangement of the hinge-teeth is as follows:—In the right valve two short entire teeth under the umbo, sometimes slightly divergent, sometimes both directed forward; a posterior tooth also entire, elongated, and directed backwards, while the space intervening between it and the other teeth is deeply indented or excavated. In the left valve the teeth are similar, but more equally divergent, and the hinge-plate is excavated between each of them.

The only recent species of *Tapes* which shows an approach to the *Baroda* type of hinge is *T. sulcaria*, Lam., the hinge-plate of which is similarly excavated, but in the right valve both the median and posterior teeth are bifid, and the latter is much shorter than in *Baroda*, while in the left valve the median is a broad triangular bifid

¹ Palæont. Franç. Terr. Cret., vol. iii (1844), pl. 385, figs. 11, 12.

tooth which fills the space in the other valve, so that the differences are considerable. No species of *Baroda* has yet been found in England.

VENERELLA.—This name was proposed by Cossmann in 1886 (op. cit.) for a small group of Eocene shells which had been wrongly referred to *Venerupis* by Deshayes. He enumerated five species, the first being *V. Hermonvillensis*, Desh., which has been accepted as the type.

After indicating the points in which these shells differ from *Venerupis* he says: "They have, in fact, the greatest affinity to *Venus*, so that I propose to make them merely a group of this genus under the name of *Venerella*." It is evident that by *Venus* he meant a comprehensive genus such as that adopted by Fischer in his "Manuel de Conchyliologie" (1887), a genus with many subgenera, all of which are now regarded as separate genera. It is to be noted, however, that Fischer did not place *Venerella* under *Venus*, but under *Tapes*, in which he also included *Baroda*. Dr. Dall, in his Synopsis of the Veneridæ (1902), places it near the group which he calls *Venus* (i.e. *Mercenaria*), and as a section of *Katelsia* (Roemer), but the affinity of *Venerella* with these groups seems to me very remote.

The following description of *Venerella* is compiled from the particulars given by M. Cossmann, and from a study of specimens of two species for which I am indebted to him:—

The shell is small and ovate, concentrically striated, with a superficial circumscribed lunule. The hinge has three cardinals in each valve; in the right the anterior and median are short and directed forward; the posterior is simple (not bifid), and nearly parallel to the nymph, so that it makes nearly a right angle with the other teeth, while the intervening part of the hinge-plate is deeply excavated. In the left valve both the median and posterior teeth slope backward, while the hinge-plate is excavated in front of the median, and is truncated beneath the posterior tooth. The pallial sinus is deep, ascending, and rounded. The valve-margins are smooth.

The resemblance of the hinge, above described, to that of *Baroda* will easily be perceived; and while M. Cossmann was amply justified in separating the group from all other Eocene forms of *Venus*, I think that Fischer had good reason for placing it near to *Tapes* and *Baroda*.

Venerella may also date its existence from Cretaceous time, for the *Tapes nuciformis* of Holzapfel,¹ from the Chalk of Aix-la-chapelle, seems to be referable to it, having similar teeth and being nearly orbicular in shape.

Besides the five Eocene species which were included in this group by M. Cossmann, it appears to me that four of the species which he placed under *Mercimonia* must really belong to *Venerella*, if their hinges are correctly represented in the figures of Deshayes. As a matter of fact M. Cossmann did not give any definition of *Mercimonia*, nor did he indicate how it differed as a group from *Venerella*.

¹ "Die Mollusken der Aachener Kreide": Palæontographica, vol. xxxv (1889), p. 165.

The two most obvious points of difference are the deep excavation and abbreviation of the hinge-plate in the latter, and the non-bifid character of the right posterior cardinal. Judged by these points, the *V. deleta*, *V. Geslini*, *V. puellata*, and *V. quadrata* of Deshayes all belong to *Venerella*, and not to *Mercimonia*.

Of *V. deleta* Deshayes himself says, "la charnière est étroite, et ressemble à celle de nos *Venerupis*"; he notes the wide separation of the right posterior tooth, which he describes as "étroite allongée et simple." From his figures and those in the more recent "Iconographie Complète" of M. Cossmann, *V. Geslini*, *V. puellata*, and *V. quadrata* appear to have simple teeth.

18. TAPES, Megerle.

It is not quite certain whether the genus *Tapes*, as distinguished from *Baroda*, is represented in the Cretaceous fauna, but a species described by Zittel (*T. Rochebrunei*), from the Gosau Beds, does seem from his figure¹ to have the hinge of *Tapes*.

The genus *Tapes* should, I think, be restricted to such shells as can be included in the sections enumerated by Fischer, without any of those which he ranks as subgenera. As thus understood, *Tapes* has a small hinge-plate bearing three small cardinal teeth in each valve, placed near together, and as a rule only slightly divergent; moreover, two in the right and one or two in the left valve are grooved or bifid, only the anterior of the right and the posterior of the left being always entire. The bifidness of the teeth is always apparent in young and youngish specimens, though sometimes obscure in old individuals.

It is interesting to find that three species of *Tapes* occur in the Eocene deposits. One of these was described as *Venus tenuis* by Deshayes in 1824,² and recognized as a *Tapes* by Pictet in 1855,³ but it is difficult to say whether it belongs to any particular section of the genus. Another species (*T. Parisiensis*) was described by Deshayes in 1860,⁴ and this evidently belongs to the group which is represented in our seas by *Tapes aureus*, and in the Mediterranean by *T. texturatus* and others.

The third species has not yet been described or figured, but has been named *T. Comptoni* by Edwards, and only one specimen of a right valve is known, this being preserved in the British Museum. For the following account of it I am indebted to Mr. R. Bullen Newton:—"The *Tapes Comptoni* is a much worn right valve with a fractured anterior margin. Externally it is covered with fine, closely-set radial striations, which are crossed by somewhat distant concentric lines of growth. The internal margins are smooth. The sinus is deep, but its form is somewhat obscure, the marking having the appearance of being angulate, though in reality it may be rounded

¹ "Bivalven der Gosaugebilde in den Nordöst Alpen": Denkschr. k. Akad. Wissensch. Wien, vol. xxiv (1865), p. 124, pl. iii, fig. 4.

² Traité de Paléont., 2nd ed., vol. iii, p. 441.

³ Description des coq. foss. des Env. de Paris, p. 143, pl. xxiii, figs. 18, 19.

⁴ Anim. sans Vert. Bassin de Paris, p. 414, pl. xxix, figs. 5, 6.

as in *T. decussatus*. The specimen comes from the Middle Eocene of Brook in the New Forest. In contour and in sculpture it resembles the *Venus* (i.e. *Tapes*) *decussatus*, figured and described by Deshayes in 1824,¹ and stated to have been found at Orsay, south of Paris, in beds now classed as Oligocene."

The resemblance of *T. Comptoni* to the shell figured by Deshayes and to the recent *T. decussatus* is curious, but, in view of the horizon from which it was obtained, it is hardly likely to be really identical with either. Moreover, Messrs. Cossmann and Lambert have expressed their opinion that the shell figured by Deshayes is only a rather worn specimen of the *Venus Loewyi*, Meun., mentioned on p. 170.² It should be remarked, however, that *V. Loewyi* has crenulated margins, whereas *T. decussatus* has not.

III. SUMMARY AND CONCLUSIONS.

It will doubtless be a long time before the workers in any branch of zoology will agree as to what characters should be regarded as essentially of generic value, and what are only of subgeneric or sectional importance; but such agreement can never be expected unless everyone who studies a large family like the Veneridæ states the reasons on which he bases his grouping. My study of recent and fossil Veneridæ has led me to form some definite opinions on the relative value of the various special characters which have been used as criteria, and these I now proceed to state.

In the first place I am convinced that, in this family at any rate, the characters of the hinge afford the best and most convenient means of distinguishing the generic (and often the subgeneric) groups from one another. By this I do not mean that other characters can be neglected, or that a genus may be established solely because its teeth exhibit small peculiarities of shape or position. I mean that the hinge-plate, as a whole, exhibits a larger number of small but appreciable differences than any other portion of the shell does; the development of the teeth from the primitive laminae of the plate being a process which gives scope for a large number of variations or combinations in the disposition of the broken-up laminae.

It is really remarkable, too, how constant the teeth remain in size, number, structure, and relative position in many large groups, notwithstanding great variation in the shape of the shell. Take the genus *Callista*, for instance, which includes some of the most transversely elongate members of the family, as well as some in which the proportion of length to height is only as 5 to 4, yet the teeth maintain exactly the same relative positions, the only differences being in the length of the posterior cardinals, and in the distance separating the anterior cardinal from the anterior lateral.

By some authors the differences exhibited by the pallial sinus are still regarded as having much diagnostic importance, partly perhaps because the pallial line is an expression of obvious differences in the

¹ Op. cit., p. 142, pl. xxiii, figs. 8, 9.

² Terr. Olig. Marin d'Etampes: Mém. Soc. Géol. Fr., ser. III, vol. iii (1884), p. 80.

living animal. The depth of the sinus, however, depends on the length of the siphons, and in most cases the length of the siphons depends on the depth at which the animal buries itself below the surface of the sea-floor. The sinus therefore only represents a functional character, and not one of any great phylogenetic importance.

As a matter of fact I have been impressed with the great variations in the depth and form of the sinus exhibited by some fossil species of Veneridæ, which must, from their other characters, be grouped in the same genus. In some cases this variation extends from a slight sinuation to the presence of a deep and ascending sinus. It seems reasonable to conclude that some of these species had accustomed themselves to live at a much less depth below the surface of the sand than others, and consequently that their siphons had degenerated into short non-retractile tubes. Whatever the reason, the fact remains, and consequently I do not think that a shell should be placed in a separate genus merely because it has no pallial sinus, and when it agrees with other species in all other essential respects.

On the whole it appears to me that those characters of the animal which impress themselves on the interior of the shell are not of generic value, though they are useful in the establishment of subgenera and sections. These characters are the sinuation of the pallial line and the scars of the adductor and pedal (or protractor) muscles. In the discrimination of genera more satisfactory results can be obtained by giving preference to certain characters of the shell itself; these are (1) the hinge-plate and its teeth, (2) the features of the lunule and escutcheon, (3) the smoothness or crenulation of the valve-margins.

In accordance with these considerations I would tabulate the various genera and subdivisions which have been described in the preceding pages as follows:—

GENERA.	SECTIONS.	SUBGENERA.
<i>Dosiniopsis.</i> [<i>Dosinia.</i>]	<i>Sinodia.</i>
<i>Callista.</i>	{ <i>Calpitaria.</i> <i>Macrocallista.</i> <i>Callistina.</i>	<i>Pitaria.</i> <i>Aphrodina.</i>
<i>Tivelina.</i> [<i>Callocardia.</i>]	{ <i>Meretrissa.</i> <i>Dollfusia.</i> <i>Atopodonta.</i>	
[<i>Sunetta.</i>]	<i>Meroëna.</i>
<i>Circe.</i>	<i>Circenita.</i>	<i>Gouldia.</i>
<i>Ptychomya.</i>		
<i>Clementia.</i>	{ <i>Flaventia.</i>
<i>Cyprimeria.</i>	<i>Psathura.</i>
<i>Chione.</i>	<i>Cyclorisma.</i>
<i>Mercimonia.</i>	<i>Textivenus.</i>
<i>Baroda.</i>	<i>Venerella.</i>
<i>Tapes.</i>	<i>Veneritapes</i> (?).

Of these various groups only six or seven occur in the Cretaceous rocks of England and France; these are *Dosiniopsis*, *Callistina*, *Ptychomya*, *Cyclorisma*, *Flaventia*, *Baroda*, and possibly *Calpitaria*. It will be noticed that none of these has any modern representatives, unless possibly in the case of *Calpitaria*; in other words, all (or nearly all) the Cretaceous shells belong to groups that have become extinct.

In the Eocene, however, we find several genera and subgenera which are certainly identical with recent groups; these are *Callista*, *Macrocallista*, *Pitaria*, *Circenita*, *Gouldia*, *Clementia*, and *Tapes*, while *Meroëna* is not far removed from *Sunetta*.

In the Oligocene three other groups make their appearance, viz., *Sinodia* (if not represented in the Eocene), *Circe*, and *Chione*; while in *Meretrissa* we have a near approach to *Meretrix*.

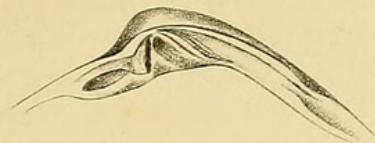
There are a few groups which do not seem to have continued to exist beyond Eocene or Oligocene times; these are *Atopodonta*, *Aphrodina*, *Tivelina*, *Dollfusia*, *Cyprimeria*, *Mercimonia*, *Psathura*, *Textivenus*, and *Venerella*; unless the last named is still represented by a West American shell which was described by P. P. Carpenter under the name of *Clementia subdiaphana*, but is referred to *Venerella* by Dr. W. H. Dall.

Another point which a study of these fossil forms has pressed upon my attention is the more generalized and less differentiated facies of the cognate Eocene groups. This is perhaps most apparent in the case of *Callista* and *Pitaria*; thus several species, which by their hinge seem to belong to *Callista*, have the external surface and the shorter ascending pallial sinus of *Pitaria*, and I have therefore been compelled to establish an intermediate group for their reception.

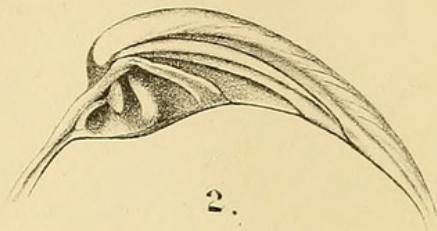
Again, in *Tivelina* we seem to have a group of shells which has branched off from the common ancestor of *Callista* and *Pitaria*, for in some of the species the hinge resembles that of *Callista*, in others it is like that of *Meretrix*, and in some it makes a near approach to *Pitaria*. *Tivelina* seems to have been a plastic group, i.e. one which had a special tendency to develop variations while still retaining a certain general facies; thus it varies in shape, in surface sculpture, and in depth of sinus, as well as in the hinge-characters.

With regard to the peculiar minute discontinuous radial striæ which are a special feature of the recent genera *Callista* and *Meretrix*, these are plainly visible on good specimens of *Chionella ovalina* and *Macrocallista lævigata*, but they do not seem to be present in *Aphrodina nitidula*, for, though the surface was certainly smooth and may have had a vernicose periostracum, I have not been able to detect any such striæ even in the best-preserved specimens.

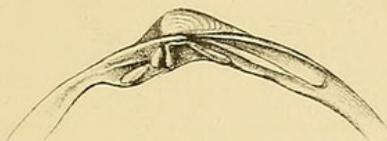
Finally, it may be noted that in *Meroëna* we seem to have a link between *Callista* and *Sunetta*—the smooth valve-margins, the more obtuse escutcheon-borders, and the breadth of the posterior tooth, marking a less degree of differentiation; and in good specimens of *M. trigonula* I have detected the characteristic ingrained striæ of *Callista*.



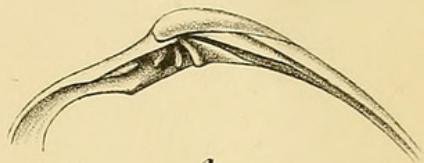
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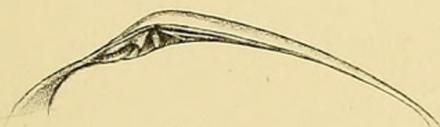
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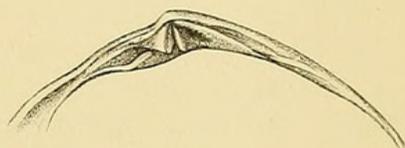
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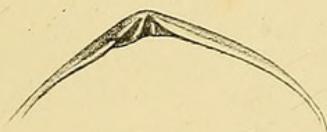
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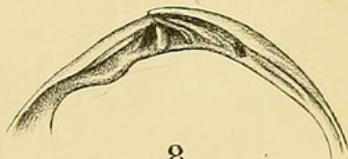
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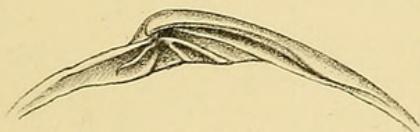
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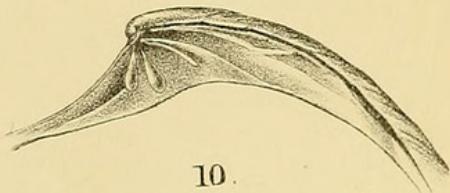
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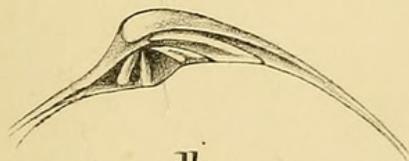
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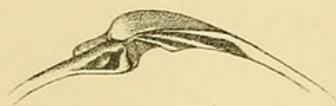
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11.



12.

J. Green del. et lith.

HINGES OF SOME CRETACEOUS AND EOCENE VENERIDS.



Jukes-Browne, A. J. 1908. "ON THE GENERA OF VENERIDÆ REPRESENTED IN THE CRETACEOUS AND OLDER TERTIARY DEPOSITS." *Proceedings of the Malacological Society of London* 8, 148–177.

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