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The Tertiary Sea-Urchins of Middle California.

BY

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WITH TWO PLATES.

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THE TERTIARY SEA-URCHINS OF MIDDLE CALIFORNIA.

BY JOHN C. MERRIAM.

CONTENTS.

I. INTRODUCTION.

IN THE course of an investigation of the invertebrate faunas of Middle California, the writer has found the existing figures and descriptions of the sea-urchins either incomplete or inaccurate to such an extent as to make desirable their reintroduction to those interested in the palaeontology of this region. The writer by no means desires to cast reflections on the work of those who first brought the species to light, realizing that with abundant material at hand it is much easier to revise than is the work of original description.

Both geologically and biologically the sea-urchins are among the most deserving of attention of the Calif ornian invertebrates. The comparatively short vertical range of the species, together with their usually good preservation, makes them admirable horizon determiners, while the intimate relationship of some of the forms to each other indicates considerable possibilities in the study of the history and evolution of the clypeastroid branch of the class on this coast, when the faunas of adjoining regions are better known.

[i6il March 3,1899.

II. HISTORY AND RELATIONSHIPS OF SPECIES.

The one new species, *Schizaster Le Contei,* PL XXI, fig. 1, here added to the list of forms known from Middle California, is of special interest, as it occurs in the lowest Tertiary, Martinez, and represents a family not known in this region later than that time. It seems to be confined to the Martinez and serves as a characteristic fossil of that formation.

The Tejon formation, resting on the Martinez and forming the upper portion of the Eocene on the Pacific Coast, is not known to contain any echinoid remains, though they may be expected to appear in later collections.

In the Miocene the Clypeastridae begin and they continue as the only representatives of the class up to the beginning of the Recent period.[1] The oldest certainly known form of this family is *Clypeaster* (?) *Brewerianus*^ PI. XXI, fig. 2, of the Contra Costa County Miocene. This species is small and shows no specialized characters, and, as will be shown later, is probably the ancestor of some of the younger forms.

In what have been considered the lowest beds of the San Pablo formation, immediately overlying the Miocene of Contra Costa County, is found the oldest species of the more specialized division of the Clypeastridae. included in the subfamily Scutellinae. This species, *Scutella Gabbi?* PI. XXII, fig. 5, is structurally considerably removed from *Clypeaster Brewerianus* and it is doubtful whether they are nearly related. The *Scutella* is probably an immigrant from some other region.

Immediately above the *Scutella* beds the characteristic San Pablo species, *Astrodapsis tmnidus,* PI. XXI, fig. 3, is very abundant. The *Scutella* and *A. tumidus* have been

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[1] **A new species of regular sea-urchin has recently been discovered by Dr. H, W. Fairbanks in the Miocene of southern California. Such forms may also have been represented in middle California, but as the middle and southern portions of the State show in general quite different faunas, we cannot from this occurrence draw any definite conclusions as to the existence of such forms farther north.**

[9] *Echinarachnius Brewerianus* **of earlier writers.**

[8] ***ClypeasUr Gabbi* of earlier writers.**

seen in abundance within less than ten feet of each other and may be found to overlap. *A. tumidus* does not show much affinity to *S. Gabbi,* but is closely related to the older form, *Clypeaster Brewerianus.* From this species it is distinguished mainly by the strong relief of the petals, and it is probable that *C. Brewerianus* is the ancestor of *A. tumidus.* Since in the sequence of strata the beds with *S. Gabbi* lie between those containing these two species, and *Clypeaster* was absent during the intervening period, the modification or evolution was probably brought about in some other region, *Astrodapsis* afterwards coming in to replace the disappearing *Scutella.* Closely related to *A. tumidus* is the larger and thinner *A. Whitneyi,* PL XXI, fig. 4, which probably belongs to the later portion of the San Pablo. Both species were confined to this epoch, and with their extinction the more generalized Clypeastroids disappeared from this region. Along the line of descent from *Clypeaster Brewerianus* through *Astrodapsis tumidus* to *A. Whitneyi* the gradual increase in size is quite noticeable. The maximum diameter of the first species is 33 mm., of the second 45 mm., and of the third 60-65 mm.

During the Merced epoch, following the San Pablg, the Scutellinae reappear, represented by *Scutella interlineata,* PI. XXII, fig. 6. This form shows considerable resemblance to *S. Gabbi* and has in common with it the supramarginal anus. *S. interlineata* differs from *S. Gabbi* in being much larger, in the position of the apical system, which is quite eccentric, and in the more pronounced Supramarginal character of the anus. These differences are in the direction of greater specialization, except the position of the anus. This opening is travelling back from the lower surface toward the apical shield. Taking into consideration the points of relationship of these species, the fact that the differences may be due to specialization of the older form, and the order of occurrence of the two, it is probably safe to assume, that *S. interlineata* is a modified descendant of *S. Gabbi.*

In the Quaternary deposits *Scutella* is **replaced** by an *Echinarachnius* which is a common form at the present time. This species, *E. excentricus,* PL **XXII,** fig. 8, is probably nearly related to *E. Gibbsi,* PL **XXII,** fig. 7, a form cited from the middle or later Tertiary. *E. Gibbsi* occurs near Buena Vista Lake, Kern County, in deposits which have been referred to the Miocene, and is also cited by Ashley from his transition beds between the Merced and the Miocene near Santa Cruz. This species much resembles the *excentricus,* but shows a greater degree of eccentricity of the apical system than is found in that species. The high degree of specialization in *E. Gibbsi* is not easily explained when we consider that it is the older form. As both forms are immigrants, and as their life-periods do not appear to overlap in this region, they are probably derived from a common stock, less specialized than either form, which lived in some other Pacific region during the middle Tertiary.

The table on the page opposite illustrates the occurrence and probable relationships of the known species of middle Californian sea-urchins. Unbroken lines connecting species indicate such structural and successional relationship as suggests descent. Dotted lines indicate doubtful descent or doubtful genetic relationship.

III. DESCRIPTION OF SPECIES.

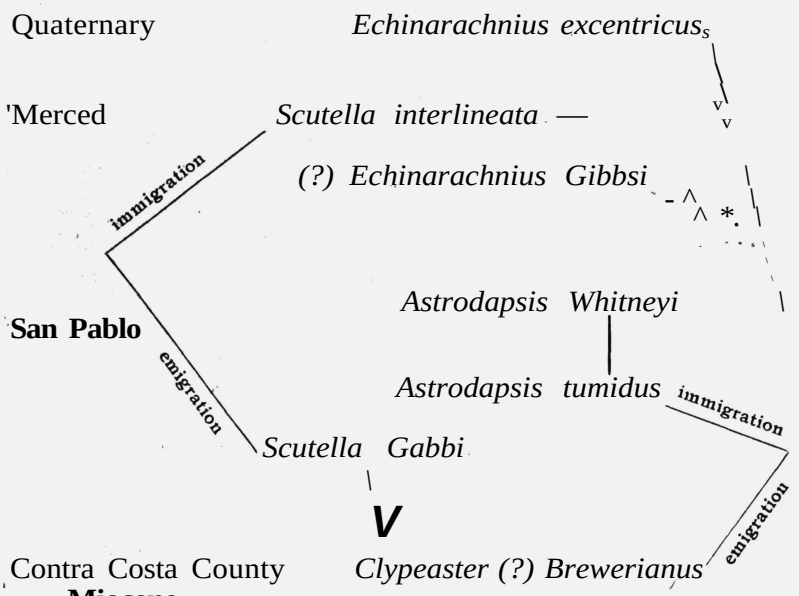
Genus **Schizaster** *Agassiz.*

Schizaster **Le Contei,** sp. nov.

PLATE XXI, FIGS, I AND *1a,*

Schizaster, sp., Journ. Geol, Vol. V, p. 773, Dec, 1897.

Small forms averaging a little less than 20 mm. in length. **The largest** specimen measured is about 23 mm. long. Test **distinctly notched** anteriorly by the groove of the anterior **ambulacrum,** truncated **posteriorly; upper** surface much elevated, with a sharp **ridge running from the apical system to** the posterior end, summit situated far back. Apical system eccentric, posterior, anterior to the summit.



Ambulacra broad, sunken; anterior laterals reaching a little more than half way to the margin; posterior laterals very short, less than half the length of the anterior pair, sometimes almost circular in outline. Ambulacral pores elongated, apparently yoked.

Mouth opening well forward, broad, two-lipped. Anus high up on the truncated posterior end.

Numerous large spines much like those of *Schizaster* have been found at 9ne locality in the Martinez, but if they belong to this genus at all they were probably derived from another and much larger species. Tubercles larger on the actinal surface. Peripetalous fasciole quite distinct on one specimen. Traces of what appears to be the lateral fasciole have been seen beneath the anus.

Though crushed fragments of this species have been known to the writer for some years, the first recognizable specimens were discovered by the members of the class in jpslasontology, in April, 1897.

Not rare in the Martinez in Contra Costa County. Specimens preserved only as impressions or casts, usually badly crushed.

Genus Clypeaster *Lamarck.*

Clypeaster (?) Brewerianus *Rimond.*

PLATE XXI, FIG. 2.

Echniarachnius Brewerianus REMOND., Proc. Cal. Acad. SdL, Vol. Ill, 1863-67, p. 53.

Echinarachnius Brewerianus. Figured by GABB., Geol. Surv. Cal., Palaeontology, Vol. II, 1869, p. 36., PL XII, figs. 65 and 65a.

Small forms averaging between 25 and 30 mm. in long diameter, the largest specimen measuriug about 35 mm. long. Test elliptical to circular, depressed, not markedly thin at the margins.

Ambulacra not standing in relief, broad, wide open at the ends, pores continuing to the margin. Inner row of rounded pores diverging gradually to the margin, drawing together only very slightly at about two-thirds of the distance. The outer pore rows at first diverge strongly but draw together again sharply at the point where the inner rows tend to converge. At this point they change their form from elongated to rounded and continue to the margin nearly parallel with the inner rows. The plates of the ambulacral areas increase slowly in size from the apical shield to the margin, the increase being most rapid at the point where the pore rows draw together. Near the margins the pores stand about half-way between the inner and outer ends of the plates.

Anus marginal to inframarginal. Tubercles nearly the same size on the upper and lower sides of the test.

Very few specimens have been obtained which show the lower surface, and the writer has been unable to determine the character of the ambulacral furrows. As this species is closely related to *Astrodapsis tumidus*, in which the furrows are clypeastroid, it is probable that they are much the same here and that the *Brewerianus* should be classed with, or near, *Clypeaster* rather than with *£chinaracknius*$_9$ a# heretofore.

Common in the Contra Costa County Miocene.

Genus Astrodapsis *Conrad.*

Astrodapsis tumidus *Rimond.*

PLATE XXI, FIG. 3.

Astrodapsis tumidus REMOND., Proc. Cal. Acad. Sci., Vol. Ill, 1863-67, p. 52.

Astrodapsis tumidus. Figured by GABB., Geol. Surv. Cal., Palaeontology> Vol. II, 1869, p. 37, PI. XIII, figs. 68 and 68a.

Specimens ranging up to 45 mm. in diameter, average between 30 and 35 mm. Test circular to elliptical, depressed; margins, particularly in old individuals, inclined to be thickened and rounded, usually notched at the ends of the ambulacral areas.

Ambulacra always more or less elevated and showing, on perfectly preserved specimens, a faint groove running from the marginal notch more than half-way up to the apical system. Petals wide open at the ends, pores continuing almost to the margins. Inner rows of rounded pores only slightly convergent near the margin. Elongated pores of outer rows converging near the margin, becoming rounded and running parallel with the inner rows from that point.

Anus marginal or inframarginal. On well preserved specimens the inferior surface shows well marked, straight, undivided ambulacral grooves, which pass into the marginal notches and extend themselves on the upper surface, forming the median groove of the ambulacral areas. The tubercles are not noticeably different in size on the upper and lower surfaces.

The internal skeleton consists of a pair of strong, radially placed plates, extending half the distance from the margin to the center in each interam - bulacral space.

San Pablo formation, excepting the lowest beds.

Astrodapsis Whitneyi *Rémond.*

PLATE XXI, FIGS. 4 AND 40.

Astrodapsis Whitneyi REMOND., Proc. Cal. Acad. Sci., Vol. Ill, 1863-67, p. 52.

Astrodapsis Whitneyi. Figured by GABB., Geol. Surv. Cal., Palaeontology, Vol. II, 1869, p. 37, PL XIII, figs. 67 and 670.

The average specimens of this species are considerably larger than those of *A. tumidus.* The largest specimen examined measured between 60 and 65 mm. in diameter. Test circular, strongly arched above; margin thin; marginal notches at the ends of the ambulacra deep.

Petals considerably elevated, with median groove running from the marginal notch toward the apex, pores similar in form and arrangement to those of *A. tumidus.*

Ambulacral furrows of the inferior surface well marked, straight, undivided. Anus inframarginal. Tubercles not differing materially on the upper and lower surfaces of the test, frequently smaller than in *tumidus.*

San Pablo formation, probably in the upper beds.

Genus Scutella *Lamarck.*

Scutella Gabbi *Rémond.*

PLATE XXII, FIGS. 5 AND *5a.*

Clypeaster Gabbi **RÉMOND., Proc, Cal. Acad. Sci., Vol. Ill, 1863-67, p. 53.**
Clypeaster Gabbi. **Figured by GABB., Geol. Surv. Cal., Palaeontology, Vol. II, 1869, p. 36, PI. XII, figs. 64 and 64^.**

Test circular, much depressed, margin thin. Average specimens 25 to 30 mm. in diameter, largest specimens ranging-up to 40 and 45 mm. in diameter.

Petals short, not extending more than two-thirds of the distance to the margin; excepting the anterior one, they are nearly closed at the ends. Anterior petal wide open. Excepting in the anterior area, the ambulacral plates suddenly enlarge and the area rapidly widens beyond the ends of the petals. In these areas, pairs of small, round pores, diverging strongly from the ends of the petals, may be present almost to the margins. In the anterior petal the plates do not enlarge as noticeably toward the margin as in the others, neither do the more persistent pore pairs diverge as much.

Apical shield with four genital pores, there being none at the end of the posterior interambulacral area."* Anus marginal to supramarginal; in quite a number of specimens it is found to be entirely on the upper surface. No marked difference is noticeable between the tubercles of the upper and lower surfaces.

The ambulacral furrows of the actinal surface are not usually well preserved and have been clearly seen on only a few specimens; they divide dichotomously a little less than half-way to the margin.

San Pablo formation, in the lowest beds.

Scutella interlineata *Stimpson.*

PLATE XXII, FIG. 6.

Scutella interlineata **STIMPSON, Pacific R. R. Rep., Vol. V, 1856, p. 153, PI.** IV, fig. 30.
Scutella interlineata. Redescribed by RÉMOND., Proc. Cal. Acad. Sci*, Vol. Ill, 1863-67, p. 14,

Test pentagonal to circular, angular or truncated posteriorly, somewhat arched above; summit nearly central and in front of the eccentric apical system, specimens ranging up to over 120 mm. in diameter.

Ambulacra rather broad, of unequal length, anterior three of about the same length and longer than the posterior pair. Anterior petal open at the end, the others nearly closed. Few if any pores continuing **beyond** the ends of the petals.

The distance from the eccentric apical system to the posterior margin is to the distance to the anterior margin as 1 to 1.5. The anus is supramarginal, being separated from the margin in adult specimens by about the width of one of the marginal interambulacral plates.

No specimens have been seen by the writer in which the ambulacral furrows are well shown. On such specimens as show the lower side, the furrows seem to be dichotomously divided near the mouth. This agrees with Re*mond's description, which also states that the furrows are not as well marked nor as much branched as in *Eckinarachnius excentricus.*

The spines of the upper surface are about 1 mm. long; they are longitudinally striated and at the distal end are strongly swollen and obliquely truncated or bent. The spines of the lower surface are slender striated rods about 2 to 3 mm. long. The tubercles differ little in size on the upper and lower surfaces.

The internal skeleton comprises numerous irregular pillars and plates near the margin and a pair of radial plates in each interambulacral space.

Common in the Merced series.

Genus Echinarachnius *Leske.*

Echinarachnius Gibbsi *Remond.*

PLATE XXII, FIG. 7.

Scutella Gibbsi R£MOND, Proc. Cal. Acad. Sci., Vol. Ill, 1863-67, p. 13.
Scuiella Gibbsi, Figured by GABB, Geol. Surv. Cal., Palaeontology, Vol. II, 1869, p. 37, PL XII, figs. 66 and 66a.

Test quadrate-oval in outline. Upper surface well arched, summit behind the middle of the long diameter but in front of the very eccentric apical system. Specimens ranging up to 70 mm. in length.

Petals broad, open at the ends. Posterior laterals wide apart, ovate in outline, one-half the length of the anterior pair. Anterior petal longer than the anterior laterals; scattered pores continue some distance beyond the end.

The apical shield is very eccentric. In a specimen measuring 52 mm. in length, the distance from the apical shield to the posterior margin is to that to the anterior margin as 1 to 2.18; in a specimen 70 mm. long the ratio is 1 to 2.89. Four genital pores are present. The madreporic body is large and is pentagonal in outline. The anus is inframarginal.

The well marked ambulacral furrows are dichotomously branched near the mouth-opening and send off numerous secondary branches from these forks. The numerous tubercles of the upper surface are very small and are set in faint pits. On the lower surface the tubercles are fewer in number and larger, and stand in well defined pits.

From Neocene beds near Buena Vista Lake, Kern County, and listed by Ashley[1] from his transition beds near Santa Cruz.

[1] Proe. Cal. Acad. Sci., 2d Ser., Vol. V, 18951 p. 328-

Echinarachnius excentricus *Eschscholtz.*

PLATE XXII, FIG. 8.

***Scutella excentrica* ESCHSCHOLTZ, ZOOI. Atl., PI. XX, fig. 2, 1826.**
***Echinarachnius excentricus* VALENCIENNES, Voyage Ve*nus, PL X, 1846.**

Though a discussion of this species is perhaps not properly included in a treatise on Tertiary forms, its doubtful occurrence in the Pliocene is considered a warrant for its introduction. Moreover, the position the species occupies as the last of the Clypeastroids in this region makes desirable a comparison with the extinct forms. This is graphically done on Plate XXII, where *E. excentricus* appears with its nearest allies from this Coast.

From *E. Gibbsi* the *excentricus* differs in the less degree of eccentricity of the apical system and in the greater complexity and length of the ambulacral furrows. The distance of the apical shield from the posterior margin is to that from the anterior margin as 1 to 1.8+. The ambulacral furrows are split up into a great number of small branches, of which the strongest pass over the margins and extend over the upper surface. Four of the strongest furrows run to the lateral petals and stretch through their median areas almost to the apical system. Those furrows not passing to the petals sometimes reach half-way to the apical system.

Quaternary, possibly also in the later Pliocene. The fossil forms do not differ materially from those of the Recent period.

PAL;EONTOLOGICAL LABORATORY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA,
September, 1898.

EXPLANATION OF PLATE XXI.

All figures natural size.

Fig. 1. *Schizaster Le Contei*^ sp. **nov.**
View of an obliquely crushed specimen from above.

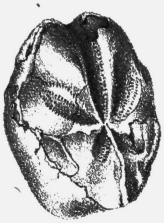
Fig. *1a.* Lower surface of the specimen of *Schizaster Le Contei* shown in fig. 1.

Fig. 2. *Clypeaster* (?) *Brewerianus* R£MOND.

Fig. 3. *Astrodapsts tumidus* R£MOND.

Fig. 4. *Astrodapsis Whitneyi* REMOND.

Fig. 4a. Lower surface of the specimen of *Astrodapsis Whitneyi* shown in fig. 4.



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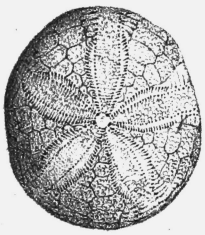
1a



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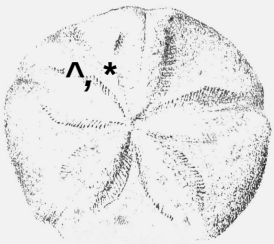

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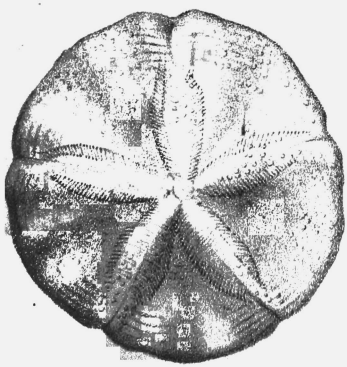

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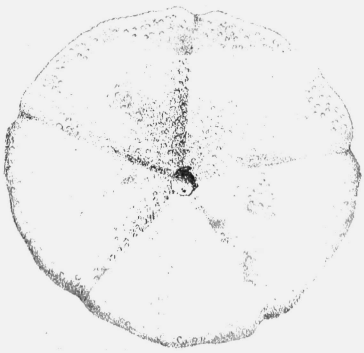


4a

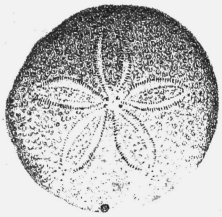
MARY H. WELLMAN, DEL. . ittVJMTONXRST.Sr.

JOM f, 5CHIZASTER LE CDNTEI SE NDV. FlD.3. ASTRDMPSIB TUMinUS *HEMpND.*
R&Z CCffEASTEH BREWERIANUS *REMDNR* FlB.4-4S ASTHDIIAPBfS V/ffltNEY] *HEMDNR*

EXPLANATION OF PLATE XXII.

All figures natural size.

Fig. 5. *Scutella Gabbi* **REMOND.**
Fig. 5a. *Scutella Gabbi* **REMOND.**
Showing form **and arrangement of plates and pores.**
Fig. 6. *Scutella interlineata* STIMPSON.
Fig. 7. *Echinarachnius Gibbsi* RÉMOND.
Fig. 8. *Echinarachnius excentricus* ESCHSCHOLTZ.



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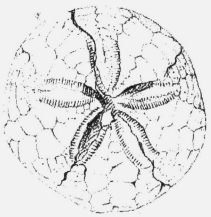

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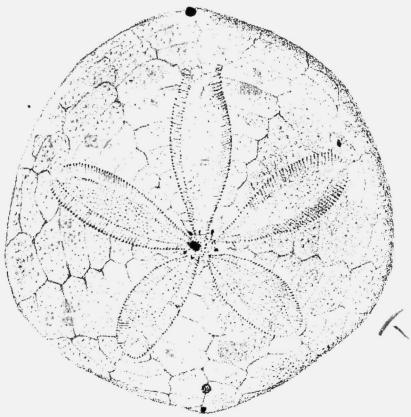

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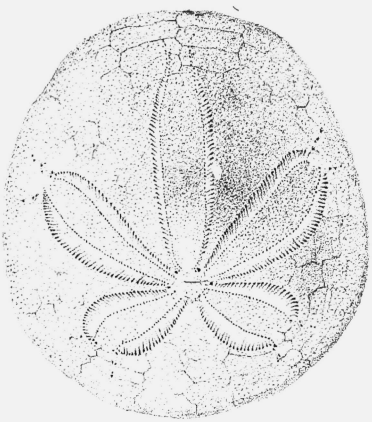

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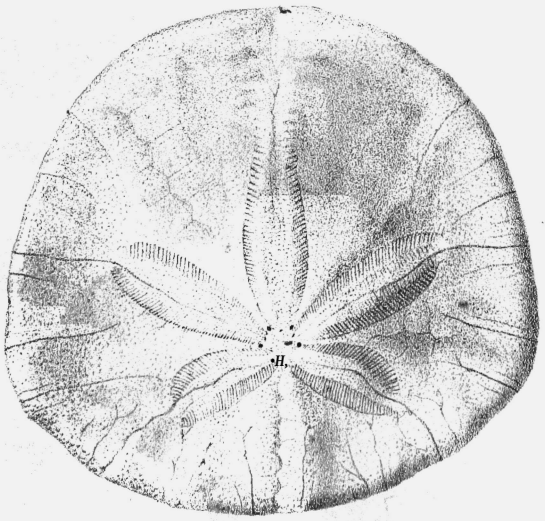

8.

MARY H. WELLMAN, DEL. LITH. BRITTON & REY, S.F.

, M5-5.[5] SCUTEIIA EABBI*HEMONU.*

TIB.B. SCUTELIA,ISTERnNMIA.*STIMPSDK*

Tm.7. ECHINAHACHNIUS GIBBSI*HEMDNR*

FtG. B. ECHINAHACHNIUS EXCENTRICUSZSZK