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A PEEL TECHNIQUE FOR OSTRACOD CARAPACES, AND STRUCTURES REVEALED THEREWITH IN *HIBBARDIA LACRIMOSA* (SWARTZ AND ORIEL)

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VOLUME XIV

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CONTENTS

INTRODUCTION

THIS paper describes a technique for making successive peels of ostracods and also describes certain structures revealed in female specimens of *Hibbardia lacrimosa* (Swartz and Oriel) by this method. The peel technique is particularly useful for study of internal features of fossil ostracod carapaces. In *Hibbardia lacrimosa,* a Middle Devonian beyrichiid ostracod, it shows that the overlapping right valve is rabbeted to fit around the edge of the left, that only the right valve has a well-developed submarginal ridge and marginal denticles, and that each female valve has an unusual internal rodlike strut, presumably at the proximal limit of the brood space. Some of the peels showing these structures are illustrated in Plates II-V.

Among beyrichiid ostracods, details of the contact margin, the hinge, the internal structures of the female, and the thickness of various parts of the carapace have been neglected by most workers in favor of the form, lobation, and ornamentation—characters which are considered to have taxonomic value. This approach may leave many important relationships unnoticed. The classification of Paleozoic ostracods has hardly reached the state of exactitude in which all diagnostic features are known and other features can be ignored.

Only a few authors have expanded their field of observation to include these structures, which can be seen only by the use of special technique. Bonnema (1913*a*, Fig. 5; 1913*b*, Fig. 5; 1930, Fig. 9) illustrated a cross section of *Beyrichia tuberculata* (Klöden). He regarded the natures of the hinge and overlap in this species as criteria of orientation. Hessland (1949, Pl. 14, Fig. 9) illustrated a transverse section of *Beyrichia kloedeni* McCoy and commented on the shape and significance of the brood pouches. Spjeldnaes (1951, Pl. 103, Fig. 1) gave figures of thin sections of *Beyrichia jonesi* Boll. On polished surfaces through female carapaces, Kesling found internal structures in *Phlyctiscapha rockportensis* Kesling (1953*a*, Pl. 2, Figs. 8-13) and in *Hibbardia lacrimosa* (Swartz and Oriel) (1953*b*, Pl. 9, Figs. 3-6).

The internal structures of female beyrichiid ostracods deserve special study. In *Beyrichia jonesi* Boll (Spjeldnaes, 1951, Pl. 103, Fig. 1) and *Phlyctiscapha rockportensis* Kesling (Kesling, 1953*a*, Fig. 1, Pl. 2, Figs. 8-13) there are internal walls which appear to mark the proximal limit of the brood space. Other species of beyrichiids should be examined. It is possible that similar structures occur in all ostracods of the family. Internal structures proximal to the brood space may prove to be a familial character.

The contact margin and the marginal, submarginal, and velate structures should also be carefully observed in this family. The statement, found in many beyrichiid descriptions, that the valves are "equal" or "nearly equal" conveys the idea of one valve the mirror image of the opposite, except, perhaps, for a slight difference in size. Similarly, many details of morphology have been dismissed with the simple declaration "overlap R/L." The few published photographs of thin sections and polished surfaces show that the contact margin can scarcely be called "simple," no matter how that term is applied, and that the marginal, submarginal, and velate structures of one valve differ significantly from those in the other.

I am grateful to Dr. Chester A. Arnold, Dr. George M. Ehlers, and Dr. Lewis B. Kellum for helpful criticism of this paper. I also thank the Horace H. Rackham School of Graduate Studies of the University of Michigan for providing the special photographic equipment used in preparation of the plates.

PEEL TECHNIQUE

In micropaleontology the method used in a procedure often has as much significance as, or more than, the immediate object of research. Whether or not this is such a circumstance, I believe the method described here will prove of interest and be applicable to many problems in paleontology.

Most techniques for studying internal structures of ostracods have been unsatisfactory for one reason or another. Microradiographs work for specimens that are hollow or that have matrix of different composition from the carapace. Many Paleozoic carapaces, however, are composed of calcite and are filled with clear crystalline calcite; in most species they are much thicker in the middle than near the edges. I have tried unsuccessfully to detect internal structures in them with radiography. Thin sections of ostracods show many internal features clearly, but only one or two can be made from a specimen; furthermore, the making of sections which are thin and even enough to clearly differentiate structures is somewhat of an art, and a poor section is wasted time and specimen. Serial polished surfaces can be used effectively for some structures, but they leave no record.

Successive peels through a carapace not only reveal internal structures and show their spatial relationships, but also provide a permanent record. Such peels obviously cannot be made in quite the same way as for a large slab of rock. The ostracod carapace must be embedded in a medium which is soluble neither in the peel solution nor in the acid used for etching. Plaster and similar compounds make good peels, but disintegrate in weak hydrochloric or acetic acid. On the other hand, Canada balsam or its substitutes stand up under the acid, but dissolve in the peel solution.

Bioplastic, which is insoluble in almost all liquids, is a good embedding medium. The embedding process involves three steps: (1) A supporting block ¾ inch thick is made by pouring Bioplastic into a mold made of 1- by 3-inch glass slides glued and taped together to form a small box. (2) On another glass slide the specimen is glued with tragacanth in the desired orientation, and a drop of Bioplastic is placed on it. The Bioplastic flows around the specimen and spreads out onto the glass; at intervals, additional Bioplastic is dropped onto it to build up a gently sloping mound with the specimen in the center. When it has set, this mound can be broken free of the glass slide. (3) After the Bioplastic in the mold has hardened, the specimen and its surrounding mound are set atop the surface of the block and a second layer of Bioplastic, sufficient to cover the specimen and fill the mold, is poured. The whole is then allowed to set and is cured with heat as recommended by the manufacturer. The block of Bioplastic with the embedded specimen is removed from the mold by pulling off the tape, dissolving the glue, and pulling the slides free.

The preparation of a peel from a mounted specimen is not difficult. The block is ground down until the desired level is reached in the specimen. A satisfactory abrasive is 1000-mesh carborundum powder; finer-grained abrasives produce no better results. The polished surface of the specimen is cleaned and etched by immersing the block in very dilute acid. About 15 seconds in 2 per cent hydrochloric acid is sufficient for most specimens. The block is removed from the acid and held in a gentle flow of cold tap water for several minutes. The etched surface must dry gradually; if it is touched, details of many features are irreparably damaged. The block is then placed in a box of sand with the etched surface up, and peel solution poured onto the surface and spread evenly in a 2-mm. layer. Air bubbles can be removed with a needle. The peel dries in about 48 hours and can be pulled free after its edges are carefully loosened by a razor blade. The peel is placed between two glass slides for study.

The solution used is known to paleobotanists as Darrah's peel solution. It contains:

Paralodion	1 oz.
Butyl acetate	250 cc.
Fusel oil (Amylic alcohol)	30 cc.
Xylene	10 cc.
Ether	3 cc.
Castor oil	3 cc.

Several operations in the preparation should receive careful attention. (1) Bioplastic must be catalyzed in accordance with the instructions; if it has not cured properly, it will be tacky and useless. It should be remembered that Bioplastic is insoluble in almost all reagents, and I know of no way to recover the specimen undamaged from a poor mount. (2) If the specimen is etched too deeply, the peel will adhere tenaciously, and may tear in the peeling process. Furthermore, the sides of the cavity left by prolonged etching may have considerable topography, which will produce ragged edges on the peel. (3) The etched surface must be handled with extreme care. It should not be wiped dry, or handled in any way. (4) The block must be level before the peel solution is poured. A small but accurate level is a necessity. If the block tilts slightly, the peel will have a thin edge and will be difficult to pull off without tearing. (5) The peel solution must be uniform in thickness and bubble-free. (6) The peel must be completely dried before handling. When the surface no longer dents with a needle, the block and peel can be removed from the sand box and further dried under a low lamp.

Microscopic examination reveals that the features of the specimen are outlined by topographic differences in the peel. It is assumed that these differences result from slight variations in solubility of various parts of the specimen. Details of the structure of the calcite in the shell are shown in some peels. The peel technique works well for entirely calcareous specimens. The contact between the inner surface of the shell and the calcite filling is distinct in most peels. In particular, this method offers clear discernment of hinge, closing structures, and thickness of shell material. Although it is not quickly done and requires care, the procedure yields results that I can duplicate in no other way.

STRUCTURES OF *HIBBARDIA LACRIMOSA* (SWARTZ AND ORIEL)

Taxonomy.—This species was first described as *Amphissites lacrimosus* by Swartz and Oriel (1948, pp. 553-54, Pl. 79, Fig. 15) from an immature valve. Kesling (1953*b*) showed that the species was a beyrichiid on the basis of its dimorphism, and made it the type of a new genus, *Hibbardia.* He described and illustrated immature carapaces of several instars, as well as the adult dimorphs.

Peels.—Successive peels were made of eight specimens, shown in Plate I before embedding. Each specimen is indicated by a letter, which corresponds to the letter shown on successive plates for peels of that specimen.

The time of etching was varied between 15 and 25 seconds. The peels made after etching for 25 seconds (see Pl. II, Fig. 7; Pl. III, Fig. 6; Pl. IV, Fig. 7; and Pl. V, Fig. 5) have many details in the outer region obscured by the topography on the lateral edges of the peel. The normal depth of etching can be determined on those peels made nearly tangent to the carapace, for example, in those illustrated in Plate II, Figures 13-14 and in Plate V, Figures 10-12. About 20 peels can be made from a specimen, each etched deeply enough to register significant details.

Preservation.—Most of the specimens were filled with calcite, but specimens C, D, and G had considerable pyrite in their fillings and did not produce good peels. In those specimens which contained some clay admixed with the calcite, as in specimens B and E, the crystals of calcite were much smaller than in specimens containing little or no clay, and internal structures appeared to be much better preserved. The nature of the filling does not appear to be related to external features of the carapace, and cannot be detected from the exterior.

Marginal denticles.—Very thin, fragile, fused denticles occur along the margin of the overlapping right valve. No trace of denticles could be found in the left valve. The denticles had been broken from some of the specimens, but were preserved in B, D, and E. A few were also present in F and H. Denticles can be seen in peels shown in Plate V, Figures 10-11.

Submarginal ridges.—The submarginal ridges of the two valves are very dissimilar. That in the right valve is complete from corner to corner, but that in the left is well developed only in the anterodorsal and posterodorsal parts of the valve. It seemed, from the exterior of the carapace, that the submarginal ridge in the left valve might be similar to that in the right and that its ventral part was concealed by the overlapping edge of the right valve. The peels show that this is not true.

Near the anterodorsal corner, the submarginal ridge of the right valve is not as high as that of the left (Pl. IV, Figs. 3, 15). A little below this, however, the two ridges are about the same height (Pl. IV, Figs. 5, 16), and in the middle of the anterior region apparently only the right ridge is present (Pl. IV, Fig. 8; Pl. V, Fig. 6). In the ventral region, the submarginal ridge of the right valve is large but not high or thin (Pl. II, Figs. 1-9, 17-19; Pl. III, Figs. 1-8, 23), and that of the left valve is very small and inconspicuous, difficult to find except where intersected at a low angle (Pl. IV, Fig. 12). In the middle of the posterior region, only the ridge of the right valve is large and distinct (Pl. IV, Figs. 6-8; Pl. V, Figs. 4-5, 17). Between this region and the posterior corner, the ridge on the right valve continues without much change in size, whereas that on the left increases markedly in height. Strangely, the sharpest and highest parts of the submarginal ridges are those in the left valve near the anterior (Pl. IV, Fig. 15) and posterior (Pl. V, Fig. 14) corners.

Velate ridge.—The velate ridge is about equally developed on the two valves. The part of the valve containing the velate and submarginal ridges is, aside from these structures, much thicker than other parts (Pl. II, Figs. 17-19; Pl. IV, Fig. 16; Pl. V, Figs. 14-16).

Overlap.—The right valve is rabbeted to fit the rather blunt free edge of the left (Pl. II, Figs. 17-19; Pl. IV, Figs. 5-10, 16; Pl. V, Figs. 3-7, 14-17). The contact margin of the right valve is so shaped that the overlapping part of the valve in the anterodorsal and posterodorsal regions is subtriangular in cross section, tapering to an edge (Pl. IV, Fig. 15; Pl. V, Figs. 15-17), but in the ventral region is subquadrangular (Pl. II, Figs. 17-19). The part of the valve forming the inner surface of this contact margin is nearly continuous with the rest of the inner surface of the valve (Pl. IV, Figs. 3-7; Pl. V, Figs. 2-6), except in the ventral region, where it projects inward (Pl. II, Figs. 1-12, 17-19; Pl. III, Figs. 1-8).

In the left valve, the overlapped part tapers gradually to the free edge in the posterodorsal (Pl. V, Figs. 14–15) and anterodorsal (Pl. IV, Fig. 15) regions, but elsewhere (Pl. II, Figs. 17-19; Pl. III, Fig. 23) it tapers abruptly, with the two sides of the contact margin set at about right angles.

Hinge.—The hinge of the right valve is a ridge, which fits into a groove in the left (Pl. II, Fig. 16). This ridge is of about the same width through the middle of the hinge, but is a little thicker in the end regions (Pl. II, Fig. 21).

Shell structure.—The peels show thin lines through many elements of the reticulation (Pl. II, Figs. 16, 20; Pl. IV, Figs. 15, 17) and through the frill (Pl. II, Fig. 19; Pl. IV, Fig. 16; Pl. V, Figs. 14-17). These lines do not appear to be pore canals because of their small size. Furthermore, peels which are tangent to the surface of the specimen and cut the reticulation show thin lines through the middle of each element of the reticulation (Pl. V, Figs. 19-20). Thus, each structural unit of the shell in the sides of the carapace seems to be cup-shaped, bounded by the proximal half of the surrounding reticulation.

Internal rodlike structure in female.—Well-preserved female carapaces show a rodlike structure within each valve, sloping up from the inside edge of the contact margin (Pl. V, Figs. 9-10) to the side of the valve in front of and a little below the central pit (Pl. III, Fig. 2; Pl. V, Fig. 6). Perhaps this structure acts like a strut, making the valve stronger in the region of the brood pouch. It is of interest that the structure terminates ventrally inside that part of the valve which is marked by a bifurcation of the frill.

Other female ostracods of the family Beyrichiidae should be studied to determine if they have internal dimorphic structures associated with the brood space, similar to the strut in *Hibbardia lacrimosa* or the partition in *Phlyctiscapha rockportensis.*

Objects within the carapace.—Several objects enclosed within the carapace were discovered on peels. The nature of these objects and the manner in which they came to be enclosed in the carapace are matters of conjecture.

One of these objects (Pl. III, Fig. 22), located in the ventral part of the carapace near the plane of closure, is nearly circular in cross section with an average diameter of .06 mm. It has a dark border and a thick inner lining of calcite. It may have been an egg, some kind of food which the ostracod was eating at the time of death, or some foreign object swept by chance into the carapace before the valves closed for the last time.

A second object (Pl. III, Fig. 23), from the same specimen as the first, and located a little behind it, is oval, about .09 mm. wide and .11 mm. long. Like the first object, it has a dark border and a lining of calcite. It may possibly be an immature ostracod carapace.

The third object (Pl. III, Fig. 13) is in the brood space of the same specimen. It is oval, about .12 mm. wide and .16 mm. long. It has indentations along its borders which look like the reticulation on an immature carapace.

In some of the specimens, such as A (Pl. II, Figs. 1-14) and H (Pl. III, Figs. 14-20), the recrystallization of the calcite forming the steinkern may have destroyed the carapaces of any young ostracods that remained in the adult female.

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PLATES

EXPLANATION OF PLATE I

(All figures $\times$ 14)

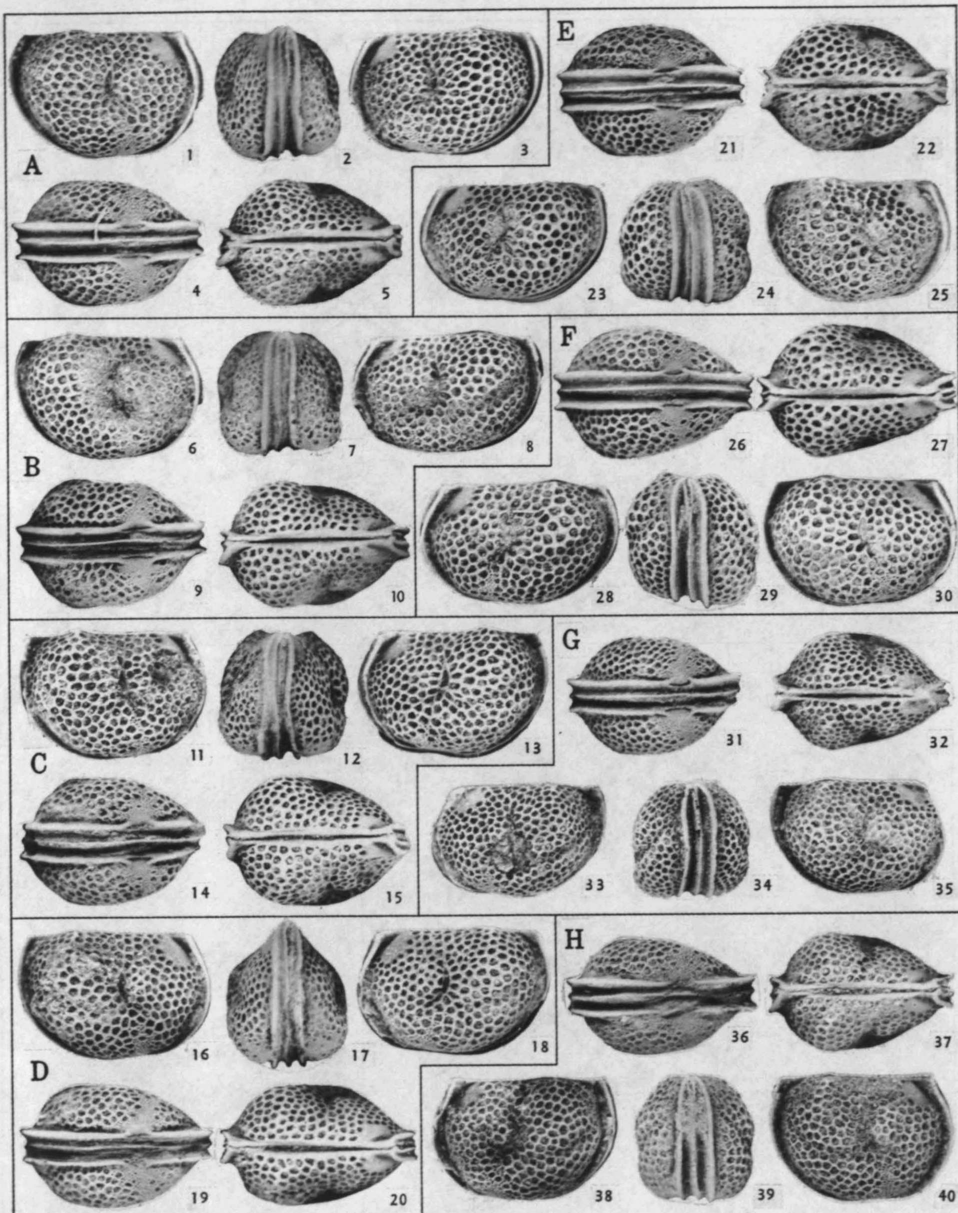
Hibbardia lacrimosa (Swartz and Oriel)

Eight female specimens, designated A through H, were made into successive peel sections, some of which are illustrated in Plates II through V. Specimens A and B were ground to cross sections, C and D to parasagittal sections, and E through H to frontal sections. D and G contained so much pyrite that the peels were very poor. B and E had the best retention of internal features.

FIGS. 1-20. Right lateral, anterior, left lateral, ventral, and dorsal views of four carapaces. Specimen B (Fig. 9) retains some of the marginal denticles of the right valve. The anterior view of specimen D (Fig. 17) is inclined from below.

FIGS. 21-40. Ventral, dorsal, left lateral, posterior, and right lateral views of four carapaces. Specimen E (Figs. 21, 24) retains the marginal denticles of the right valve in the ventral and posterior regions.

PLATE I


A
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D
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G
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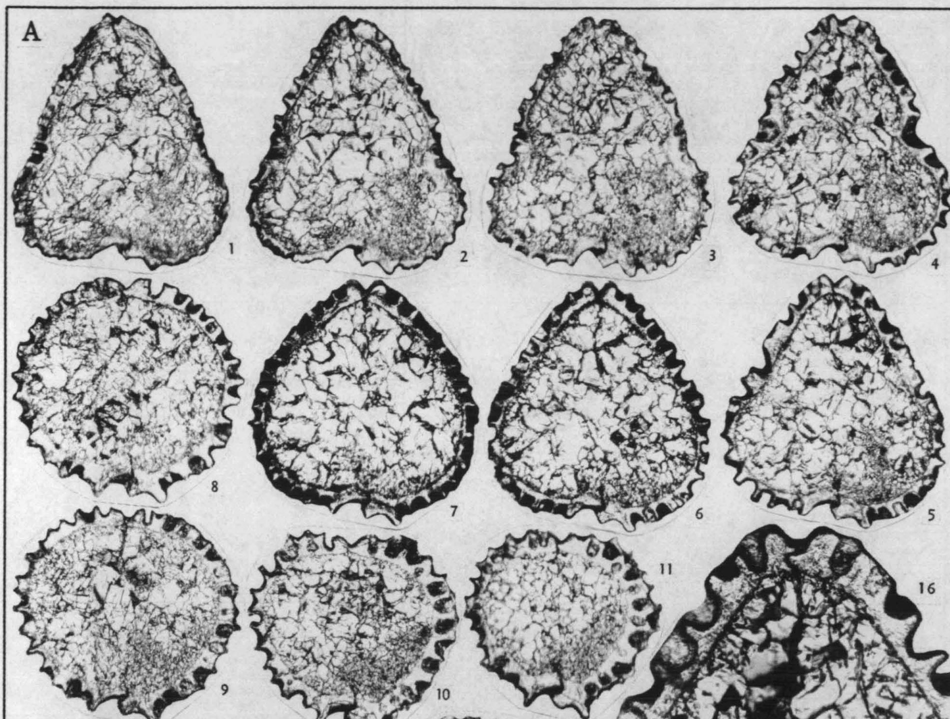
PLATE II



EXPLANATION OF PLATE II

Hibbardia lacrimosa (Swartz and Oriel)

FIGS. 1-15. Selected cross peels from anterior to posterior in specimen A. The peels show features in reverse, so that the figures appear as they would be seen from the rear, with the right valve on the right side in each figure. Fig. 4 shows the pit. × 28.

FIGS. 16-20. Enlargements of parts of peels shown in Figs. 4, 2, 4, 6, and 4, respectively, illustrating details of the hinge, contact margin, and pit. × 70.

FIGS. 21-22. Two successive parasagittal peels through the right valve in specimen C. The reversal of features in the peel makes the figures appear as seen from the right side of the specimen. Fig. 21 shows the hinge bar of the right valve very well. × 28.

EXPLANATION OF PLATE III

Hibbardia lacrimosa (Swartz and Oriel)

FIGS. 1-12. Selected cross peels from anterior to posterior in specimen B. Because the peels reproduce features in reverse, the figures appear as seen from the rear, with the right valve on the right. Fig. 2 shows the internal rodlike structure associated with the brood space. Fig. 4 passes through the pit. × 28.

FIGS. 13, 22, 23. Enlargements of parts of peels shown in Figs. 3, 1, and 4, respectively, illustrating details of three unidentified objects enclosed within the carapace. × 70.

FIGS. 14-20. Selected frontal peels from top to bottom in specimen H. The figures appear as seen from below, with the right valve in the upper half of each figure. × 28.

FIG. 21. Parasagittal peel near the right side of specimen D, as seen from the right side of the specimen. The pit shows up very well. Pyritization has destroyed many details in this specimen. × 28.

PLATE III

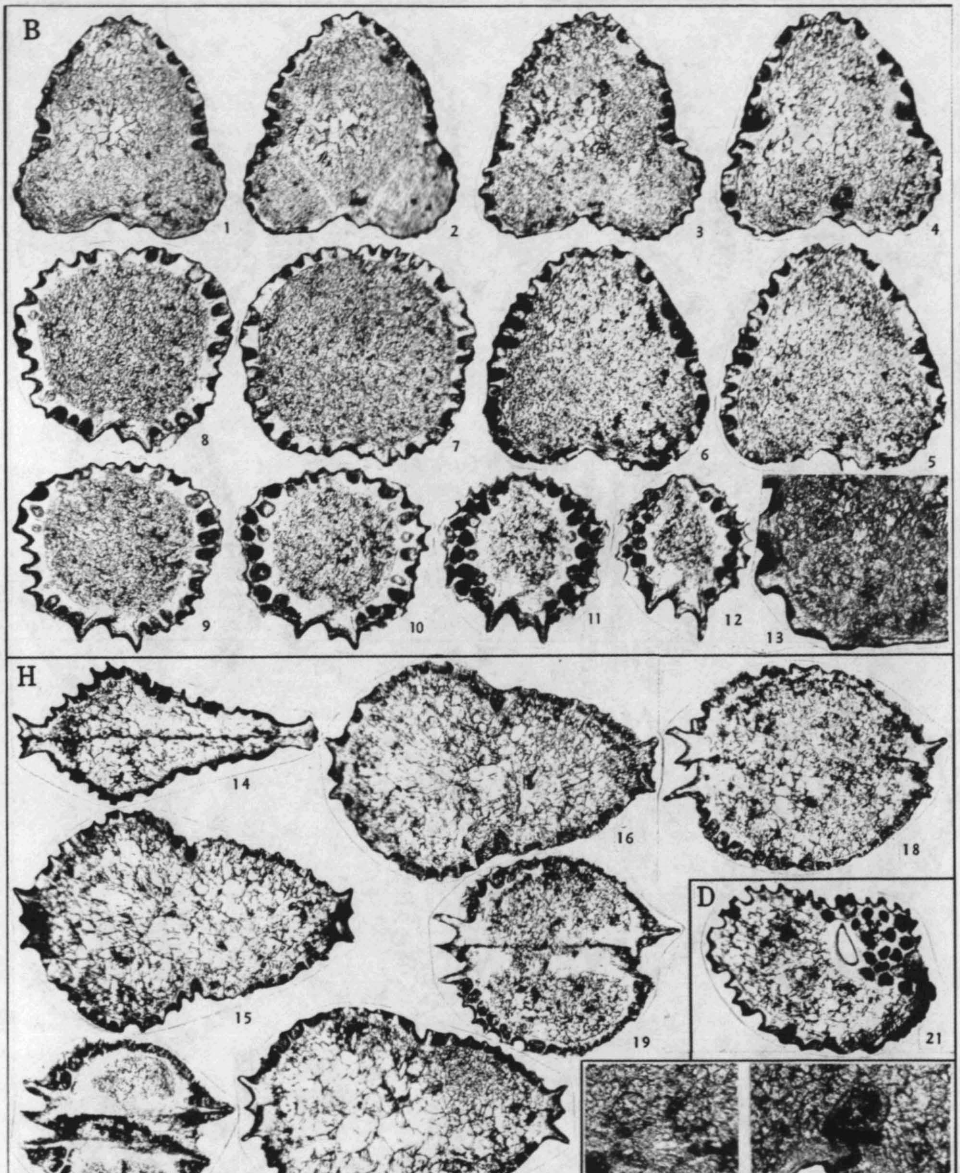
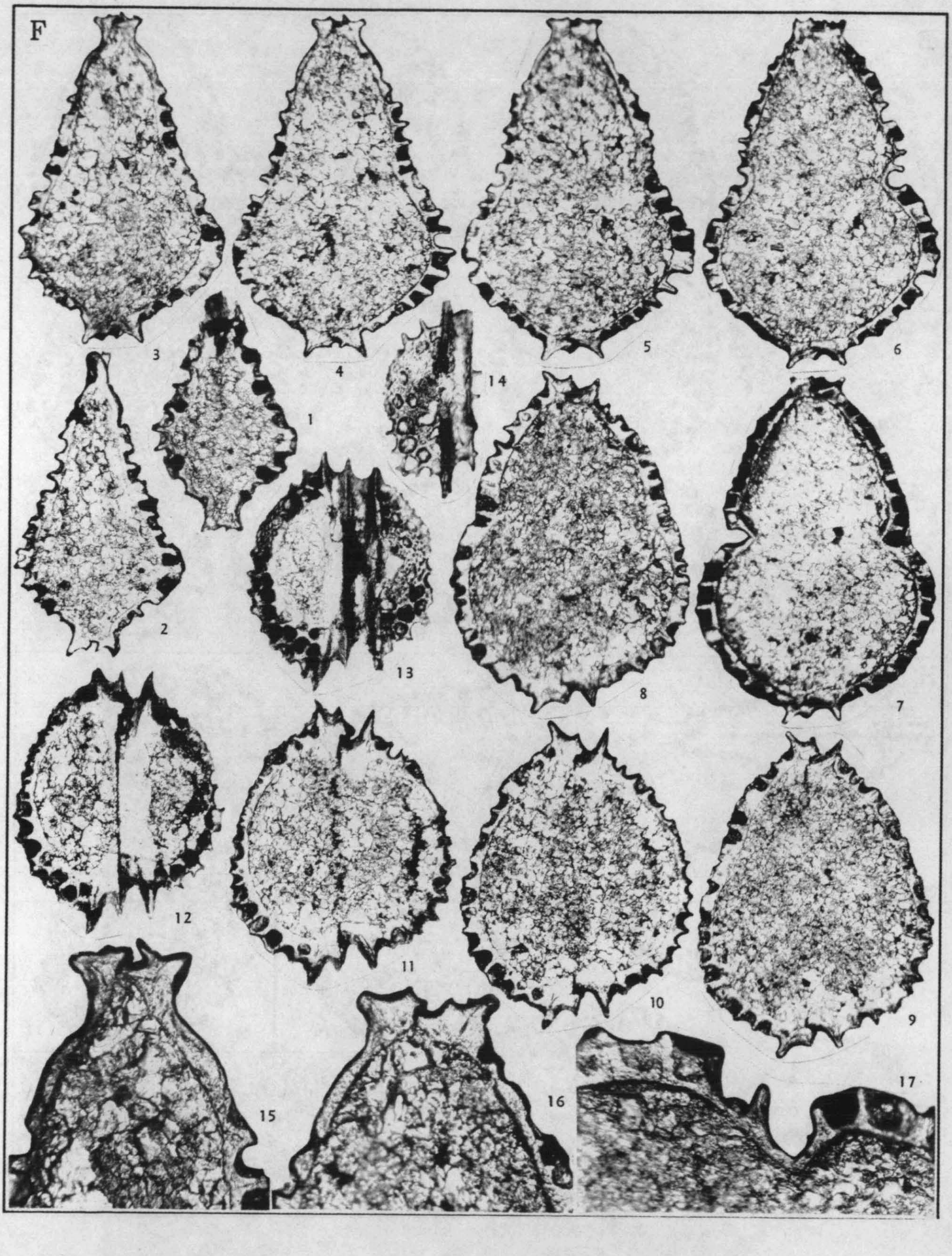


PLATE IV



EXPLANATION OF PLATE IV

Hibbardia lacrimosa (Swartz and Oriel)

FIGS. 1-14. Selected frontal peels from top to bottom in specimen F, as seen from below, with the right valve at the left in each figure. Figs. 6 and 7 show the pit. The peel shown in Fig. 7, made after longer etching than the other peels, has details of the reticulation obscured. × 28.

FIGS. 15-17. Enlargements of parts of peels shown in Figs. 3, 5, and 7, respectively, illustrating details of the contact margin and the pit. × 70.

EXPLANATION OF PLATE V

Hibbardia lacrimosa (Swartz and Oriel)

FIGS. 1-12. Selected frontal peels from top to bottom in specimen E, as seen from below, with the right valve in the left half of each figure. The upper ends of the internal rodlike struts are shown attached to the valves in Fig. 6, cross sections of them in Figs. 7 and 8, and their ventral attachments in Figs. 9 and 10. Marginal denticles of the right valve can be seen in Figs. 10 and 11. × 28.

FIG. 13. Frontal peel through the pits in specimen G, as seen from below. Many details of the specimen have been destroyed by pyritization. × 28.

FIGS. 14-17. Enlargements of parts of peels shown in Pl. IV, Figs. 2, 4, 5, and 8, respectively, illustrating details of the contact margin in the posterior part of the carapace. × 70.

FIG. 18. Enlargement of part of peel shown in Pl. III, Fig. 2, illustrating details of the dorsal part of the internal rodlike strut. × 70.

FIGS. 19-20. Two successive parasagittal peels near the right side of specimen C, as seen from the right. These show the pit and the adjacent reticulation. × 28.

PLATE V