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Lower Devonian Manlius/Coeymans Formation of Central New York, USA

CARLTON E. BRETT

A SHOWPIECE OF THE YALE PEABODY MUSEUM

In the late 1800s, a number of spectacular slabs of well-preserved fossil crinoids were discovered from the Lower Devonian thin-bedded limestones that had been excavated in small quarries for building and agricultural lime production in the township of Litchfield, Herkimer County, New York. The best-known localities were farm quarries in the hamlets of Jerusalem Hill and Days Corners (Fig. 114). A most spectacular, and now famous, slab with fossil crinoids was excavated by Charles Beecher and Charles Schuchert in the quarry of John Salisbury around the turn of the century. It was shipped in a series of crates weighing more than 2,100 kg and reassembled in the Yale Peabody Museum as one of the richest single-specimen slabs of fossil crinoids then known in North America. The slab, measuring 2.1 by 1.8 m, is presently displayed in a wall case at Yale University and has been the subject of several studies. In 1905, Mignon Talbot described the slab and its fossils, noting the occurrence of four species of crinoids. The most abundant are *Cordylocrinus plumosus*, followed by *Melocrinites* (now *Ctenocrinus*) *pachydactylus* and two new species: *Mariacrinus beecheri* (now *Ctenocrinus nobilissimus*) and *Thysanocrinus* (now *Ambicocrinus*) *arborescens*. With more than a thousand specimens of these four crinoids (some 887 calyces of *Cordylocrinus* alone), this slab contained more crinoids than had been found at that time in all the rest of the fossil-bearing beds of New York State.

The stratigraphy of the Helderberg Group, including beds containing the crinoids, was revised by Rickard

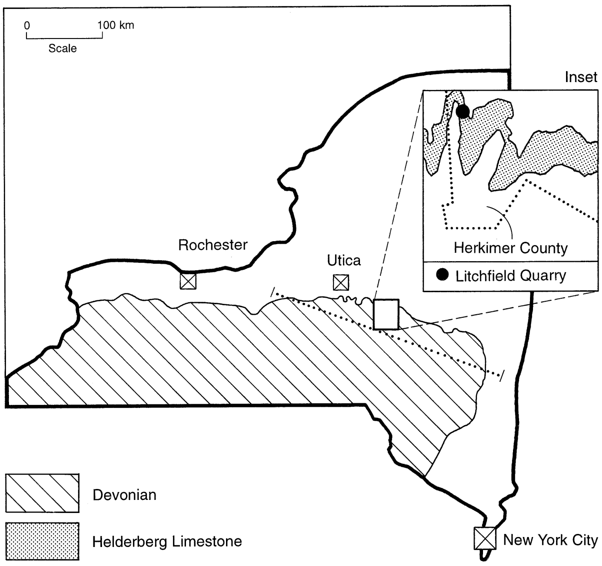

Fig. 114. Location map for Manlius/Coeymans crinoid locality near Litchfield, N.Y. Dotted line indicates approximate line of cross section shown in Fig. 115. (After Hicks & Wray in press.)

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(1962), and depositional environments were considered in detail by Laporte (1967, 1975). Goldring (1923) discussed and illustrated all of the crinoids then known from the Litchfield area, including those from the famous Days Corners Quarry site. The type specimens and many other crinoids from the Litchfield area, illustrated by Goldring, are presently housed in the extensive collections of the New York State Museum in Albany.

However, relatively little subsequent work was undertaken on these spectacular fossil assemblages until 1988, when two students at Yale University, Jason Hicks and Charles Wray, made a detailed taphonomic and palaeoecological study of the famous Beecher slab in the Peabody Museum. The result of their work has been submitted for publication, and a good deal of what is noted about the fossil occurrence in this chapter is derived from that study.

The famous crinoid-bearing slabs from the Litchfield area are derived from thin, platy limestones of the Helderberg Group of Early Devonian age (Lochkovian, 405–408 million years old). In the Litchfield area, the lower two formations assigned to the Helderberg Group interfinger with one another (Rickard 1962). Crinoids are reported from transitional beds near the contact of the Olney Member of the Manlius Formation and the overlying massive crinoidal limestone of the Deansboro Member of the Coeymans Formation (Fig. 115).

SHALLOW LAGOONS AND CRINOIDAL SHOALS

The Manlius Limestone, in its type locality, is a particularly fine-grained, laminated, light grey weathering limestone. Portions of the Manlius Limestone display features such as mud cracks, small-scale rippling and very fine, wavy laminations, attributed to stromatolitic algal mats; these features are indicative of the wet–dry regime of the supratidal mud flat zone. These portions of the Manlius have generally been interpreted as intertidal to very shallow subtidal (Fig. 116). Lagoonal facies are also common within Manlius rocks and consist of thin, rather evenly bedded, light blue-grey laminated limestones separated by fossiliferous shaly partings; this facies is commonly referred to as ribbon-bedded limestone. Some of these layers display graded bedding indicative of storm deposition. Certain bedding planes are covered with low-diversity assemblages of brachiopods, bivalves, ostracodes and *Tentaculites*; the latter may display bimodal orientation suggestive of oscillating or wave activity. In parts of the Manlius Formation, repre-

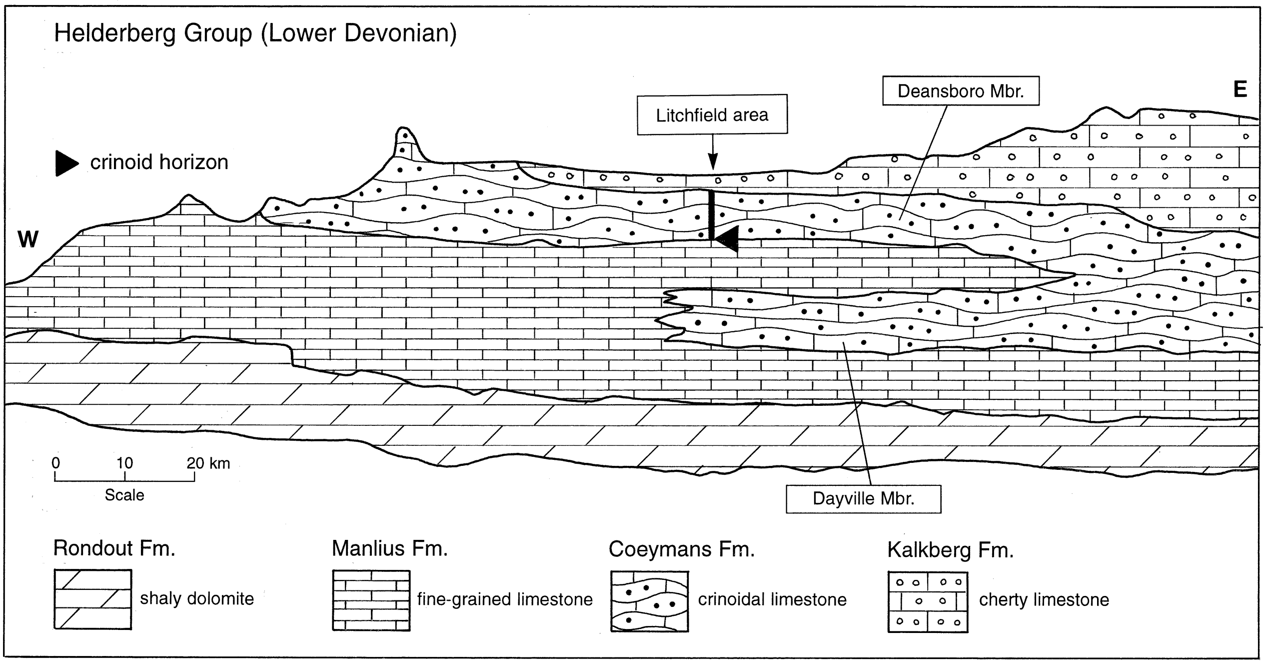

Fig. 115. Generalized stratigraphic profile for the Lower Devonian Helderberg Group of central New York; see Fig. 114 for line of cross section. (Modified from Rickard 1962.)

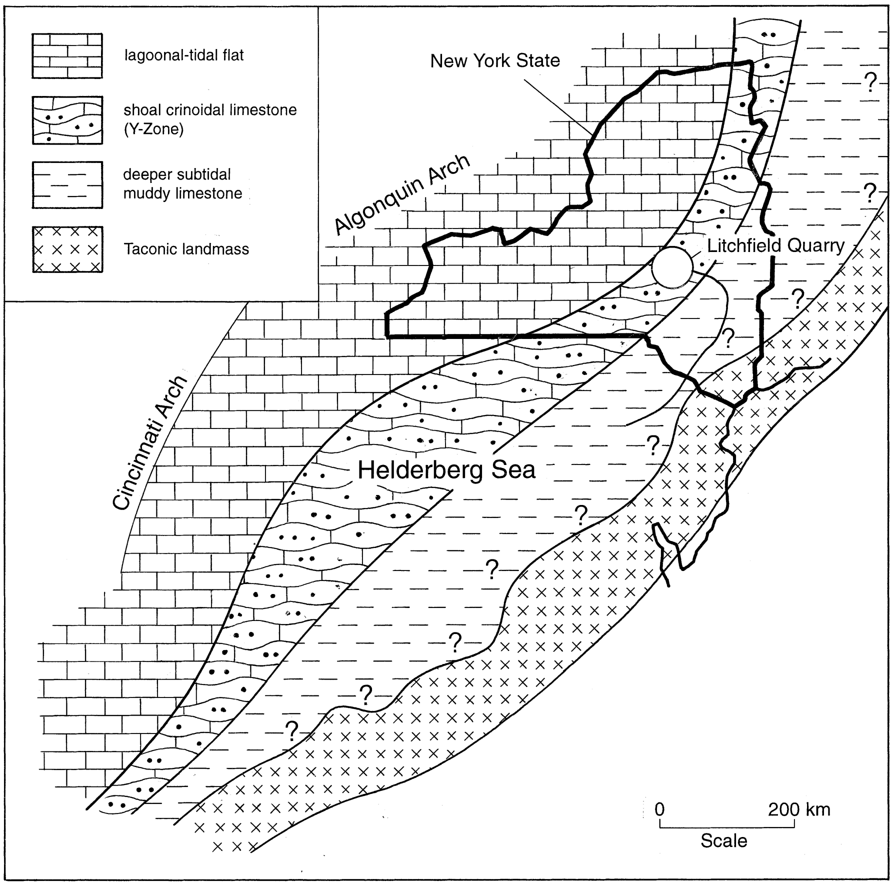

Fig. 116. Palaeogeography of Early Devonian Helderberg Group. Curved line emanating from position of Litchfield indicates northeastern limit of Devonian outcrop. (Modified from Hicks & Wray in press.)

senting the outer portions of the lagoon, cabbage head–like stromatoporoids and favositid corals may occur in large quantities, forming small patch reefs or, more commonly, biostromes of skeletal material or interbedded lime mud.

The Manlius Formation interfingers with and is eventually overlain by tongues of the Coeymans Limestone (Fig. 115). In contrast to the fine, platy, often thin-bedded to laminated weathering Manlius Limestone, the Coeymans is thick-bedded to massive skeletal limestone. It is composed primarily of the disarticulated plates and columnals of crinoids and cystoids. In addition, the Coeymans Limestone, in the central New York area, commonly possesses small, sausage-shaped calcitic holdfasts of the rhombiferan cystoid *Lepocrinites*. Complete crinoids and cystoids are rare within the Coeymans, which consists of skeletal debris that was probably reworked several times by storm and, possibly, normal fair-weather waves. There is relatively little mud in the Coeymans; rather, the echinoderm skeletal material is bound together by sparry, crystalline calcite cements. The absence of lime mud indicates that these skeletal deposits were winnowed by waves and/or currents that removed the fine-grained sediments.

GOOD PRESERVATION IN LOW SPOTS OF THE SEA FLOOR

The famous Yale slab and numerous smaller limestone slabs in the New York State Museum (Fig. 117) display exquisitely preserved crinoids, many of which preserve long sections of gently curving stems. On some bedding planes, stems and crowns occur in tangled masses, suggesting that these organisms were swept together by currents during the time of deposition. Further evidence for current orientation has been obtained in the studies

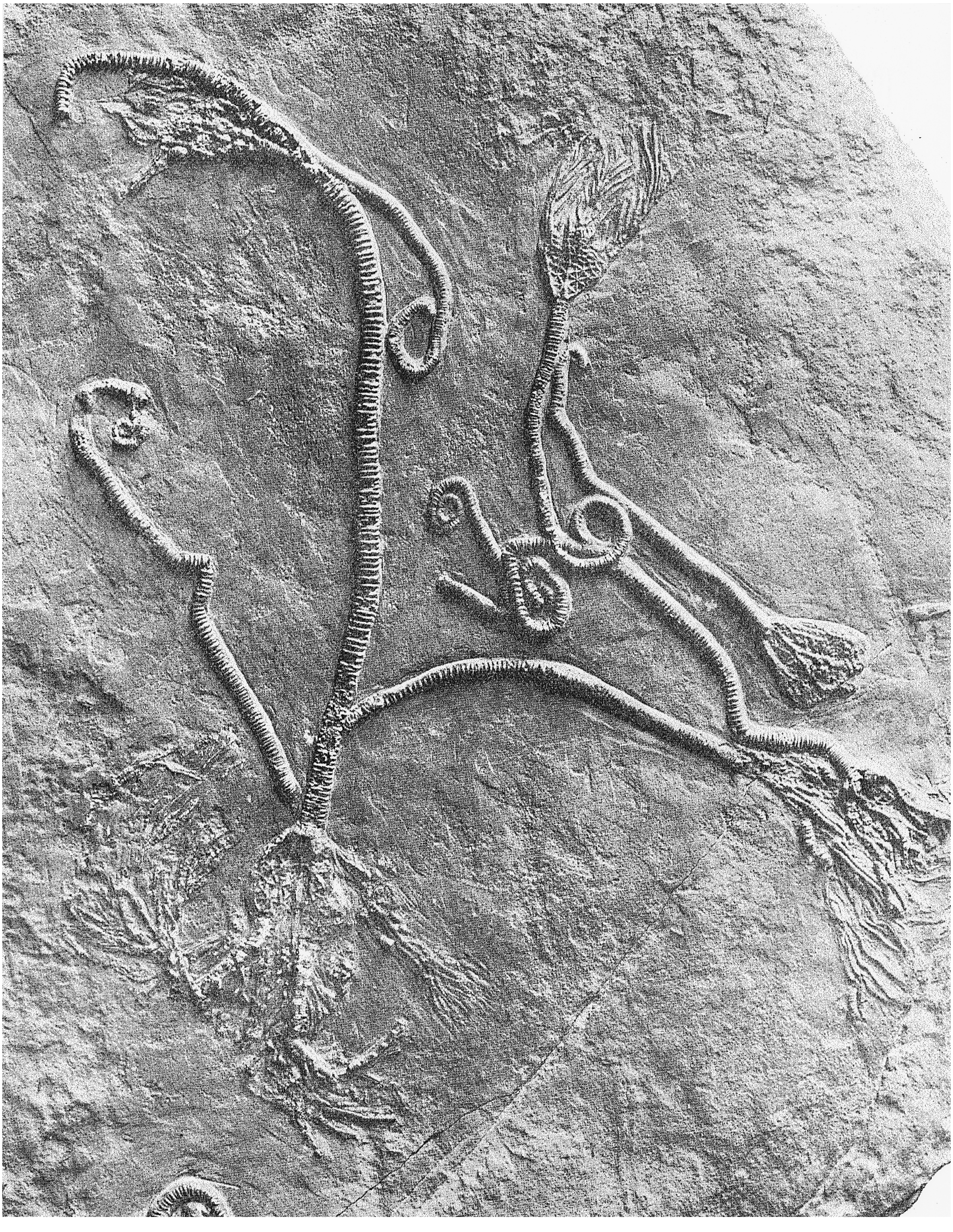

Fig. 117. Upper surface of slab with six nearly complete individuals of *Ctenocrinus pachydactylus*; note coiled distal stems. Manlius/Coeymans transitional limestone, Jerusalem Hill, Litchfield, N.Y. (New York State Museum; from Goldring 1923.) ×1.

of Hicks and Wray. They observed two prominent modes of orientation. One may represent the rolling of stems with the current. Another mode, at approximate right angles to the first, may represent complete individuals in which the stems were splayed out parallel to the current, with the crowns, slightly heavier, acting as drags or anchors.

The crinoids of the Yale slab appear to have been accumulated in a low spot on the sea floor or in a slight low-energy pocket where the remains became trapped during very local transport because of a locally lowered current velocity. Some of the slabs in the New York State Museum display complete crowns with outstretched arms, but they lack stems. Similar preservation has been observed in Triassic *Chelocrinus carnalli* beds (see Chapter 21). The absence of stems can be explained in one of two ways: either the crinoids died some brief period before their final burial and decay of ligaments had thus allowed the disarticulation of the crowns from the stems, or the crowns were autotomized. Modern crinoids may voluntarily cast off portions of their stems or arms during stress. This process, referred to as autotomization, could account for the stemless crowns. Perhaps the storm disturbances, which ultimately led to mass mortality and burial of the crinoids, stimulated the animals to cast off their stems. However, the intact nature of most crowns argues against this process, as it is the arms that are frequently cast off during autotomization in extant crinoids. Most accumulations on some bedding planes may represent the other side of this story – that is, the stems that were separated from the crowns and that were then moved separately because of slightly different hydrodynamic properties.

Crinoids on the Manlius bedding planes were buried in fine, yellowish, slightly dolomitic, carbonate-rich siltstone. This material resembles sediments in the mud-cracked supratidal facies of the Manlius that may have been washed from the shoreline during times of heavy hurricanes. Long-distance transport of the crinoids seems unlikely because the delicate pinnulate arms of many specimens are intact. However, local transport is evident from the orientation and aggregation of crinoid clusters. Once the remains had been aggregated, they were rapidly buried in the fine silt and not exhumed later. Early diagenetic cementation of the carbonate may have protected the crinoids from severe compaction. However, later diagenetic effects, particularly dissolution under pressure, have detracted somewhat from their appearance.

PREDOMINANCE OF LONG-STEMMED CRINOIDS WITHOUT PERMANENT HOLDFASTS

Crinoids on the Manlius slabs include seven species, heavily dominated by pinnulate camerates and the small cladid *Lasiocrinus*. These crinoids predominantly possessed long, relatively flexible-appearing stems with no permanent holdfast (Fig. 119). *Ctenocrinus* is the largest of the camerate crinoids; the slightly smaller *Ctenocrinus nobilissimus* is similarly adapted (Fig. 118). These forms had complex ramulate and pinnulate arms. Cowen's (1981) functional study of these melocrinids suggested that the evolution of heavily ramulate arms was a strategy for more effective filtering of a particular volume of water for suspended plankton. In any event, it is reasonable to postulate that these crinoids were adapted to the filtration of relatively small food particles by leeside suspension feeding in a manner similar to that of many modern isocrinids, which likewise possess highly efficient space-filling pinnulate arms (Figs. 235, 236). *Ctenocrinus* had a long, heteromorphic stem that appears to have had considerable flexibility (Fig 117). These stems typically formed distal coils and perhaps in some cases formed loops that helped to support the upright portion of the stem. These loops would have lain on the sea floor with a vertical portion of the column rising from them, rather like a coiled rattlesnake (the type specimen of *Acanthocrinus rex*, Fig. 124, can serve as a comparison). The long stems, sometimes approaching 1 m in length, served to elevate the large crowns into positions of higher current strength for feeding.

Two other, somewhat more common crinoids occupied a lower tier, typically 30 cm or less above the sea floor. *Cordylocrinus* (Fig. 120) belongs to the group of hapalocrinids that, relatively early in their evolutionary history, developed whorled radicular cirri on the stem. *Cordylocrinus* and its relatives appear to have borne runner-like portions of the stem on the sea bottom in the manner of modern isocrinids. Presumably, therefore, these crinoids may have fed from relatively low levels within the water column. They possessed sparsely branched but delicately pinnulate arms, which were presumably utilized in filtration-mesh feeding. The wider gaps of these arms may have been adapted for the interception of suspended particles somewhat larger than those of the longer-stemmed *Ctenocrinus*.

Likewise, the small but comparatively long-stemmed (up to 20 cm) cladid *Lasiocrinus* (Fig. 119) with its densely branched arms was presumably adapted for filtration-mesh feeding on relatively larger particles. Like

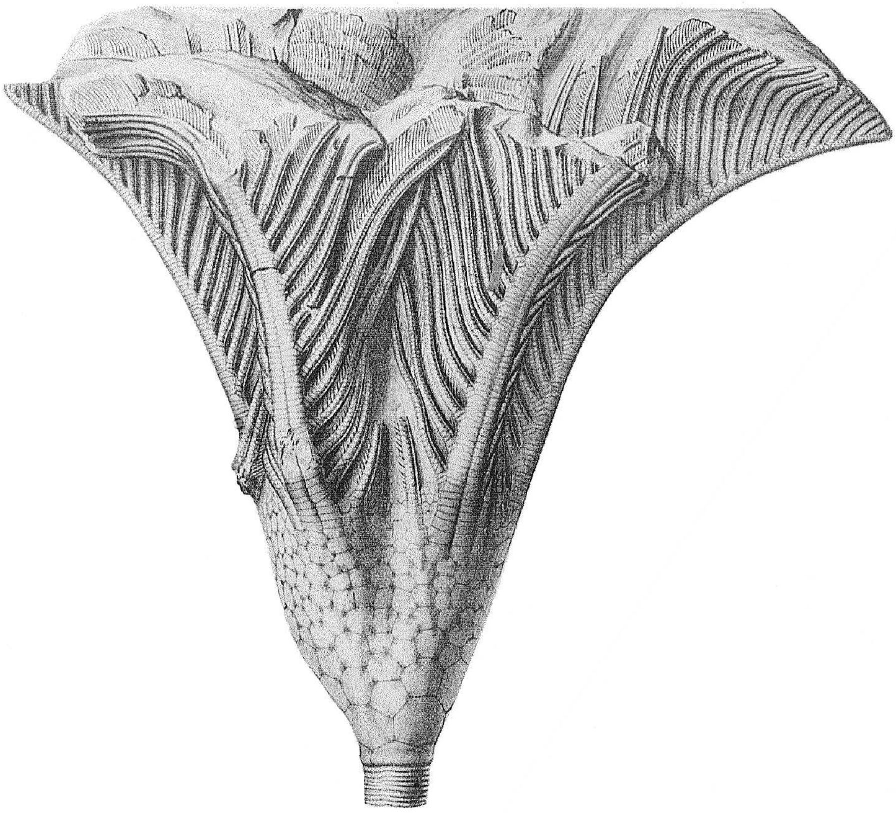

Fig. 118. *Ctenocrinus nobilissimus*, posterior view of Hall's type specimen. Note highly ramulate arm trunks. Manlius/Coeymans Limestone, Litchfield, N.Y. (American Museum of Natural History; from Goldring 1923.) ×1.

Cordylocrinus, *Lasiocrinus* possessed whorls of flexible radicular cirri on the stem, which may have aided in temporary attachment and adjustment of position on soft and shifting substrates of carbonate silt and fine sand. This small cladid appears to have been a generalist and perhaps an opportunistic species. It lived in large numbers in shallow lagoonal settings that were not inhabited by a high diversity of other echinoderms. *Lasiocrinus* tends to occur in clumps of up to hundreds of individuals on certain bedding planes in the fine-grained ribbon rock facies of the Manlius Limestone, where few other crinoids or other fossils are common. *Lasiocrinus* is present, but less common, in the more diverse camerate-dominated assemblages, such as the *Cordylocrinus* and *Ctenocrinus* associations.

The Manlius assemblages are heavily dominated by crinoids. However, a relatively low diversity of brachiopods, primarily the spiriferid *Howellella*, and small rhynchonellids occur on some of the crinoid-bearing slabs. In addition, large, smooth ostracods and the annulated tubes of *Tentaculites* may be common. Small ramose bryozoans and pteriniids (wing oyster bivalves) are typically associated. Only a few other echinoderms, aside from the four to five crinoids, occur in these assemblages. Most notable among these is the small mitrate (carpoid echinoderm) *Anomalocystites*. Some beds in the crinoid-bearing Manlius facies show evidence of early submarine cementation to form hardgrounds. These slabs may bear abundant encrusting edrioasteroids. These are small (0.5–1 cm in diameter) discoidal echinoderms that resemble fixed starfish with a web of interambulacral plates between the rays. Edrioasteroids apparently filter-fed in areas of cleaner water near the substrate.

Finally, although not common in the crinoid-rich assemblages of the Manlius transition beds, the rhombiferan *Lepocrinites* does occur rarely. However, it is the dominant echinoderm in the adjacent crinoidal shoal deposits of the Coeymans Formation. These echinoderms appear to have been adapted to a high-energy environment and a substrate of shifting skeletal sands. Their particular attachment strategy is quite unique.

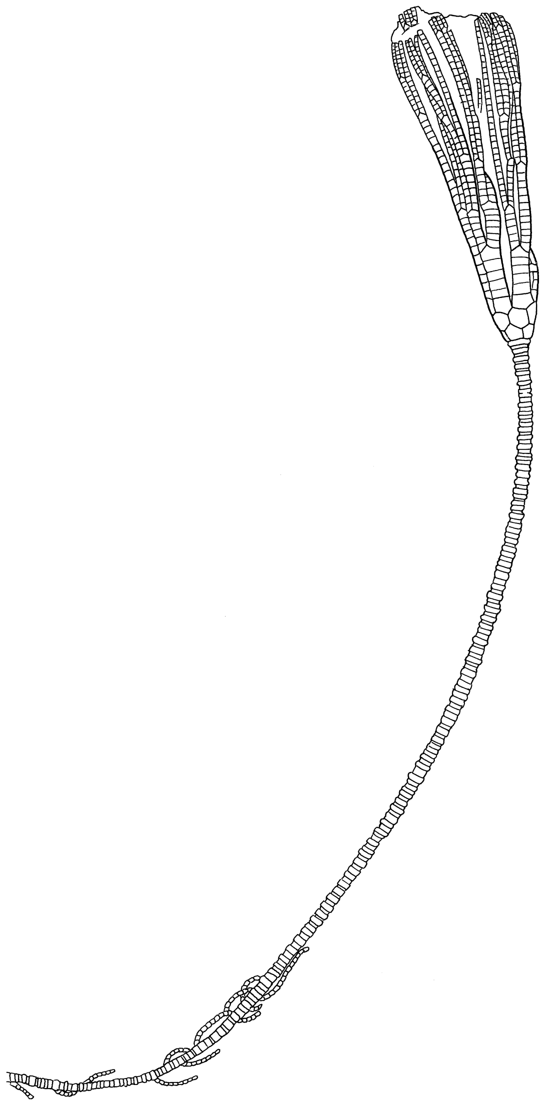

Fig. 119. *Lasiocrinus scoparius*. Complete specimen with crown and stem with whorls of radicular cirri along the distal end. Manlius/Coeymans transition at Jerusalem Hill near Litchfield, N.Y. (American Museum of Natural History; redrawn from Goldring 1923.) ×2.7.

They possessed a long, cylindrical or sausage-shaped body at the end of their short, stocky stems. This solid piece was apparently inserted into the loose skeletal sand or silt and served as an anchoring device.

A SHOAL-MARGIN ASSEMBLAGE

Crinoids are not common in most of the Manlius facies, although specimens of the small cladid *Lasiocrinus* may occur in considerable numbers on some bedding planes in the platy ribbon-bedded facies. This small crinoid may have become adapted to the conditions of the lagoon.

Presumably, the lime mud was transported from part of the lagoon into the lower-energy environments to the west and northwest of the Coeymans depositional belt (Fig. 116). The Coeymans Limestone may display cross-stratification and graded bedding. All this suggests that the skeletal debris accumulated under high-energy, turbulent water conditions close to or at normal fair-weather wave base. These skeletal sand and gravel deposits have been interpreted as offshore shoal facies that accumulated in the zone commonly referred to as the Y Zone or, in other words, the region at which fair-weather waves commonly disturb the sea floor. The development of a skeletal shoal or bar complex probably sheltered a shallower, more onshore zone or lagoons and muddy carbonate tidal flats. This is the environment represented by the Manlius Limestone. Although the lagoon was sheltered and was thus an area for the accumulation of fine-grained sediments on a day-to-day basis, occasional storms washed skeletal debris onshore and swept it into the shallow lagoon.

Crinoid beds are best developed in an area of interfingering between the Manlius and Coeymans facies.

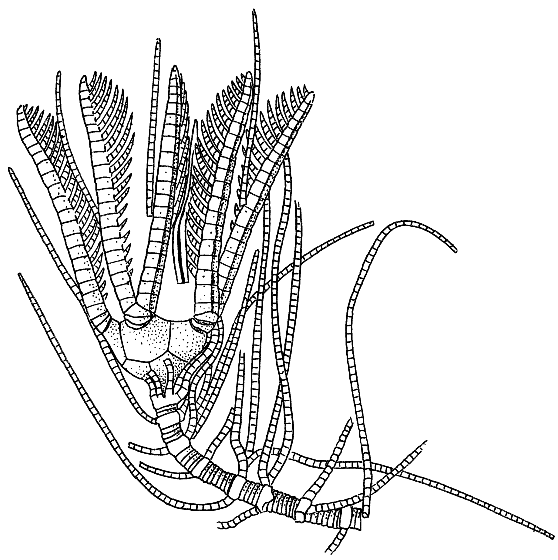

Fig. 120. *Cordylocrinus plumosus*. Note whorls of radicular cirri spaced regularly along the stem. Manlius/Coeymans Limestone, Days Corners near Litchfield, N.Y. (American Museum of Natural History, Yale University Collection; redrawn from Goldring 1923.) ×3.

These probably represented the inner margin of the skeletal shoal. Here, water was sufficiently well aerated and agitated to support dense stands of suspension-feeding crinoids but also quiet enough to prevent dislodgement and transport of the weakly rooted crinoids. Intermittent storms, however, disrupted the delicate crinoid gardens and dumped fine carbonate silt onto the slightly decayed remains on the sea floor. As in several other shoal-margin assemblages, the loose tethering of the Manlius crinoids may have made them particularly vulnerable to such episodic events.

IMPORTANT COLLECTION IN THE UNITED STATES

New York State Museum, Albany