FOSSIL BEDS OF THE FALLS OF THE OHIO

Stephen F. Greb,
Richard Todd Hendricks,
Donald R. Chesnut, Jr.

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PART I—INTRODUCTION

The Falls of the Ohio on the Ohio River at Louisville, Kentucky, is world famous for its fossil beds. Fossils can be seen in the rocks along the shore most of the year, but the best time to see large areas of exposed fossil beds is when the Ohio River is at low levels during the summer. This booklet was put together to help educators, students, geologists, and amateur rock hounds understand the geologic history of the Falls area. It is divided into three parts. Part I discusses the general geology and history of scientific discovery of the Falls area (p. 1 to 5). Part II is a walking tour, and describes the fossil beds and some of the key areas in which to see fossils (p. 5 to 10). Part III describes common fossils at the Falls and includes numerous photographs and discussions about the types of animals that formed the fossils (p. 10 to 29).

The fossil beds at the Falls of the Ohio are part of a National Wildlife Conservation area and an Indiana State Park and are therefore protected by both Federal and State laws. ROCK AND FOSSIL COLLECTING IS NOT PERMITTED. Also remember that the Falls area is subject to flooding. For your own safety read warning signs in the parking area before walking down to the fossil beds.

Location

The Falls of the Ohio is located on the Ohio River between Louisville, Kentucky, and Clarksville, Indiana, north of McAlpine Dam (No. 41) and south of the elevated railway bridge (Fig. 1). The best access is to take the Jeffersonville, Indiana, exit off of Interstate Highway 65 (first exit north of the river if driving north, last exit before the river if driving south), then drive south to Riverside Drive and west along the river $^{1}/_{4}$ mile past the railroad bridge underpass. Look for signs to the fossil beds. A parking lot and Visitors Center are planned for completion in 1993.

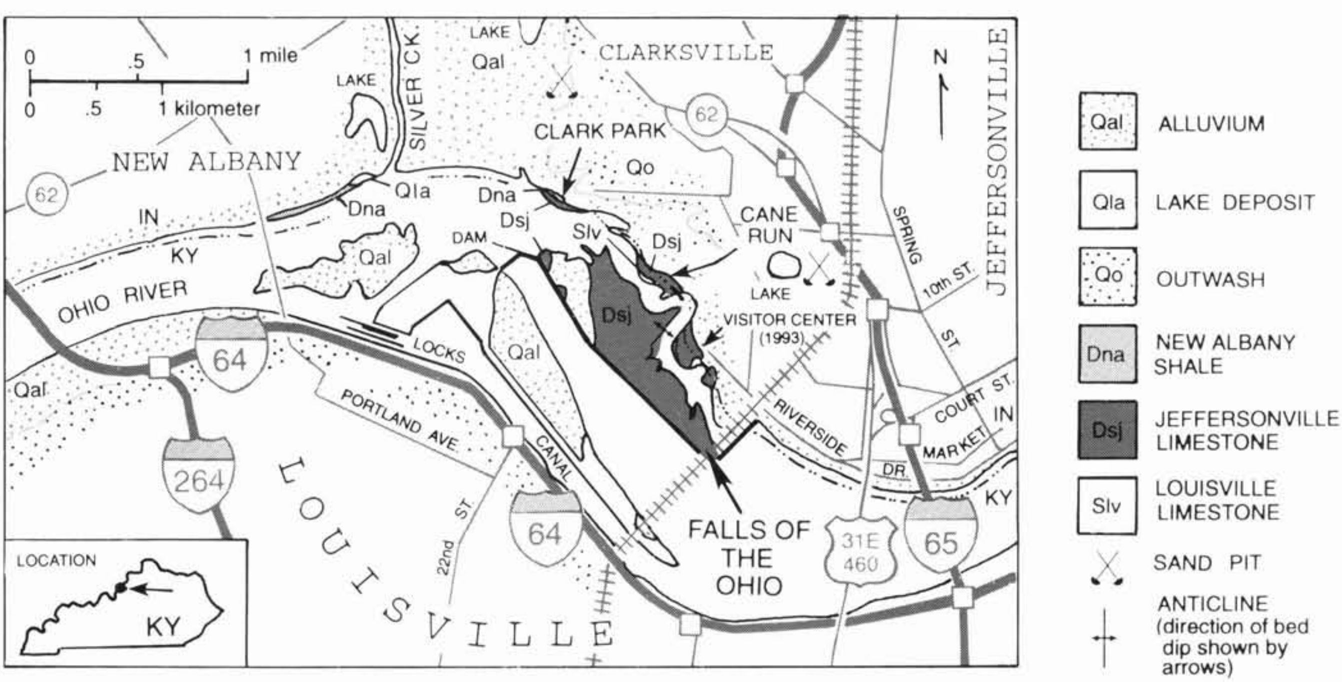


Figure 1. Geologic map of the Falls of the Ohio area showing the units of rock exposed. The main fossil beds are shown in detail in Figure 5.

Geology of the Falls Area

The Falls of the Ohio is the only outcropping of bedrock along the length of the Ohio River. The area is so named because the bedrock forms a natural series of rapids in which the river falls 8 m (26 ft.) in 4 km (2.5 miles). The rapids were a natural obstacle to explorers of the region, and were the reason the cities of Louisville, Jeffersonville, Clarksville, and New Albany developed where they did. The famous explorer George Rogers Clark founded the first permanent English-speaking settlement of the Northwest Territory at the Falls. Later, in 1803, his brother William set out from the settlement adjacent to the exposed bedrock with Meriwether Lewis to explore the Louisiana Purchase.

Figure 1 is a map of the Falls area showing the types of rocks and sediments and the names of rock units exposed at the surface in the area. Figure 2 arranges the rock units from youngest to oldest in a geologic column. These units and the fossils they contain can be used to determine the geologic history of the Falls area.

Quaternary Period

Within the last 50,000 years, great sheets of glacial ice moved south from northern Canada toward the modern Ohio River Valley. Geologists call this time the Pleistocene Epoch of the Quaternary Period, but most people call it the Ice Age. Two ice sheets may have reached the present-day location of Louisville, Kentucky. The last ice sheet, which was part of the Wisconsinan glacial interval, reached to within 96 km (60 miles) of Louisville (Wayne, 1952; Powell, 1970). As the glaciers spread south from Canada they eroded huge amounts of rock and sediment, which were pushed in front of or became frozen into the moving ice. When the glaciers reached into Indiana they began to melt, releasing vast amounts of water that carved deep river valleys into southern Indiana and Kentucky. The valleys were filled with the sediment eroded by the glaciers. Each time another glacier advanced into Indiana, the existing drainages were altered by the new meltwaters and sediment. Twelve thousand years ago the meltwater from the Wisconsinan ice sheet changed the course of the pre-glacial Ohio River and formed the modern Ohio River Valley. Much of the valley was filled with sediment washed from the ice sheet when it finally melted (called outwash). Other parts of the valley were filled by sediment deposited in large lakes when streams became choked by the huge volume of sediments being deposited. In some areas more than 65 m (200 ft.) of outwash and lake sediments were deposited (Fig. 2).

Although much of the present Ohio River Valley is filled with sediment, bedrock is still exposed at the Falls. It is possible that the modern river has eroded through a part of its own valley and exposed a part of an older, bedrock ridge or valley wall left over from an older glacial river (Powell, 1970). Another explanation is that geological structures buried deep beneath the river valley may have pushed the bedrock upward at the Falls. Evidence for this explanation is that the rocks at the Falls are high-

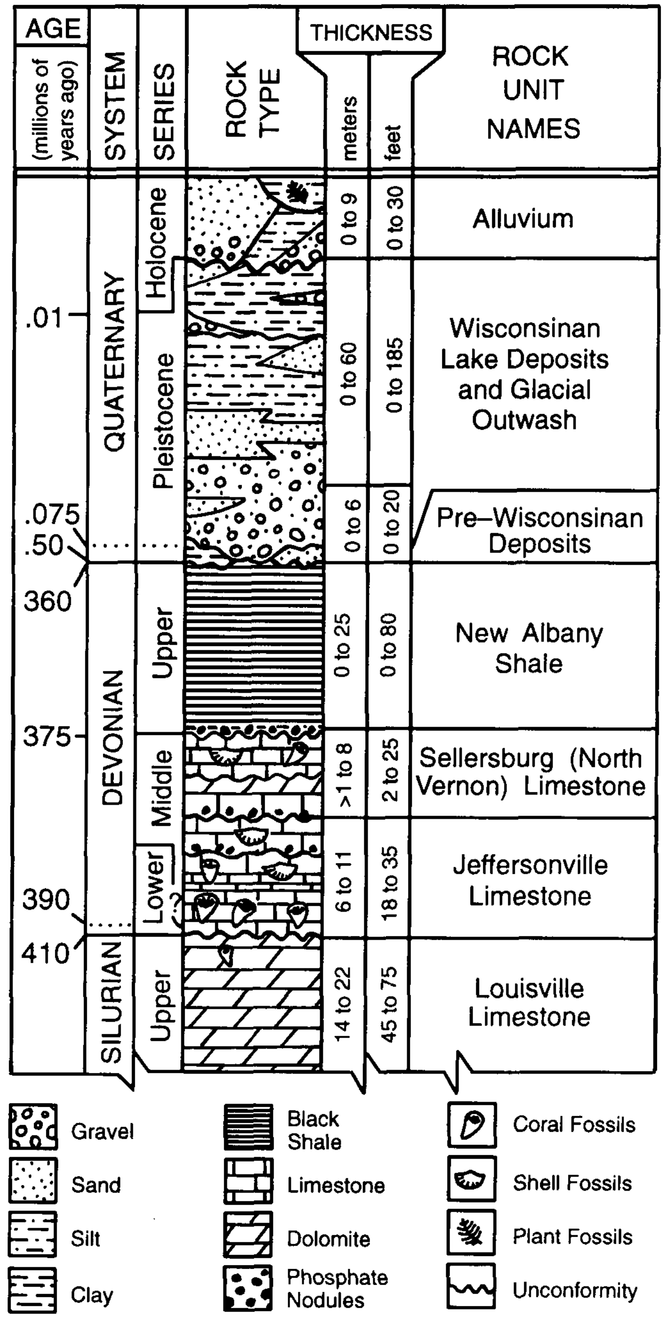


Figure 2. Generalized geologic column showing the rock units exposed in the Falls area (*after* Kepferle, 1974).

ly jointed, and rock strata just west of the railroad bridge dip to the east while strata west of the main fossil beds dip to the west; this upward bulging of strata is called an anticline (Fig. 1).

Rocks from the Ice Age can be seen several places in the Falls area. Several large blocks of sandstone with quartz pebbles occur above the Falls; these rocks are unlike rocks from the surrounding area. The nearest source for these kinds of conglomeratic sandstones is 65 km (40 miles) away. These blocks may be glacial "erratics." Erratics are rocks that have been transported by glaciers to an area where they are not normally found. The erratics in the Falls area may have dropped out of chunks of ice that floated south of the last glacier.

Several sand and gravel pits in the Falls area are mined for alluvial and outwash sediments from the Wisconsinan glacial interval (Qal and Qo in Figure 1). Also, silt and mud that have been deposited between the last ice sheet and the present are exposed along the north bank of the Ohio River near the mouth of Silver Creek (Qla in Figure 1). The muds may represent an older position of Silver Creek that was plugged with sediment to form a lake. Dark, black to blue clays and silts in the outcrop contain well-preserved leaf fossils from trees that surrounded the lake. The fossils have been radiometrically dated at 2,840 $\pm$250 years before the present (Kepferle, 1974).

Devonian and Silurian Periods

The Ice Age deposits of the Falls area rest directly on much older rocks of the Devonian and Silurian Periods (Fig. 2). These rocks were deposited between 350 and 425 million years ago, and are nearly one and a half times older than the oldest dinosaur! Rocks that were deposited in the time between the Ice Age and the Devonian Periods were eroded at the Falls, although they are preserved in other parts of the Midwest. This type of gap in the rock record is called an unconformity. Geologists have divided the rocks that were preserved into units called formations. Formations share distinctive features such as rock type and grain size, and can be mapped across large areas.

The Devonian-age formations in the Falls area, from youngest to oldest, are the New Albany Shale, the Sellersburg Limestone, and the Jeffersonville Limestone. West of the mouth of Silver Creek, dark shales of the New Albany Shale crop out along the north shore of the Ohio River (Fig. 1). The dark color of the rock is caused by organic material in the shales. In fact, so much organic material is in these shales that they are called oil shales and are considered a potential source of energy. In western Kentucky, where these organic-rich shales are between 300 and 1,500 m (1,000 to 4,500 ft.) beneath the ground, they are thought to be the source of millions of barrels of oil and trillions of cubic feet of natural gas.

The shale is underlain by a thick sequence of limestones. The Middle Devonian Sellersburg Limestone (called the North Vernon Limestone in Indiana) is as much as 8 m (25 ft.) thick in the area (Fig. 2), although just west of the railroad bridge at the Falls only the lower 1.7 m (5.2 ft.) is exposed beneath Quaternary alluvium (Perkins, 1963; Kepferle, 1974). The Sellersburg Limestone is mostly fine grained, massive to thin bedded, often dolomitic (has a sugary texture), and contains few fossils.

The Sellersburg Limestone is underlain by the Lower to Middle Devonian Jeffersonville Limestone (Fig. 2). This unit forms most of the bedrock at the Falls of the Ohio, and contains the famous fossil beds. This unit is described in more detail in the following sections. The Jeffersonville Limestone is underlain by the Silurian Louisville Limestone (Fig. 2). The Louisville Limestone is often dolomitic and is only exposed at low water levels along the river's edge at the fossil beds and sometimes at the mouth of Cane Run (Fig. 1). More complete descriptions of these units are provided in Appendix A.

The limestones and fossils these rocks contain were formed when the earth was very different than it is today. Three hundred fifty million years ago the earth's continents had not yet moved into their present-day positions. There was no Atlantic Ocean, and parts of North America were connected to what is now Europe. In fact, the Falls area was located 15 to 20 degrees *south* of the equator (Fig. 3). During Devonian and Silurian times, the Falls of the Ohio had a tropical climate, much like the Bahamas have today. Not only was the area warmer, but during Devonian and Silurian times the Falls area and much of North America were covered by a vast sea (Fig. 3). The fossils in the rocks at the Falls of the Ohio are the preserved remains of the creatures that lived in that sea.

History of Scientific Study

Fossils of Devonian and Silurian sea creatures have brought scientists to the Falls of the Ohio for more than a hundred years. In 1820, paleontologists C. S. Rafinesque of Transylvania University and J. D. Clifford named several species of corals from the Falls of the Ohio, which they described as resembling "fossilized buffalo horns." These "horn" corals are one of the most abundant kinds of fossils at the Falls. In 1882, one of America's most renowned geologists, James Hall, bought a collection of fossils from the Reverend H. Herzer of Louisville, and published the first illustrations of fossils from the Falls. Five years later, geologist and paleontologist William J. Davis of the Kentucky Geological Survey published a book on the Falls of the Ohio that contained photographs of nearly 1,000 coral fossils. The photographs in Davis's book are a record of one of the greatest collections of fossils from any single area in the eastern United States (Fig. 4).

At the turn of the century (1898–1906) G. K. Greene of Louisville published 23 different papers on the fossil beds in which he described 164 species of fossil corals. However, like many of the early scientists who came to the Falls, Green was so excited about finding new species of fossils that he misidentified many of the corals he described.

For many years scientists continued to come to the Falls, and many returned to their homelands with specimens. By the 1960's fossils from the Falls had been dispersed to museums as far apart as the Museum of Paleontology at the University of Michigan and the Paleontologisches Institut in Bonn, Germany.

In 1964, paleontologist Edward Stumm set out to reexamine the coral fossils of the Falls and accurately determine the types of fossils that had been collected by his predecessors. He was able to track most of the original specimens that had been named by Hall, Davis, Greene, and other scientists to different museums. His manuscript featured more than 400 individual specimens of corals from the Falls. It is one of the most useful books for scientists and serious collectors attempting to determine the various species of corals found in the rocks around the Louisville area.

In all, more than 600 species of marine fossils have been documented at the Falls, including corals, algae, clams, clam-like animals called brachiopods, snails, trilobites, and primitive fish. These fossils are scientifically important because more than 30 percent of the species had not been found anywhere else in the world prior to their discovery at the Falls (Powell, 1970). Collections of fossil specimens from the fossil beds can be seen in the Visitors Center and the nearby Louisville Museum of History and Science. Fossils also are stored in the geol-

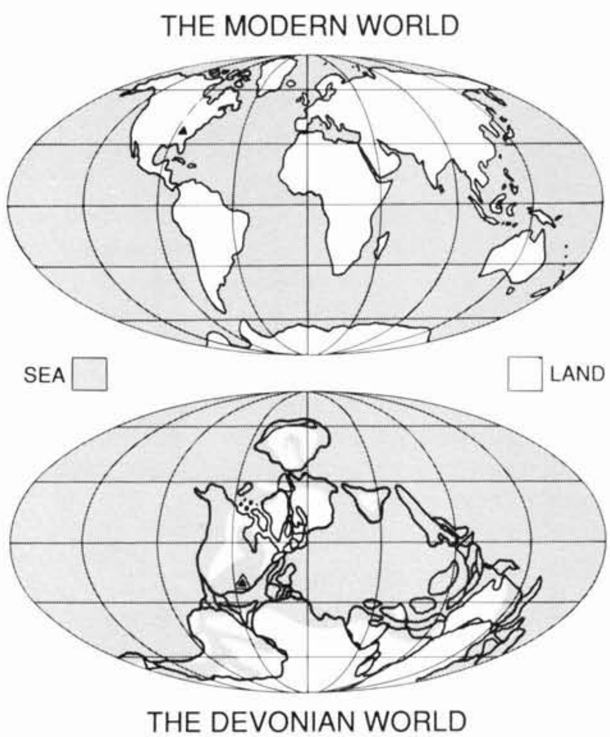


Figure 3. Diagrams showing the modern and Devonian worlds. The location of the Falls of the Ohio is shown by a triangle in both diagrams. During the Devonian, the Falls area was an inland sea south of the equator (*after* Scotese, 1986).

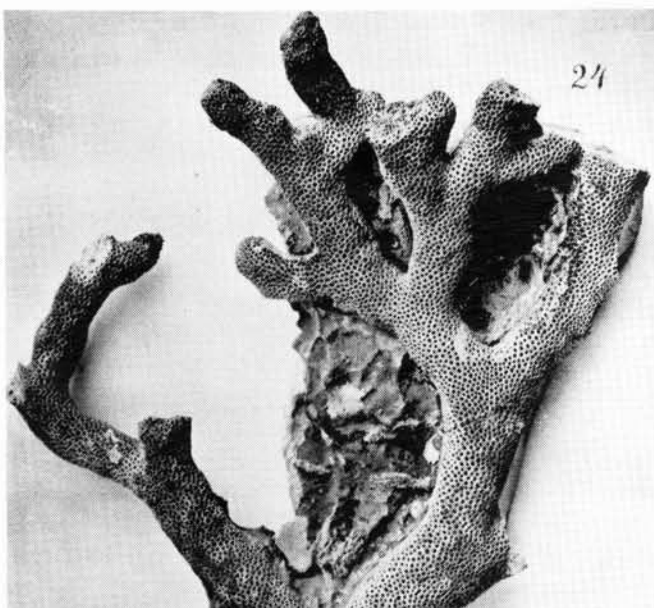


Figure 4. Photograph of a fossilized branching coral (*from* Davis, 1887). The photographs in Davis's book are all that remain of some of the original specimens.

ogy departments of the University of Louisville and the University of Kentucky in Lexington. Fossils from the Falls are in repositories of such well-known institutes as the American Museum of Natural History, United States National Museum, National Museum of Canada, National Museum in Bonn, Germany, and the Ecole des Mines in Paris, France.

Protecting the Fossil Beds

In order to preserve the fossil beds, 1,404 acres of Kentucky and Indiana along the Ohio River were dedicated as the Falls of the Ohio National Wildlife Conservation Area, protecting the fossil beds and the abundant wildlife that lives in the area under Federal law. In 1990, the State of Indiana designated 68 acres along the Indiana shore adjacent to the fossil beds as Falls of the Ohio State Park, giving additional state protection to this scientifically important area. A Visitors Center that will house exhibits and specimens from the fossil beds, so that everyone can enjoy these unique fossils, is scheduled for completion in late 1993. But to truly appreciate the thrill of discovering the fossils, don't rely solely on the exhibits; walk down to the river and discover the fossils for yourself.

PART II—WALKING TOUR

Figure 5 is a map of the main fossil beds at the Falls of the Ohio. Almost all of the rocks exposed in this area are part of the Jeffersonville Limestone. Scientists who study the Jeffersonville Limestone have divided it into several fossil zones based on the types of fossils they felt characterized each zone. Many paleontologists (Kindle, 1899; Butts, 1915; Stumm, 1964) divided the limestone into three fossil zones. Perkins (1963) mapped five zones (Fig. 5). Conkin and Conkin (1971, 1976, 1980, 1984) mapped three zones, but in different publications divided the zones into as many as five addditional subzones. In this report the zones of Perkins are used (Fig. 5). Each zone contains abundant fossils, but the types of fossils in each differ. The abundance and types of fossils change from the lower beds at the water's edge to the upper beds along the stairway or adjacent to the dam. Figure 6 illustrates the differences in the types and abundance of fossils in each of the zones mapped by Perkins. Each zone is named for a common fossil in the zone. The fossils and the creatures they represent are described in Part III of this booklet. The thickness of the black curves above each type of fossil indicates the relative abundance of the fossils in that zone. Coral fossils are most abundant in the lower 6 m (20 ft.) of the Jeffersonville Limestone; brachiopods are most abundant in the upper 5 m (15 ft.) (Fig. 6).

The reason different types and abundances of fossils are found at different levels in the Jeffersonville Limestone is that the limestone was deposited over millions of years (Fig. 2). During that time sea level changed many times and so did the animals living in the Louisville and southern Indiana area. Hence, some layers contain the remains of animals that lived in very shallow water, while other layers contain the fossils of animals that lived in deeper water. The fossil zones and best areas for viewing specific types of fossils are described below.

PLEASE DO NOT DAMAGE OR TAKE ANY FOSSILS OR ROCKS YOU SEE IN THIS AREA. These fossil beds are being studied by many scientists and are protected by Federal and State laws. Those who wish to collect specimens can find similar fossils in nearby quarries and roadcuts.

Indiana Shore—Layered Limestones and Fossil Preservation

From the parking area along Riverside Drive, two sets of stairs and a paved trail lead to the fossil beds (Figs. 5, 7a). At the bottom of the stairs, a gravel beach contains a wide variety of pebbles that were transported by the Ohio River from as far away as Pennsylvania. Sometimes fossils wash up in the loose gravel, but the best fossil viewing is in the exposed bedrock.

You don't have to go far to see fossils. Within 15 m (50 ft.) of both stairs are several rock ledges. A small outcrop of rock is near the bottom of the east stairs as you face south toward Louisville, and a more extensive ledge at the same level extends off to the right (of the west stairs) (Fig. 5). In the ledge you can see the layering of the limestone (Fig. 7b). The limestone was formed by the deposition of muds, silts, sands, and organic debris on the seafloor. These sediments contain calcite (calcium carbonate), the principal mineral in limestone. One of the ways calcite forms is from the breakdown of skeletons of seashells and corals.

Each limestone layer contains different amounts and kinds of fossils. The upper ledges are part of the fenestrate bryozoan-brachiopod zone and the *Brevispirifer gregarius* zone of the Jeffersonville Limestone (Fig. 5). The ledges contain abundant fossil brachiopods and bryozoans (Fig. 6) that stand out as white and dark-gray shapes in the light-gray limestone. The different types of brachiopods and bryozoans and how they lived are described in Part III.

In the second ledge down from the west stairs you can see small, horn-shaped corals. The corals stand out in relief from some of the bedrock surfaces. The types and sizes of corals are different from those in the overlying ledge. Many of the corals are encrusted with small,

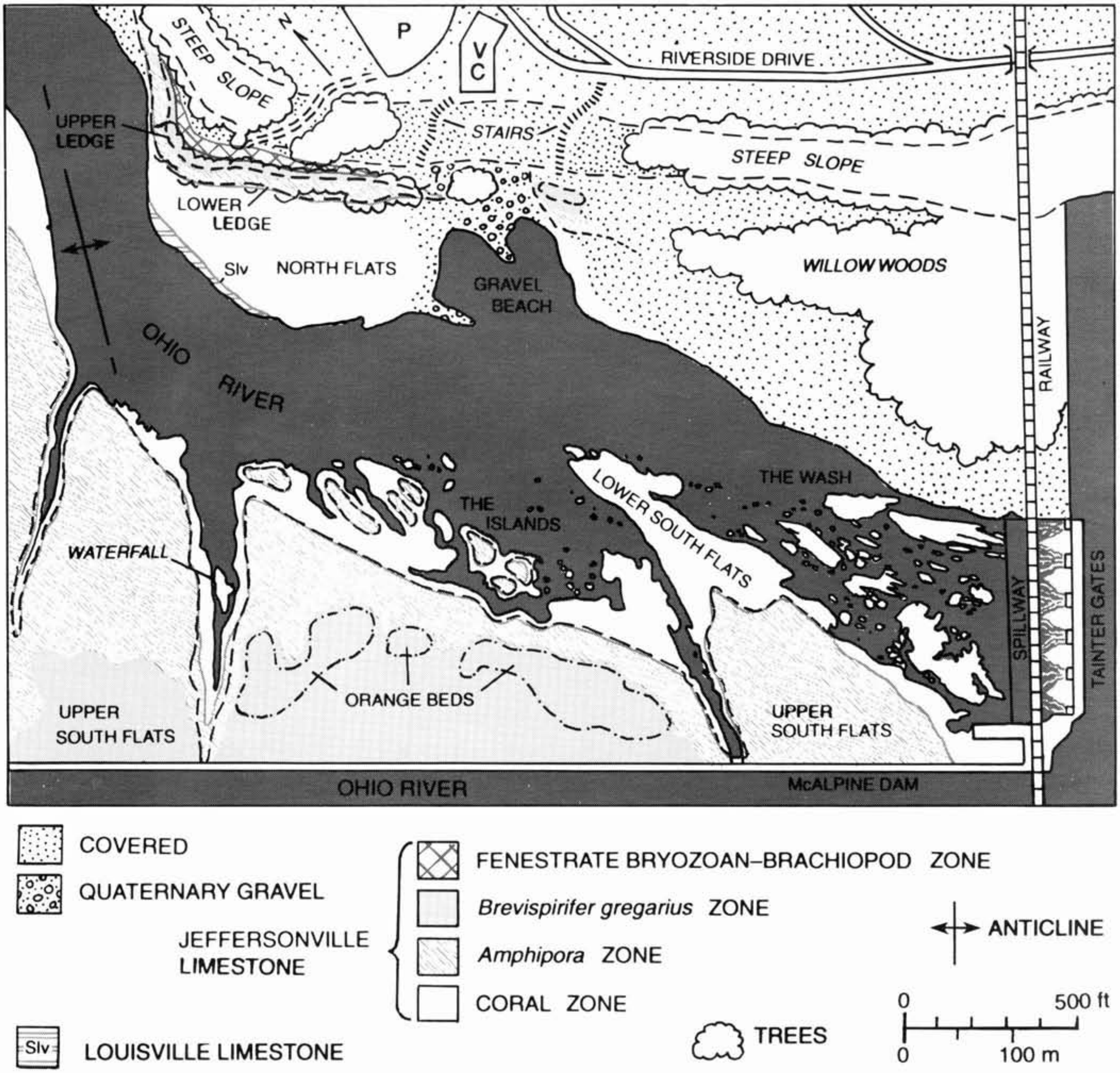


Figure 5. Map of the main fossil beds at the Falls of the Ohio. The Visitors Center (VC) and parking lot (P) are planned to be completed at the end of Riverside Drive in 1993. Because of changing water levels, areas shown on this map may be more or less exposed at different times of the year. The different areas shown on the diagram are described in the text. Most of the areas at river level are in the Jeffersonville Limestone.

tubular fossils called stromatoporoids (pronounced STROME-a-TOP-a-royds). In fact, this level of the Jeffersonville Limestone is named for the stromatoporoid *Amphipora* (Fig. 6), which is also described in Part III.

Not only do the types of fossils change, but the kinds of limestones change in the different sedimentary layers. The limestone ledges just above the main fossil beds on the north flats contain numerous small caves and cavities in a layer of the limestone that was more easily weathered than the limestone layers above and below it (Fig. 7b). These solution cavities occur at several levels in the Falls area.

From the lower ledge you can walk to the broad limestone flats along the Indiana shore in which the upper part of the coral zone is exposed much of the year (Fig. 5). Along the shore toward the spillway (east) are many

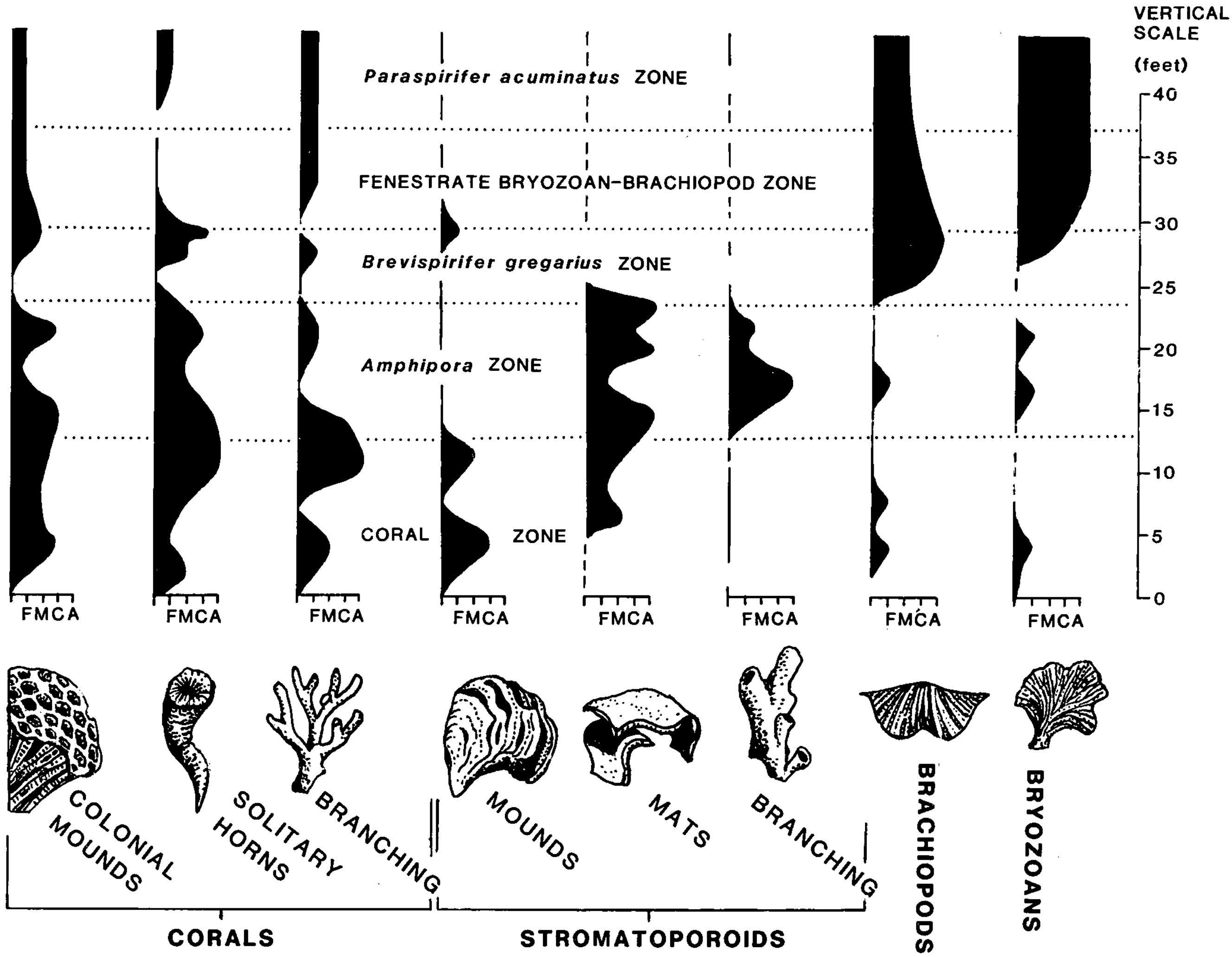


Figure 6. Fossil distribution zones of the Devonian Jeffersonville Limestone at the Falls of the Ohio. The abundance of each type of fossil is shown by the horizontal scale (A=abundant, C=common, M=many, F=few). The thicker the black shading, the more abundant the fossil at that level. The names applied to different zones indicate an abundant or distinguishing fossil at that limestone level (*after* Perkins, 1963).

examples of a type of fossil that looks like peeling onions or fossil cow dung. These fossils are another type of stromatoporoid fossil. You can see pictures of them in Part III. The reason the fossils stand out from the rock is that the minerals in the fossils have been replaced by quartz. When the fossil was a living animal its skeleton was made of calcium carbonate, the same mineral composing the limestone (Fig. 8a). But at some time during burial, the calcium carbonate in the fossil was dissolved (Fig. 8b) and replaced by quartz (Fig. 8c). Quartz is harder than limestone, so it doesn't weather as easily as the surrounding bedrock.

On the north flats you can see many large mounds sticking up from the bedrock. These are preserved mounds of corals and stromatoporoids that were buried by layers of limestone. The corals tend to be preserved as large, white, circular shapes, whereas stromatoporoids are smooth and dark gray. Sometimes the stromatoporoids consist of alternating dark and light layers that may look like dart boards. Detailed descriptions and pictures of these fossils are presented in Part III.

Spillway and Spillway Wash— River Erosion and Fossil "Hash"

From the Indiana shore you can get to the broad exposures of fossil beds across the fishing pond by walking along the spillway below the upper tainter (flood) gates of the dam (Figs. 5, 7c). Most of the year this will require getting your feet wet. THE SPILLWAY SHOULD ONLY BE CROSSED AT LOW WATER LEVELS BECAUSE CURRENTS ACROSS THE SPILLWAY CAN BE VERY STRONG. EVEN WHEN THE WATER IS

Figure 7. Photographs from various parts of the Falls area. (a) View from the Indiana side of the river looking down on the upper fossil ledge (UL), gravel beach (GB), north flats (NF), and south flats (SF). (b) Limestone ledges west of the stairs showing caves. (c) View from the tainter (flood) gates and spillway west across the wash area. (d) Scalloped texture of bedrock near the spillway and railroad bridge. (e) View from the head of the drainage creek north toward the fishing pond, showing large fossils (F) sticking out from the bedrock. (f) View from the south flats toward the islands area at low water level. (g) Young visitor inside a small cave in the islands area at low water. (h) View of the silicified orange beds (*Brevispirifer* zone) near the dam from the upper south flats.

LOW, CAUTION SHOULD BE TAKEN BECAUSE ALGAE GROWING ON THE ROCKS MAKES THEM VERY SLIPPERY. CHILDREN SHOULD ALWAYS BE ACCOMPANIED BY AN ADULT.

Many of the rocks along the spillway are highly eroded and have a pitted or scalloped appearance (Fig. 7d). They also may contain circular depressions called potholes. These features are formed from the scouring action of swirling sand and gravel in fast-moving floodwaters (Fig. 9). It's hard to see the fossils in these beds, but if you walk out to the areas of smooth bedrock, you will see many fossils. The fossils occur as thousands of white fragments in a dark limestone matrix, like a fossil hash. When shallow water covers the wash area, or just after a rain, the limestone takes on a polished appearance, and the white fossils are striking against the dark background. These fossils occur in the upper part of the coral zone of the Jeffersonville Limestone (Fig. 5) and consist of broken pieces of corals and stromatoporoids. The different types of corals that can he seen in these beds are described in Part III.

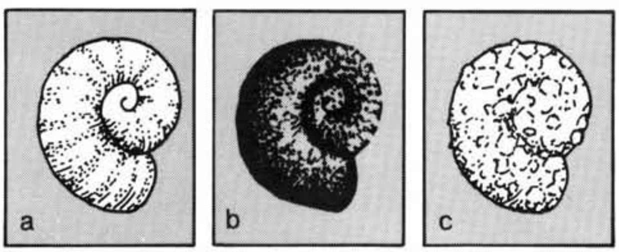


Figure 8. When an animal is buried (a), its original skeleton can be dissolved away, leaving a mold (b) that may be filled with minerals such as silica (c). If the replacement minerals are harder than the surrounding rock, the fossil will stand out in relief from the rock.

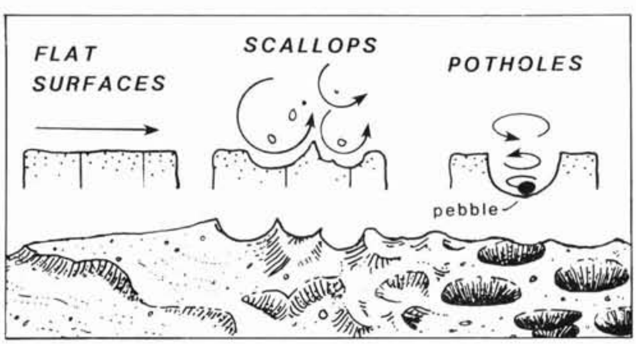


Figure 9. Diagram of bedrock erosion. Even flow across the bedrock creates flat, sometimes polished, surfaces. Churning floodwaters can create scalloped surfaces, and pebbles caught in floodwaters can drill potholes into the bedrock.

Dam and Drainage Creeks—Jointed Bedrock

The beds along the dam are visible most of the year, but flooding across the spillway prevents access to the dam during high water (Fig. 5). In many parts of the upper south flats, few fossils are visible. These areas have large fractures called joints that cut across the limestone, dividing the bedrock into a checkerboard pattern. The joints are natural cracks in the rock formed by stresses deep beneath the Falls. You can see that many of the sharp-edged ledges along the southern part of the Falls occur along these joints. The joints are natural areas of water seepage throughout the year. The river water slowly dissolves the limestone along the joints, causing them to widen (Fig. 10). As the joints grow, they intersect other joints, and blocks of limestone may break apart. These broken pieces of bedrock are then broken further or carried away during floods. In this way, the Ohio River is slowly eroding the fossil beds at the Falls of the Ohio.

Near the head of the drainage creek, many large fossils stick out in relief from the surrounding bedrock (Fig. 7e). There are good examples of large horn and colonial corals, as well as large stromatoporoids. The fossils are typical of the *Amphipora* zone of the Jeffersonville Limestone (Figs. 5–6). To obtain access to the beds west of the drainage creek it is usually easy to cross at the head of the creek along the dam.

South Flats—Coral Craters

Below the ledge in the limestone layers along the dam, broad flats of fossils are exposed much of the year. The fossils in these areas are in the coral zone of the Jef-

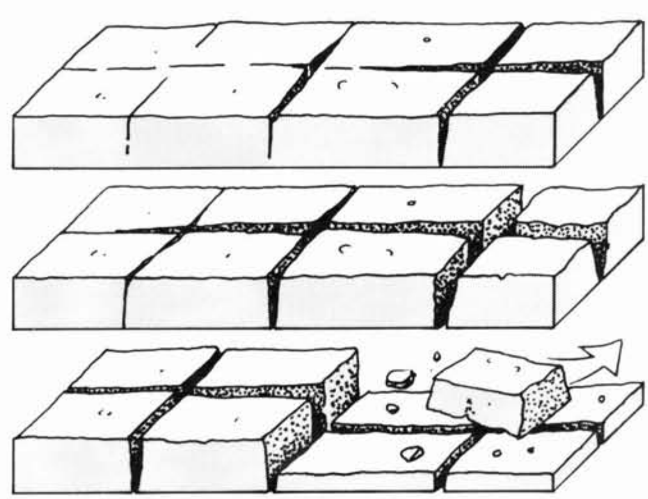


Figure 10. Diagram of jointing at the Falls. Water seeping into the joints causes them to grow and ultimately break apart layers of the bedrock.

fersonville Limestone (Figs. 5–6). There are good examples of large coral mounds and stromatoporoids, up to 2 m (6 ft.) across. The features that look like small craters are the remnants of eroded coral mounds. Originally the corals were covered by stromatoporoids and resistant layers of limestone. Cracks in the resistant layers let water seep down into the more easily weathered coral mound. Slowly the corals were eroded while the rim of covering limestone remained, forming the crater. If you look inside some of the craters you can still see the white coral fossils.

The Islands—Coral Caves

At low water levels several large islands of limestone are exposed between the south flats and the fishing creek (Figs. 5, 7f). Fossils in the upper parts of the islands are in the *Amphipora ramosa* zone, but most of the islands are comprised of fossils from the coral zone of the Jeffersonville Limestone (Figs. 5–6). At lowest water levels you can see to the bottom of the coral zone, where some of the largest coral mounds are preserved. Also, caves formed by rushing water in many of the islands cut through many of the coral mounds, so that you can actually walk into the ancient coral fossils (Fig. 7g).

Orange Beds—Crystal Snails and Fossil Shells

The uppermost beds along the dam have a distinctive orange color (Fig. 5). The color is caused by iron, which was mixed into the silica or chert that replaced the limestone at this level. Because the chert does not weather as easily as the underlying limestone, the orange beds stick out from the bedrock with very irregular surfaces (Fig. 7h). These orange layers contain many fossils that do not occur in other parts of the Falls. Thousands of fossil shells from the brachiopod *Brevispirifer gregarius* can be seen at this level, for which one of the Jeffersonville Limestone fossil zones was named (Fig. 6). Other interesting fossils in this zone are common clam fossils that have been completely recrystallized so that they look like clam-shaped mounds of quartz crystals. Large snail fossils have also been recrystallized (*see* photograph on the cover). One crystalline snail seen while this report was being written was as large as a fist.

PART III—FOSSIL IDENTIFICATION AT THE FALLS

Following is a description of many of the fossils at the Falls of the Ohio and an explanation of the types of animals that were fossilized. The descriptions focus on those fossils commonly encountered in accessible parts of the fossil beds. Photographs of fossils in this section are actual size unless a scale is drawn alongside them. If you wish more information on fossil description, a reference list is provided in the back of this booklet.

Corals

Corals are the most common and famous types of fossils at the Falls of the Ohio. Modern corals are soft-bodied organisms that grab food from seawater with their tentacles. The coral animal or "polyp" builds a hard, rock-like skeleton around its body. Numerous tentacles stick out from the top of the body for feeding. When the polyp dies, its soft tissue decays, but the hard skeleton is left behind. The hard skeleton of ancient corals is what was preserved as fossils. Different species of corals produce different sizes and shapes of skeletons, although the polyp is similar in each.

Scientists recognize three main orders of corals (Fig. 11). The corals living in the seas today belong to the order Scleractinia. The order Rugosa was dominated by solitary corals in which each coral polyp had its own skeleton. Rugose means wrinkle, and the outer surfaces of most rugose coral skeletons have a wrinkled appearance. The order Tabulata consisted entirely of groups of coral animals that lived in large colonies with a shared skeleton. Both rugose and tabulate corals are extinct now, but their fossils can be seen in the bedrock at the Falls of the Ohio (Fig. 11).

Rugose Corals

HORN CORALS

Rugose corals are often called horn corals because many species have a horn shape (Fig. 12). When the fossils are found buried on their sides, this horn shape is obvious. Some were also buried in upright position, revealing only a cross section through the horn-shaped tube. If the fossil is oriented directly upright it will look like a circular cup. All horn corals are capped by a cup, called a calyx (KAY-licks). The coral animal lived within the calyx (Fig. 12). Commonly, the calyx contains four or more vertical ridges that radiate outward from the center to the outer wall of the cup. These ridges are skeletal support plates called septa (Fig. 12).

Horn corals came in many different sizes. Small horn corals (2 to 7 cm; 1 to 3 in.) called *Zaphrenthis* (Za-FREN-tis) and *Heterophrentis* (Het-TER-o-FREN-tis) are common in many of the layers at the Falls. Both corals look very similar. The distinction between the two is that the septa within the calices of *Zaphrenthis* are knobby or spiked (Fig. 13a), while the septa of *Heterophrentis* are smooth (Fig. 13b). In life, the corals probably looked very similar.

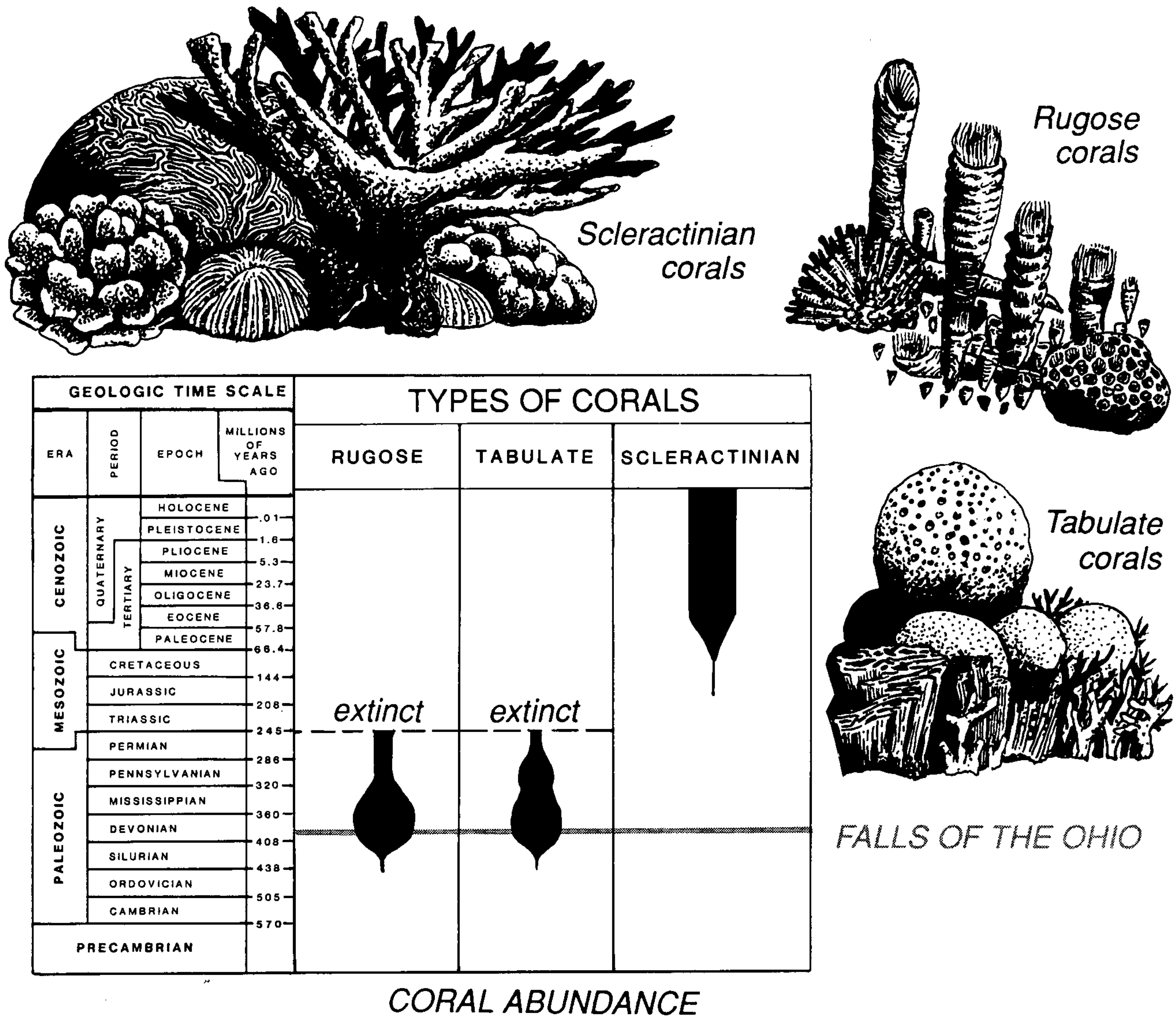


Figure 11. Diagram showing the times when the three main orders of corals flourished, and illustrations of each order. The Falls of the Ohio bedrock was deposited when both rugose and tabulate corals were abundant.

Not all horn corals were small. One of the most common horn corals found at the Falls is *Siphonophrentis* (Si-FON-o-FREN-tis) (Figs. 13c–e, and back cover). The largest species of this coral has been reported to reach lengths of 1.5 m (5 ft.), although most are less than 60 cm (2 ft.) long. They are common in the coral, *Amphipora ramosa*, *Brevispirifer gregarius*, and fenestrate bryozoan-brachiopod zones of the Jeffersonville Limestone (Fig. 5). In life, the pointed end of the *Siphonophrentis* horn was connected to the sea bottom, and the coral animal built its tube upward (Fig. 12).

Another large horn coral that looks somewhat similar to *Siphonophrentis* is *Scenophyllum* (skin-AH-fill-um). *Scenophyllum* has a small, nipple-like protrusion inside its calyx (Fig. 13e), while the calyx of *Siphonophrentis* is an empty cup (Fig. 13d). *Scenophyllum* also tends to be straighter and narrower than *Siphonophrentis*.

Many species of rugose corals at the Falls are not only bent, but exhibit a twisting shape as well. Examples of the twisting habit are *Blothrophyllum* (BLAH-thro-fill-um) and some forms of *Heliophyllum* (HEEL-ee-o-fill-um). Whereas other horn corals have a solid wrinkled tube with a single cup-shaped calyx at the top, these corals often consist of stacked cups (Figs. 14a–c). The distinctions between the two types of corals are very detailed (*see* Stumm, 1964). Like most horn corals, these stacked-cup forms started out as single calices growing upward from the sea bottom (Figs. 14d–e), but when they were knocked over (Fig. 14f) they sprouted a new calyx (Fig. 14g), which grew upward from the original

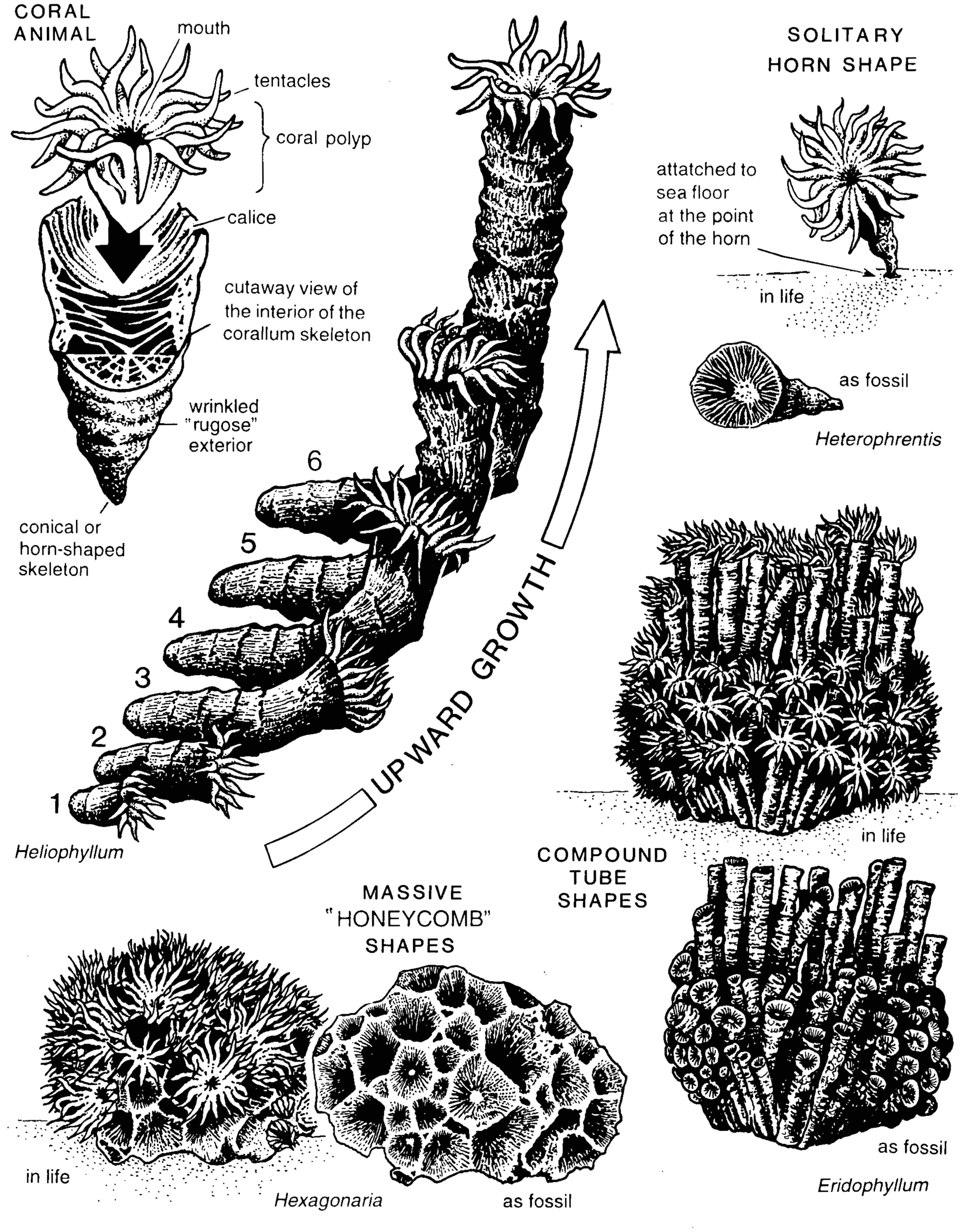


Figure 12. Diagrams of rugose corals, showing the parts of the living coral animals and their skeletons, the manner in which the horn corals grew, and the various shapes of rugose coral fossils and interpretations of what the original corals looked like when they were alive.

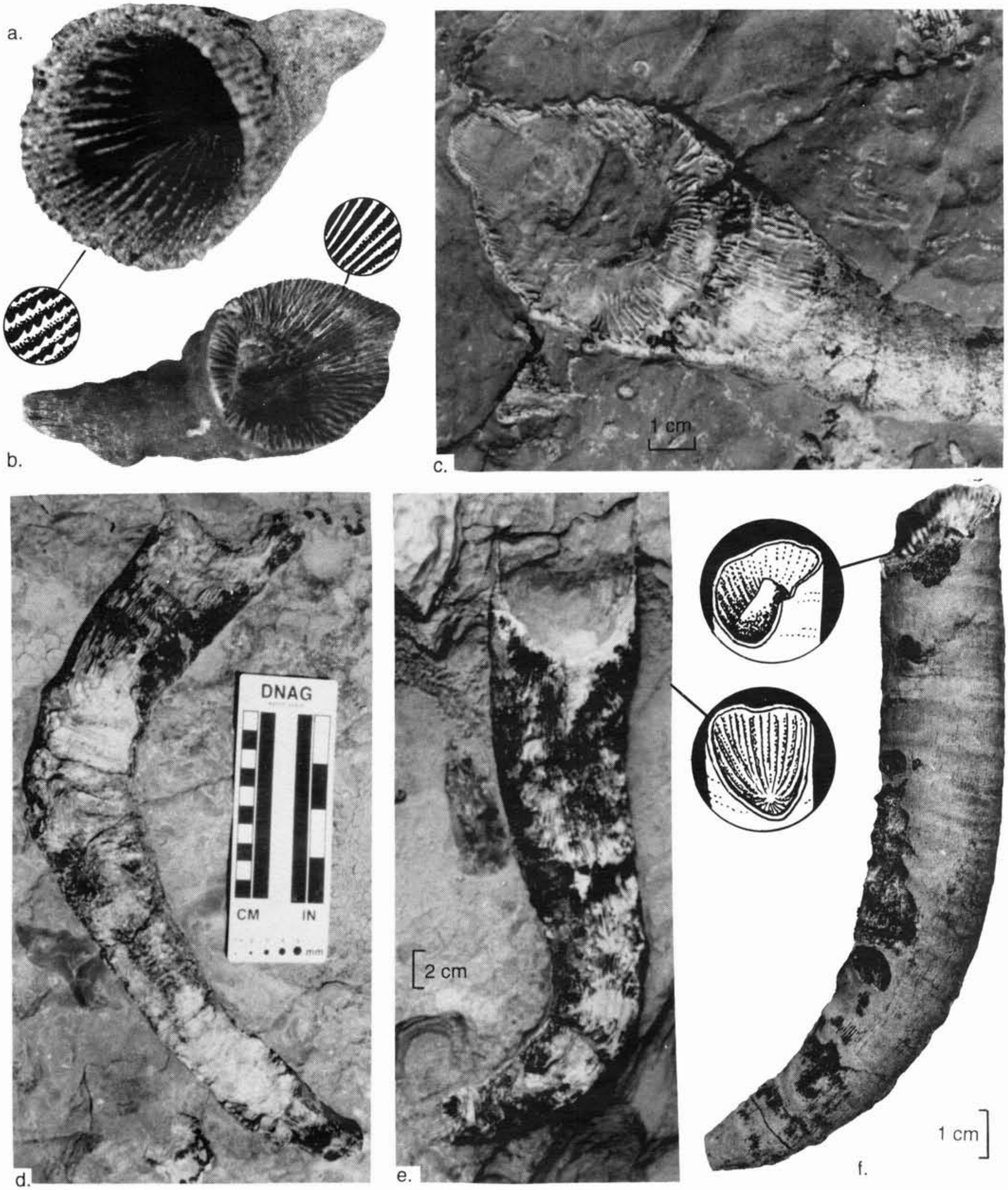


Figure 13. Photographs of solitary horn-shaped corals. (a) *Heterophrentis* with smooth septa. (b) *Zaphrenthis* with knobby septa. (c–e) *Siphonophrentis* in bedrock matrix. (f) *Scenophyllum* with nipple-like protrusion in calyx.

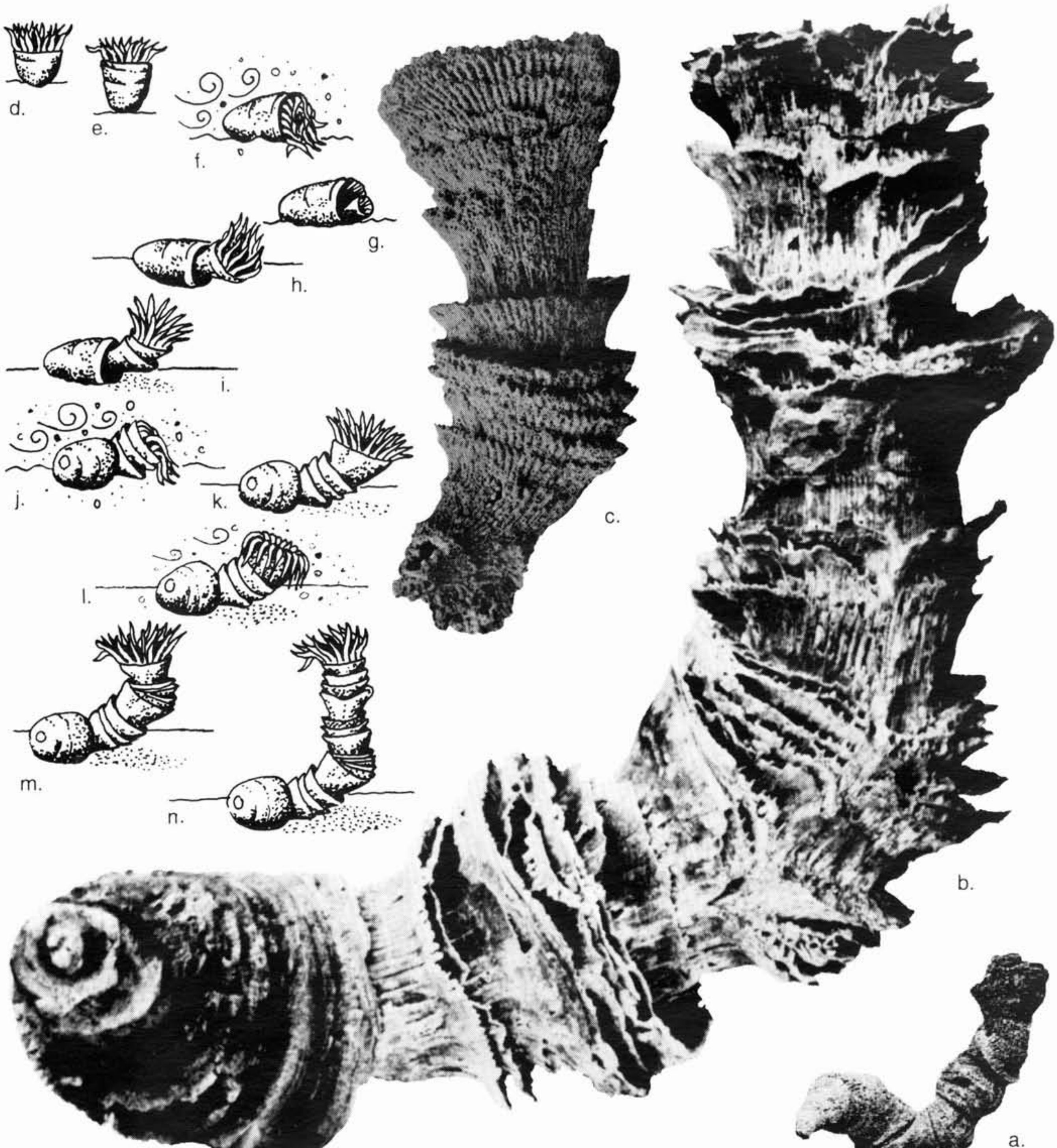


Figure 14. Photographs and illustrations of horn corals comprised of stacked calices. (a, c) *Heliophyllum* and (b) *Blothrophyllum* (photographs from Davis, 1887, plates 80, 88, and 98. The coral *Heliophyllum* was originally classified as the coral *Cyathophyllum*). (d–n) These corals grew by repeated rejuvenation of the calyx after the coral had fallen over.

coral (Figs. 14h–i). Each time the corals were knocked over, partially covered by stirred-up sediment, or perhaps affected by changing currents at the seafloor (Fig. 14j), they rejuvenated a new calyx out of the old calyx, at a slightly different angle to the old calyx (Fig. 14k).

This process led to a wide variety of twisting shapes (Figs. 14l–n).

Some horn corals never attached to the seafloor or developed a twisting shape. An example is *Aulacophyllum* (all-ACK-o-fill-um). The calyx or cup of this coral is on the side, rather than the top, of the horn-shaped tube (Fig. 15a). It is possible that when these corals were young they grew upright and then later in life fell over to a more stable position, but it is more probable that these corals grew on their sides naturally (Fenton and Fenton, 1989). *Aulacophyllum* is most common in the lower Jeffersonville Limestone where the seafloor was fine grained. Lying on its side (Fig. 15b) would give the coral more support on a fine-grained seafloor than being attached at the base of its horn-shaped skeleton.

BUNDLES AND MOUNDS

Not all rugose corals at the Falls are horn-shaped tubes. Some rugose corals grew so close together that they formed large bundles of compound tubes (Fig. 12). These corals can be difficult to identify as rugose corals. In colonies of rugose corals each tube or corallite skeleton in the colony had its own skeletal wall, while corallums in tabulate colonies shared walls. Also, septae in rugose corals are longer and generally more complex then those in tabulate corals.

A common example of a colonial rugose coral is *Eridophyllum* (er-ID-ah-fill-um). Individual tubes of *Eridophyllum* are not connected and often spread outward from a common center (Fig. 16a). When you examine these corals closely, you can see the individual, closely spaced tubes (Fig. 16b).

Another colonial rugose coral was *Prismatophyllum* (priz-MAT-o-fill-um) (Figs. 17a–c). Although the corallite tubes in this coral touched, tubes did not connect, so *Prismatophyllum* is considered a rugose coral. Also, *Prismatophyllum* calices are usually large, up to 2 cm ($^3/_4$ in.) across, whereas tabulate coral calices are usually much smaller. A similar colonial rugose coral, *Hexagonaria* (Fig. 12), which may also occur at the Falls, is often confused with *Prismatophyllum* (*see* Thompson, 1982, p. 363–364, for differences).

TABLULATE CORALS

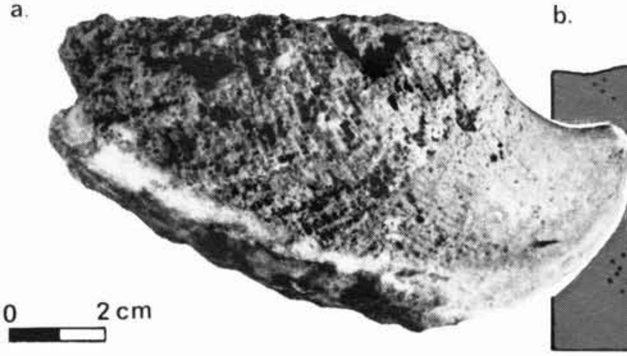
Large Mounds

The second order of corals that lived at the Falls was the tabulates (Fig. 18). The entire tabulate coral is termed a corallum, while the individual tubular chambers within the corallum are called corallites. While solitary forms of rugose corals were made up of a single corallum with large, cup-shaped calices, most tabulate corals had a large corallum comprised of a colony of corallites with very small calices. Although the individual coral animals within the tabulate calices were generally smaller than their rugose cousins, their colonies often grew to much larger sizes.

The most common types of tabulate corals at the Falls are called favositid (FAV-o-SIT-id) corals. Two types of favositid corals are abundant and they both can have similar shapes. In cross section, favositid corals exhibit parallel chambers that share walls rather than being separated as in rugose corals (Fig. 18). The chambers contain thin horizontal plates called tabulae (TAB-u-lee). The tabulae are what this order of corals is named for. These thin plates are stacked within each corallite chamber and define the fossilized living chambers of the original coral polyps. As each coral polyp grew it abandoned its old living compartment and secreted a new skeletal tabula above the old one, causing tabulae to be stacked within each chamber (Fig. 18).

Most of the rounded or bell-shaped coral fossils from the coral zone in the north flats, spillway wash, and south flats (Figs. 5–6) are the coral *Favosites* (FAV-

a.



b.

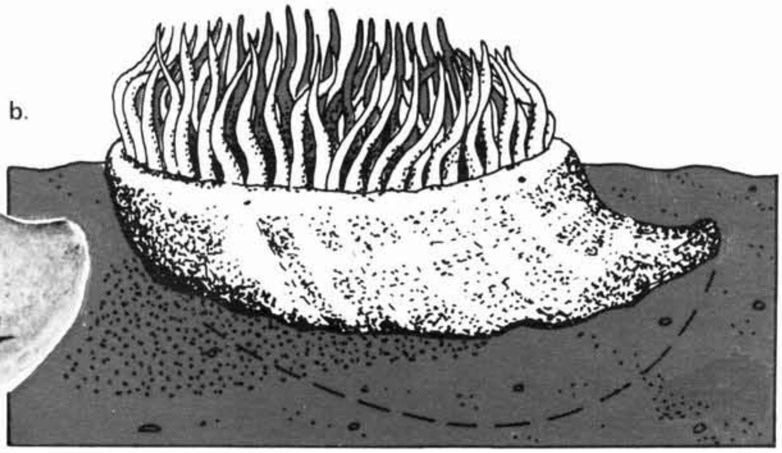


Figure 15. The rugose coral *Aulacophyllum*. (a) Photograph of fossil. (b) Illustration of the coral in life.

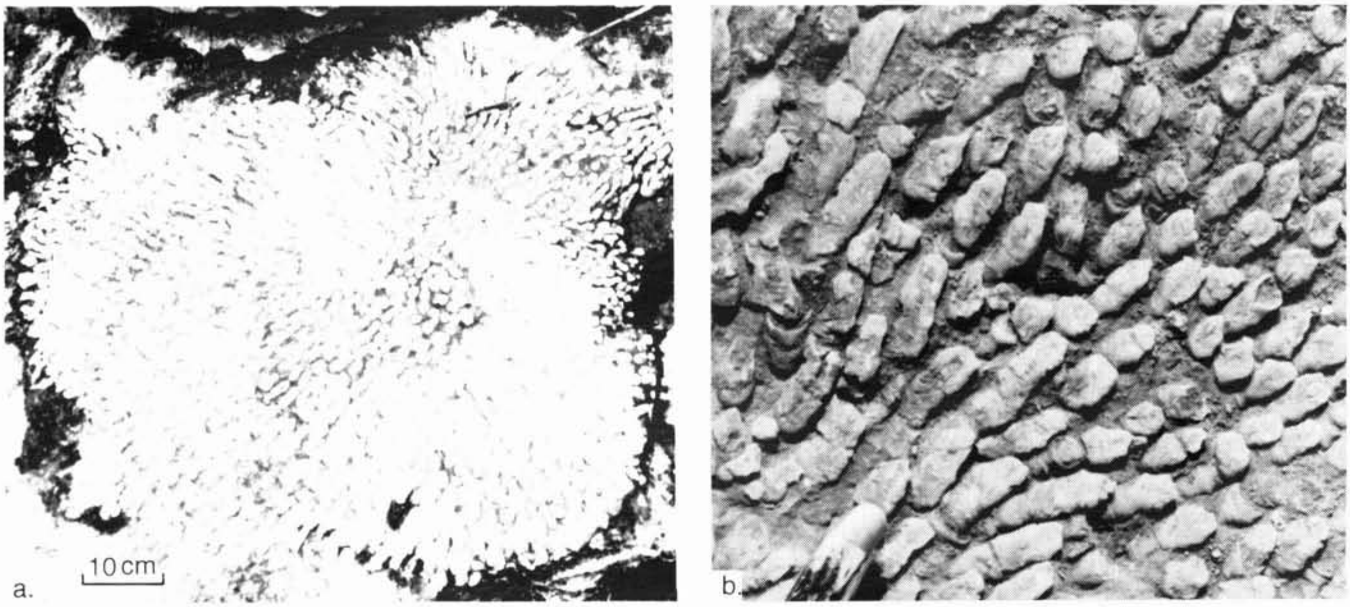


Figure 16. Photographs of the rugose coral *Eridophyllum*. (a) Rugose colony in bedrock at the Falls. (b) A close-up of the individual corallite chambers; pocket knife for scale.

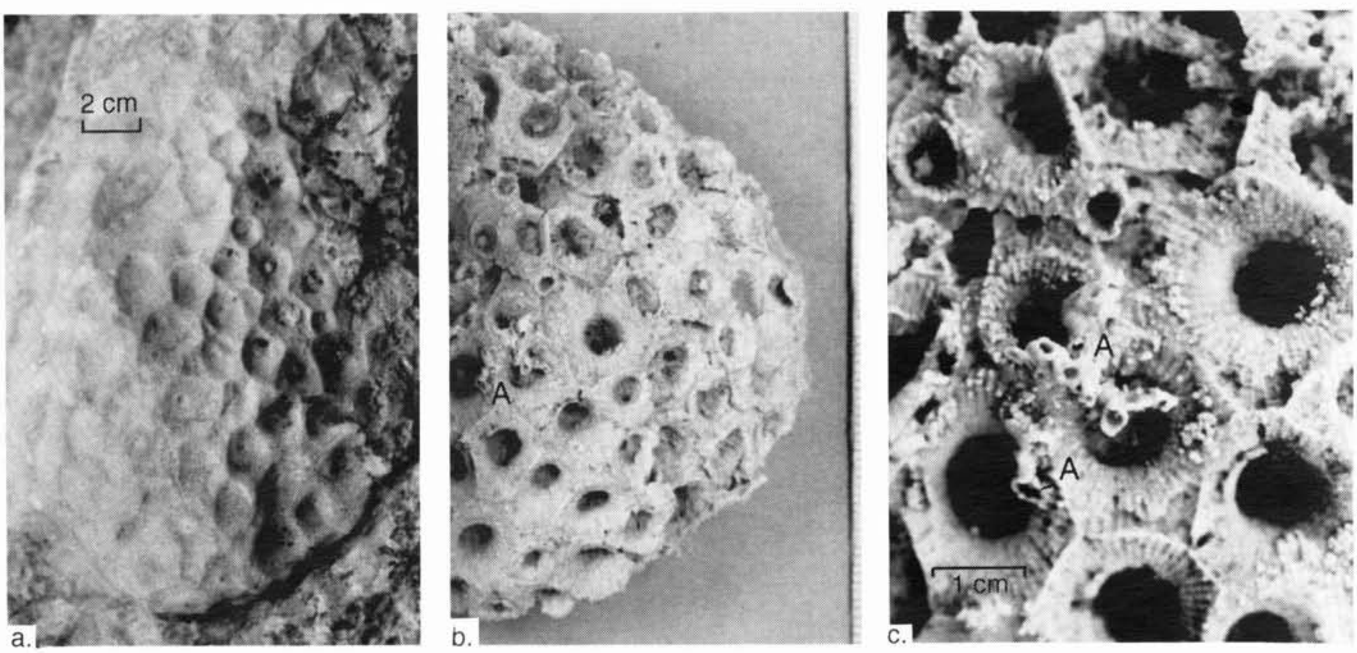


Figure 17. Photographs of the colonial rugose coral *Prismatophyllum*: (a) in bedrock from the south flats, (b) as a spherical mound washed up on the Indiana shore. (c) Close-up of the calices showing the thick skeletal walls and well-developed septa. Note encrusting *Aulopora* corals (a) (*see* p. 21).

o-SY-teez). *Favosites* corals may resemble turbans (Fig. 19b) or ham hocks (Fig. 19c). In fact, a species of this coral was named *Favosites turbinatus* because of its turban shape. This species is one of the most abundant corals in the coral zone at the Falls. Most of the *Favosites* with ham-hock shapes are less than 30 cm (1 ft.) long, but some of the *Favosites* mounds may be more than a meter (3 ft.) in diameter.

Another common tabulate coral is called *Emmonsia* (ee-MOHN-see-a). For the most part, the only difference between *Emmonsia* and *Favosites* is that the tabu-

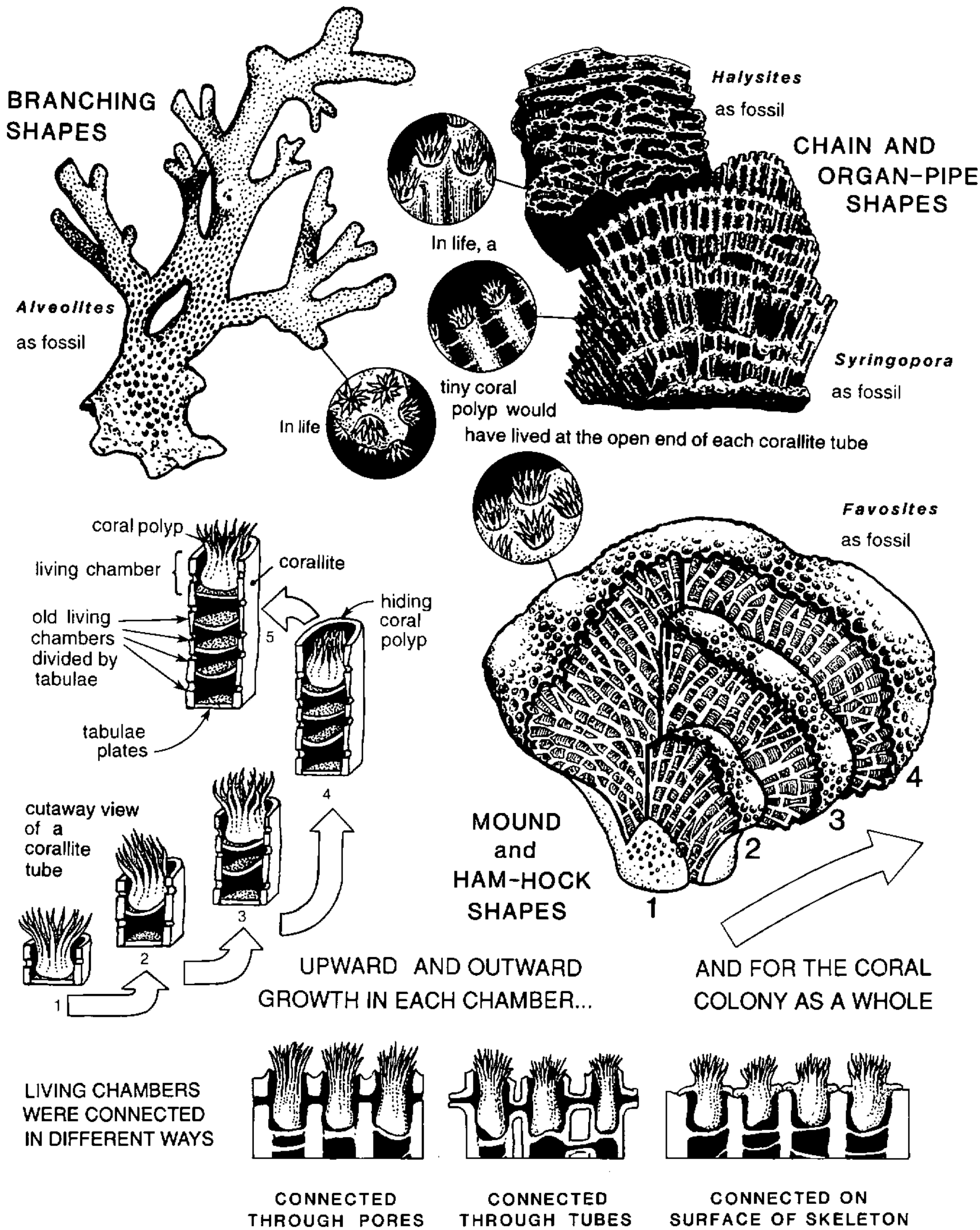


Figure 18. Illustrations of colonial tabulate corals showing how tabulate corals were connected into colonies, how they grew, and the different shapes of tabulate corals at the Falls.

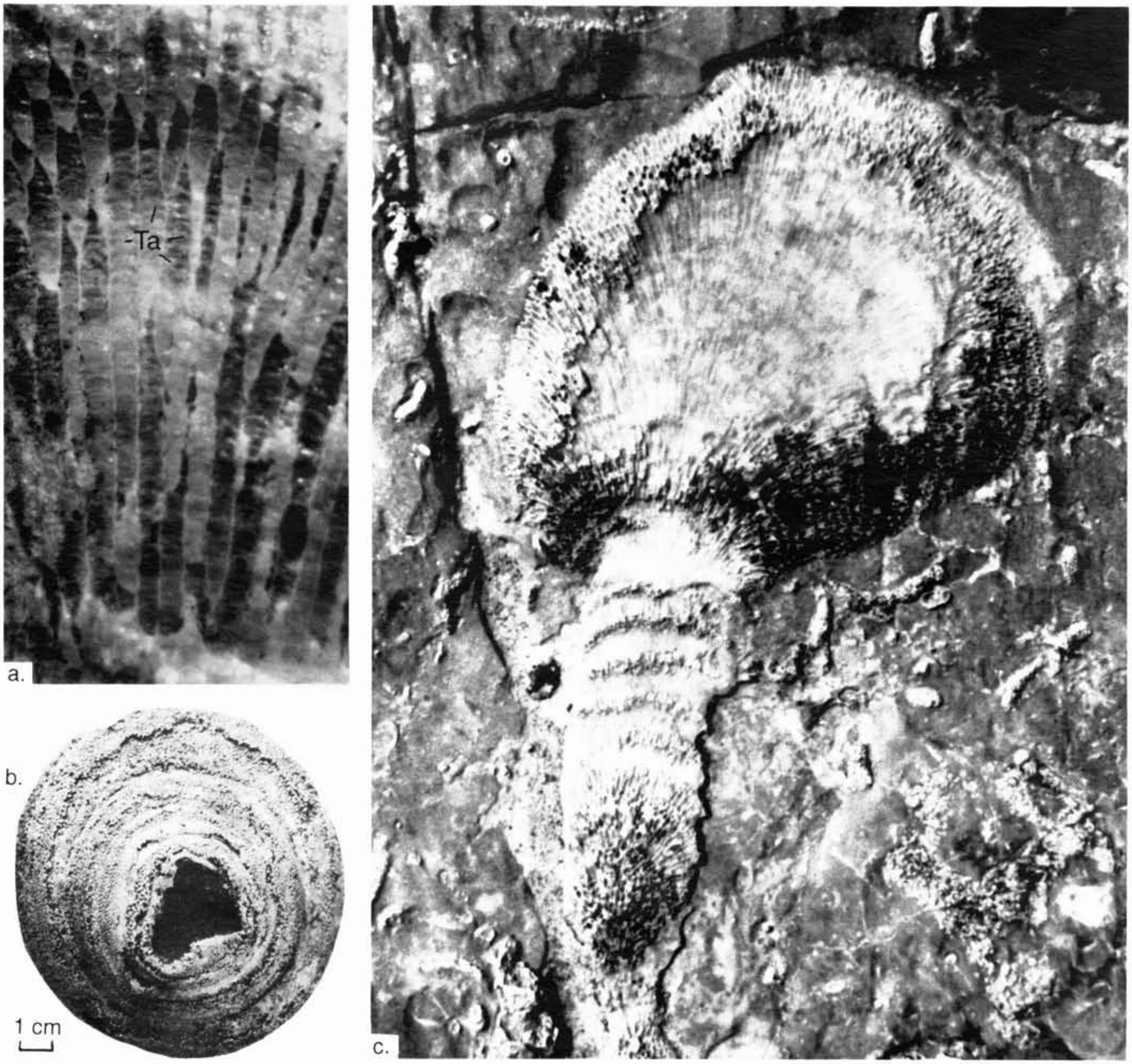


Figure 19. Photographs of mound-shaped colonial corals. (a) Close-up of corallum chambers with tabulae (Ta). (b) Circular or "turban-shaped" mound of *Favosites* as viewed from bottom. (c) Ham-hock-shaped *Favosites* in bedrock in the wash area.

lae in *Emmonsia* are poorly defined. On the exterior, the two corals look very similar. *Emmonsia* can be mound-shaped like *Favosites*. Some very large mounded colonies of *Emmonsia* are exposed in the coral zone at the bottom of the drainage creek and in the island area during low water levels (Figs. 5–6). From far away these colonies look like thick beds of limestone, but you can see the coral mound shape and the way the layers of the coral colony built upward from the beds that make up the islands (Fig. 20). Mounded coral masses like these formed an ecological habitat called a patch reef or bioherm. The mound shape was an advantage on the soft floor of the Devonian seas because the broad base provided more surface area for the coral to support itself (Perkins, 1963).

Branching Bushes

Many species of tabulate corals grew as either large mounds or as branching, bush-like colonies. For example, both *Favosites* and *Emmonsia* colonies exhibit branching and mounding habits. Large, mound-shaped *Emmonsia* colonies can be seen during droughts near

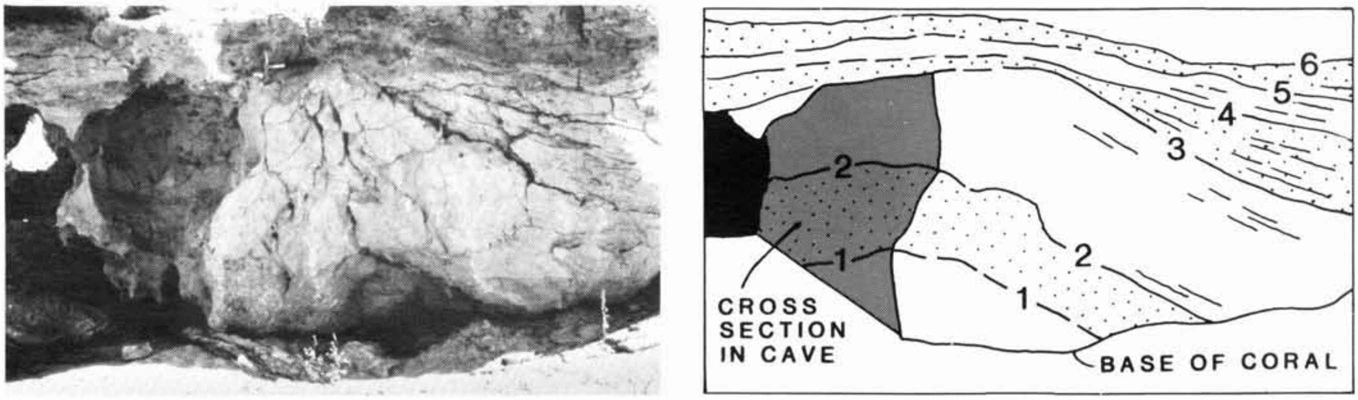


Figure 20. Photographs and explanation of large *Emmonsia* colony from the islands area at low water level. Layers (1–6) in the fossil coral are essentially growth lines that define the shape of the coral as it grew; hammer for scale.

the base of the coral zone, but smaller, branching varieties are abundant in shallower areas and can be seen most of the year. Branching forms of these corals that were buried in upright positions are common in the lower part of the coral zone, while fragmented branches are common in the upper part of the coral zone (Perkins, 1963; Conkin and Conkin, 1976). *Emmonsia* branches are among the most common types of branching coral fragments exposed in the fossil hash layers of the upper coral zone (and lower *Amphipora* zone) in the spillway wash area (Fig. 21a). *Emmonsia* is easily distinguished in these fragmented coral layers by cross sections through its branches. *Emmonsia* branches have very thin corallites and tabulae that look like very fine, hair-like lines (Figs. 21a–b) rather than the well-developed corallites and tabulae of *Favosites*.

The dark-gray limestone with abundant white fossil coral fragments by the tainter (flood) gates not only contains fragments of *Emmonsia* but many other kinds of corals as well (Fig. 21c). These broken coral branches have been called finger corals (Conkin and Conkin, 1976, 1980). Finger corals are usually less than 2 cm (0.75 in.) in width and are comprised of the broken

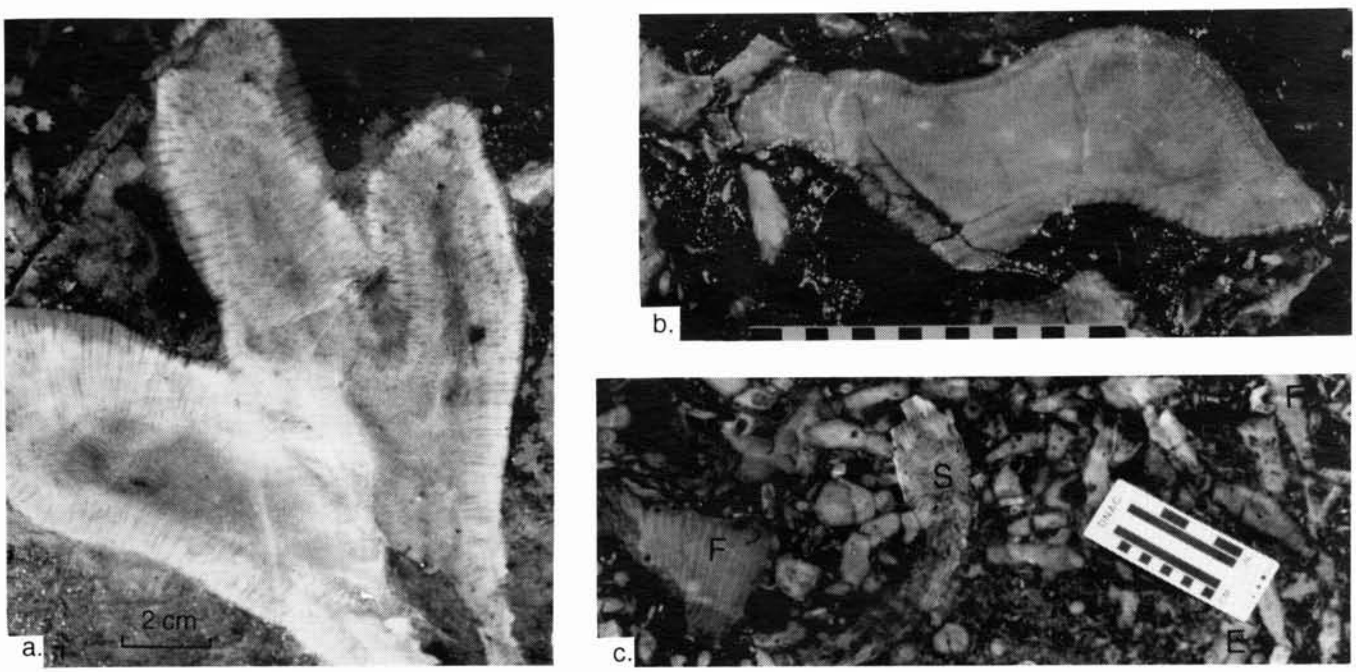


Figure 21. Photographs of fragmented corals from the spillway. (a–b) Branching *Emmonsia*; note the poorly defined fine hair-like corallites and tabulae. (c) Scattered fossil debris including the tabulate corals *Emmonsia* (E), *Favosites* (F), the rugose coral *Siphonophrentis* (S), and abundant finger corals (probably *Emmonsia*, *Cladopora*, and *Striatopora*). The beds also contain stromatoporoid fragments.

branches of many different coral species. These corals probably grew in broad thickets on the seafloor, or attached themselves to the hard surfaces of larger coral bioherms. Periodically, storms swept across the ancient seas at the Falls of the Ohio and broke the fragile branches of the coral thickets. Most of the finger coral remains can only be differentiated by detailed examination of their corallites and comparison of the internal structure of the broken fragments with structures seen in more complete fossil specimens.

Alveolites (AL-vee-o-LIE-teez) is an example of a delicately branching colonial coral that may have been broken into the fossil hash layers (Fig. 22a). The corallites on the *Alveolites* branches are so small they look like tiny pin holes. The branches were fragile and could easily have been broken into finger corals.

Another type of branching coral mixed into these beds is *Thamnopora* (tham-NAH-por-a). These branches have larger corallites than *Alveolites* (as wide as a toothpick); thin walls separate each hole so that the surface of these branches looks sponge-like (Fig. 22b). Isolated fragments of this coral are sometimes dislodged from the bedrock and washed onto the Indiana shore.

Still another type of branching coral is *Trachypora* (TRA-key-POR-a). Broken remains of this coral are common in the upper coral zone (Conkin and Conkin, 1976). The branches of *Trachypora* are about the same size as *Thamnopora*, usually less than 2 cm (0.75 in.) in width and 10 cm (4 in.) in length, but the openings of the corallites are slightly larger and highly ornamented. While *Thamnopora* had very thin walls between corallites, the corallites of *Trachypora* had thick, raised margins similar to the holes on a flute (Fig. 22c).

Another type of branching coral commonly found as fragments in the upper coral zone is *Cladopora* (clad-AH-por-a) (Conkin and Conkin, 1976). Isolated and broken branches of this coral look very similar to *Thamnopora*, and as with many of the finger corals, cannot be distinguished. However, when larger pieces are found, *Cladopora* can be distinguished from these other corals. In these larger pieces *Cladopora* commonly exhibits intertwining branches that may resemble small vines (Fig. 22d). This interwoven appearance is more common in *Cladopora* corals than other corals. A large "bush" of in-

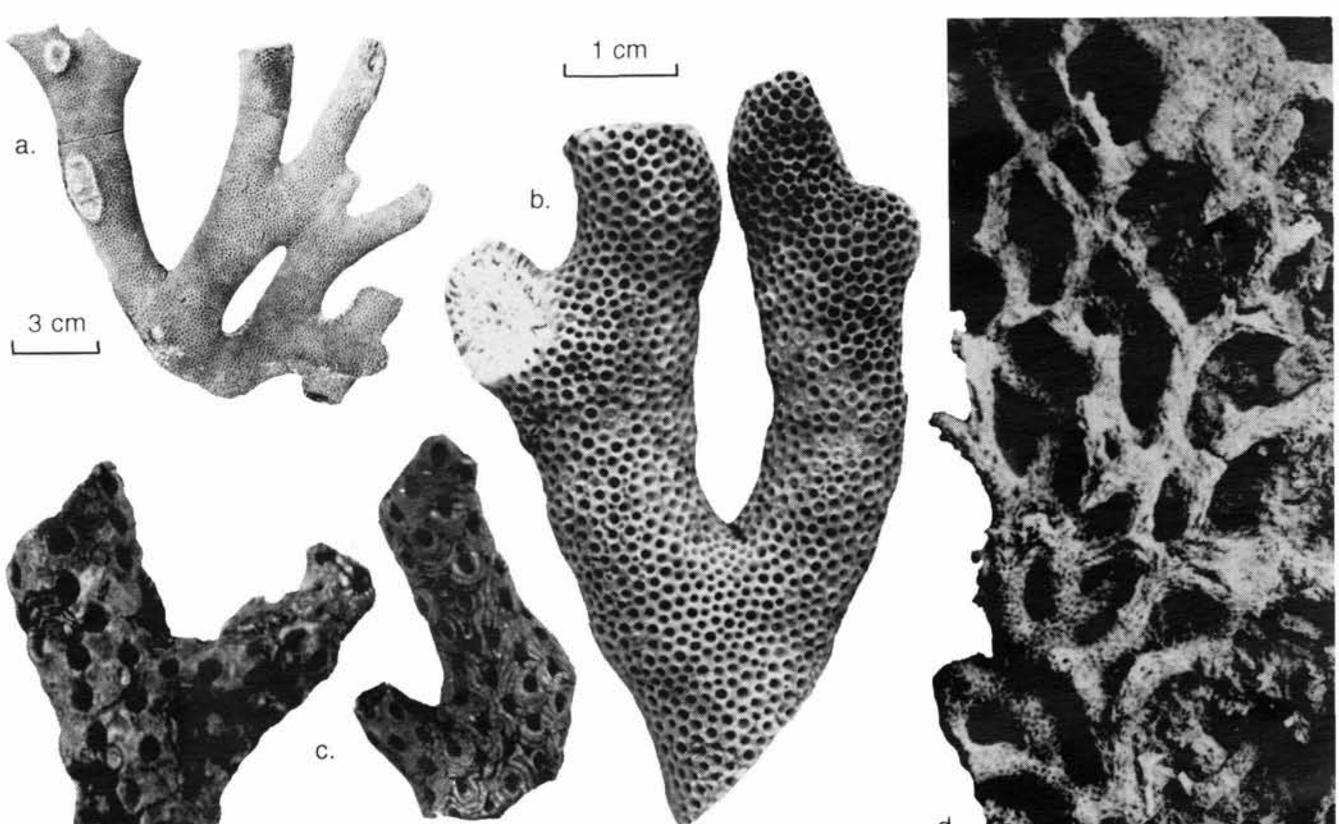


Figure 22. Photographs of branching colonial corals. (a) *Alveolites*. (b) *Thamnopora*. (c) *Trachypora*. (d) *Cladopora* (*from* Davis, 1882, plate 59).

tertwining *Cladopora* was exposed along the Indiana shore just below the second ledge from the stairs when this booklet was put together. The coral bush was more than 1.2 m (3.5 ft.) long. The corals probably grew in this twisting form in response to currents along the seafloor.

More Mounds, Tubes, and Chains

Three other types of distinctive colonial, tabulate coral shapes can be seen at the Falls. The first type is large mounds that look like fossil wasp nests. An example is the coral *Pleurodictyum* (PLOOR-oh-DICT-ee-um), which has medium-size, rounded corallites (Figs. 23a–b). These corals can be differentiated from grouped rugose corals like *Prismatophyllum* (Fig. 17 for comparison) because although both are mound-shaped, *Pleurodictyum* corallites are smaller (maximum of 1 cm; 0.4 in.) and round rather than polygonal like *Prismatophyllum*.

Some tabulate corals consist of groups of narrow tubes. These grouped tubes differ from the grouped rugose corals like *Eridophyllum* in their many connections between tabulate corallites. They can also be differentiated from *Eridophyllum* corals because their exterior tends to be smooth, rather than wrinkled like rugose corals, and the interior of coral tubes contain numerous tabulae. An example of this form of tabulate coral is *Syringopora* (sir-ING-ah-POR-a) (Fig. 24a). *Syringopora* consists of narrow tubes (each no wider than a straw) connected in fan-shaped or organ-like arrangements. Some of these coral fossils have been found growing on the sides of larger horn corals at the Falls. Others have been found encrusted by stromatoporoids. If the stromatoporoids grew on the delicate *Syringopora* tubes while the corals were living they would have helped strengthen the fragile corals (Kissling and Lineback, 1967).

A more distinctive tubular coral that any amateur can identify is the chain coral *Halysites* (Hal-ee-SY-teez) (Fig. 24b). This type of colonial coral has long tubes like *Syringopora*, but its tubes are connected and arranged in chain-like strands. *Halysites* is common only in the Silurian Louisville Limestone (Fig. 5), so most of the year it can't be seen in the main fossil beds. However, at lowest water levels *Halysites* can be seen below the base of the Jeffersonville Limestone west of the islands area, where it occurs as broken fragments above an irregular bedding surface between the Jeffersonville and underlying Louisville Limestones. The concentration of the *Halysites* corals at the base of the Jeffersonville indicates that the Silurian corals were eroded from the underlying strata and redeposited during the Devonian Period. The chain-like appearance of the corallites in this coral is its most distinctive feature (Fig. 24c).

Another type of tubular tabulate coral is easy to identify, but because of its tiny size can be overlooked. The coral *Aulopora* (awl-AH-por-a) consists of tiny straw-like tubes, usually less than 1 cm (0.4 in.) high. These corals probably required a hard substrate to anchor onto, since they commonly were fossilized as growths on larger corals (Fig. 17c).

Stromatoporoids
Mounds

Although corals are the most famous fossils at the Falls, they are not the only fossils that can be found. Stromatoporoid fossils are the remains of another type of marine invertebrate (animal without a backbone) that

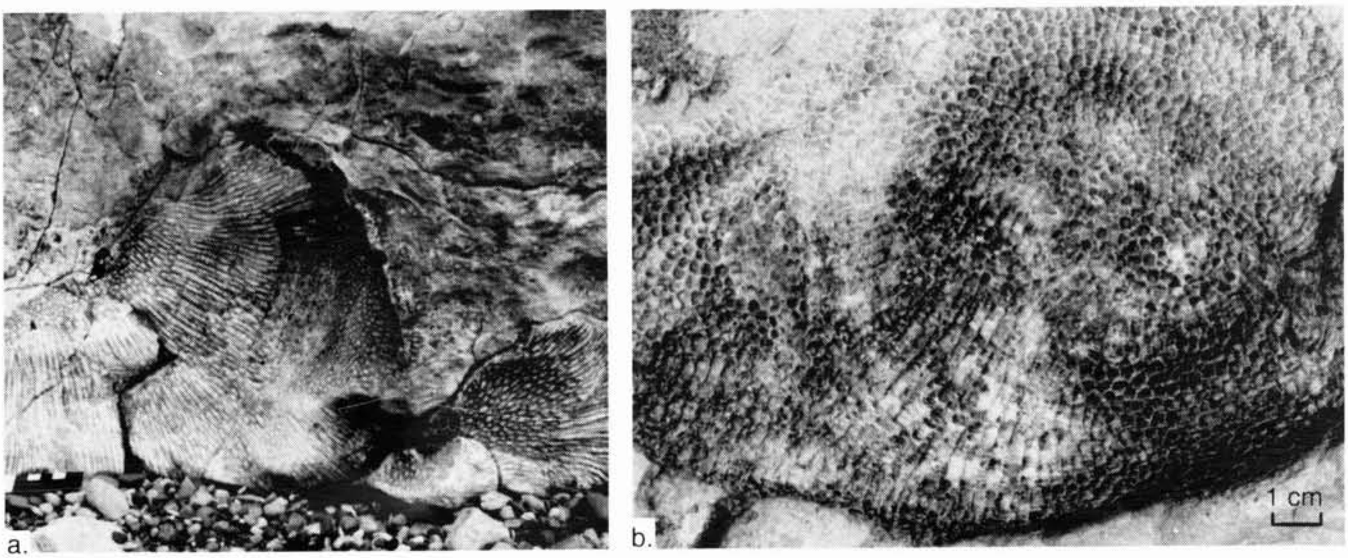


Figure 23. Photographs of the coral *Pleurodictyum*, which may look like a fossil wasp nest.

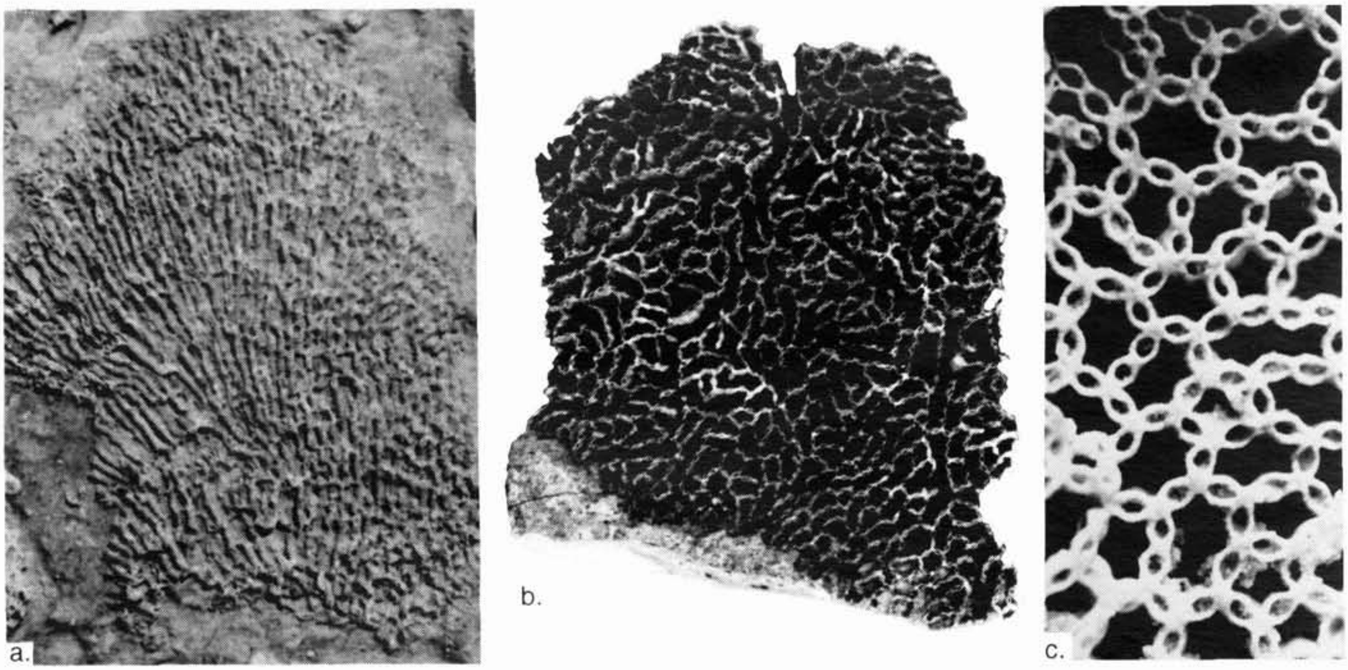


Figure 24. Photographs of colonial, tubular, and chain corals. (a) *Syringopora*. (b) *Halysites* from the Louisville Limestone. (c) Close-up of *Halysites* calices showing chain-like appearance.

was common in the shallow seas of the Falls area, although they are rare in the seas today. Stromatoporoids are thought to be the fossil ancestors of modern calcareous sponges. They are simple, filter-feeding animals that grow either as mounds or encrusting layers (Fig. 25c). Stromatoporoid fossils at the Falls are often silicified and may look like piles of fossil manure (Fig. 25a) or large peeling onions (Fig. 25b). Because they are silicified, they tend to stick out from the less resistant bedrock along the Indiana shore, the north and south flats, and the head of the drainage creek (Fig. 5). Silicification also causes the mounds to be dark gray and have a smoother appearance than the surrounding bedrock. They may also possess alternating gray and white circular bands, making them look like a fossil dart board. Individual stromatoporoid mounds vary in size, but may reach widths of 4 m (12 ft.) (Kissling and Lineback, 1967).

Crusts and Mats

Stromatoporoid fossils also occur as flat mats or crusts around other fossils. Figure 26a is a photograph of a fossil stromatoporoid that completely encrusted a *Prismatophyllum* coral. Half of the stromatoporoid was broken away from the coral, revealing that the stromatoporoid covered not only the *Prismatophyllum* but also several smaller rugose and *Aulopora* corals that had grown on top of the *Prismatophyllum* before it was encrusted by the stromatoporoid (Fig. 26b). From fossils like this one scientists can begin to recreate the ecology of the ancient seas, in which larger corals grew as pioneering animals on the soft seafloor, providing harder, stable surfaces for smaller corals once they were established. When the larger corals died their skeletons were encrusted by stromatoporoids, which created a larger hard surface for other animals to grow on. In this way, larger groups of invertebrate animals began to spread outward and upward from the Devonian seafloor.

Because the stromatoporoids encrusted animals when they were living, or soon after they died, many stromatoporoid fossils are shaped like the animal they covered. For example, the fossil in Figures 26c and 26d is not a bumpy snail fossil, but the top and bottom surface of a stromatoporoid that encrusted a snail shell. The fossil stromatoporoid acted as a mold to preserve the original shape of the shell it covered, even though the snail shell dissolved and was not preserved as a body fossil. Some of these molds can preserve more detail of the shell they encrust than the fossils of the shells themselves.

Branching Tubes

Like corals, stromatoporoids also grew as branching or tubular animals. *Amphipora ramosa* (am-FIH-por-a ra-MOSE-a) is a genus of branching stromatoporoid. Individual branches are thinner than a spaghetti noodle, and may look like fossil noodles in the bedrock (Fig. 27). *Amphipora* is common in the lower limestone ledge on

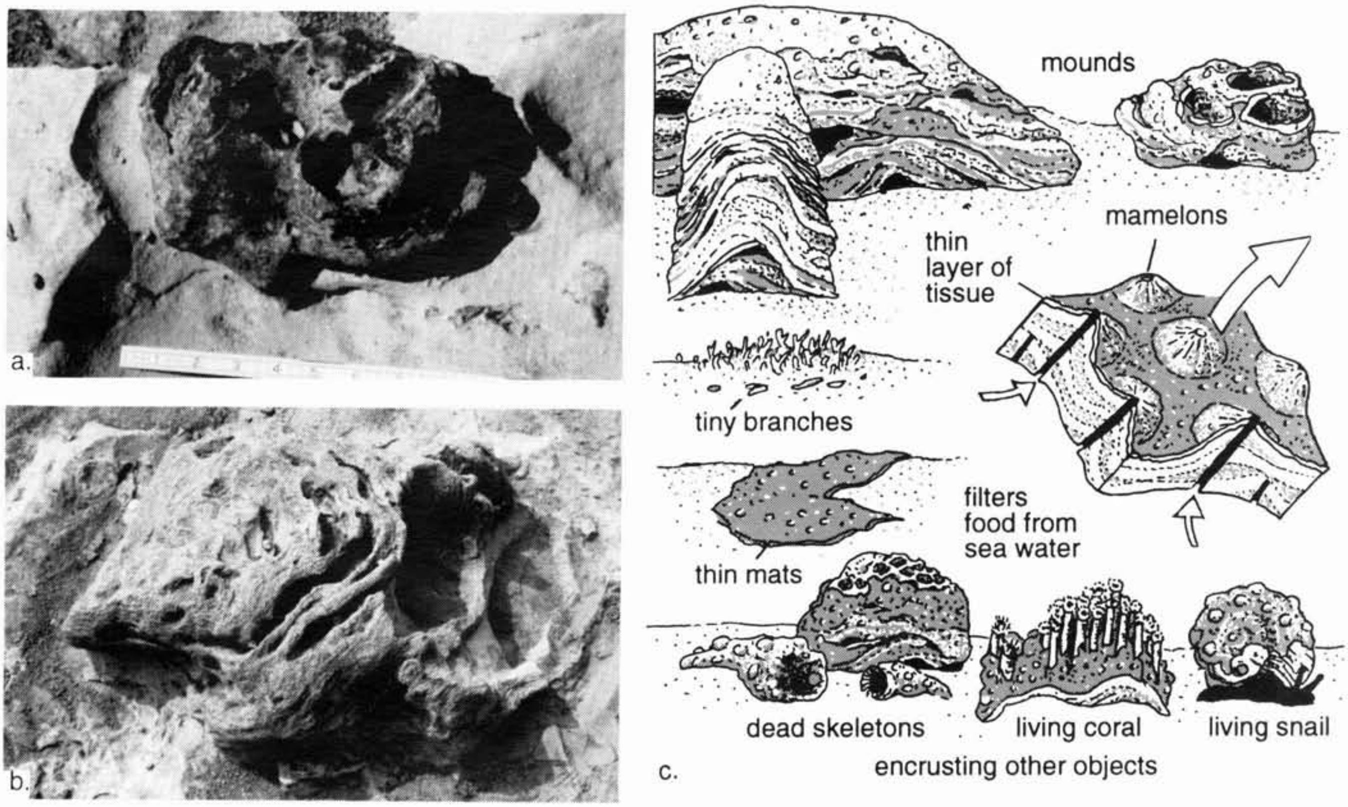


Figure 25. Photographs of silicified stromatoporoid mounds on the Indiana shore that look like manure (a) and (b). The illustration of stromatoporoids in life (c) shows how water was filtered through small bumps, or mamelons, on the surface of many stromatoporoids.

the Indiana shore, the south flats, and in some of the islands near the spillway. In fact, these fossils are so common at this level of the Jeffersonville Limestone that they have been used to characterize one of the fossil zones (Fig. 6). However, because the bedrock in which the fossils occur is similar to the underlying limestone, and because the *Amphipora* fossils are so small, it is difficult to differentiate the coral zone from the *Amphipora ramosa* zone without close examination.

While the encrusting stromatoporoids are useful indicators of animal relationships in the ancient seas, *Amphipora* and the mat-like stromatoporoids are indicators of very shallow water depths such as occur in lagoonal environments (Carozzi, 1961; Perkins, 1963).

Bryozoans

Bryozoans (bry-OH-zo-enz) are another type of fossil common in the Jeffersonville Limestone. They are most common in the bryozoan-brachiopod zone exposed in the ledges on the Indiana shore (Figs. 5–6). Bryozoans can form mounds, crusts, or tubes, as corals and stromatoporoids do, but they are most easily recognized when they occur as lacy fans or fronds. The type of bryozoans that formed these fans were called fenestrate bryozoans. The net- or mesh-like skeleton of the fenestrate bryozoans was used to filter microscopic food out of the water through tiny holes or apertures in each chamber of the net (Fig. 28).

Shelled Fossils

Brachiopods

Several types of shelled fossils can be seen at the Falls. Clam-like brachiopod fossils are common in the orange beds along McAlpine Dam (Fig. 5). Like the stromatoporoids, brachiopods are rare today, but they were abundant in Silurian and Devonian times. Brachiopods differ from modern clams (called molluscs or pelecypods) by having two dissimilar shells instead of two similar shells, as pelecypods have (Fig. 29). Many different shapes of brachiopods can be seen at the Falls.

Two types are so abundant that they are used to characterize fossil zones in the Jeffersonville Limestone (Figs. 5–6). The brachiopod *Brevispirifer* (BREV-eh-SPEAR-eh-fir) has a slightly rounded shell less than 2.5 cm (1 in.) across (Fig. 30a). Its shells are strongly ribbed and may have a hook-like protrusion along the hinge where the two shells of the brachiopod came together

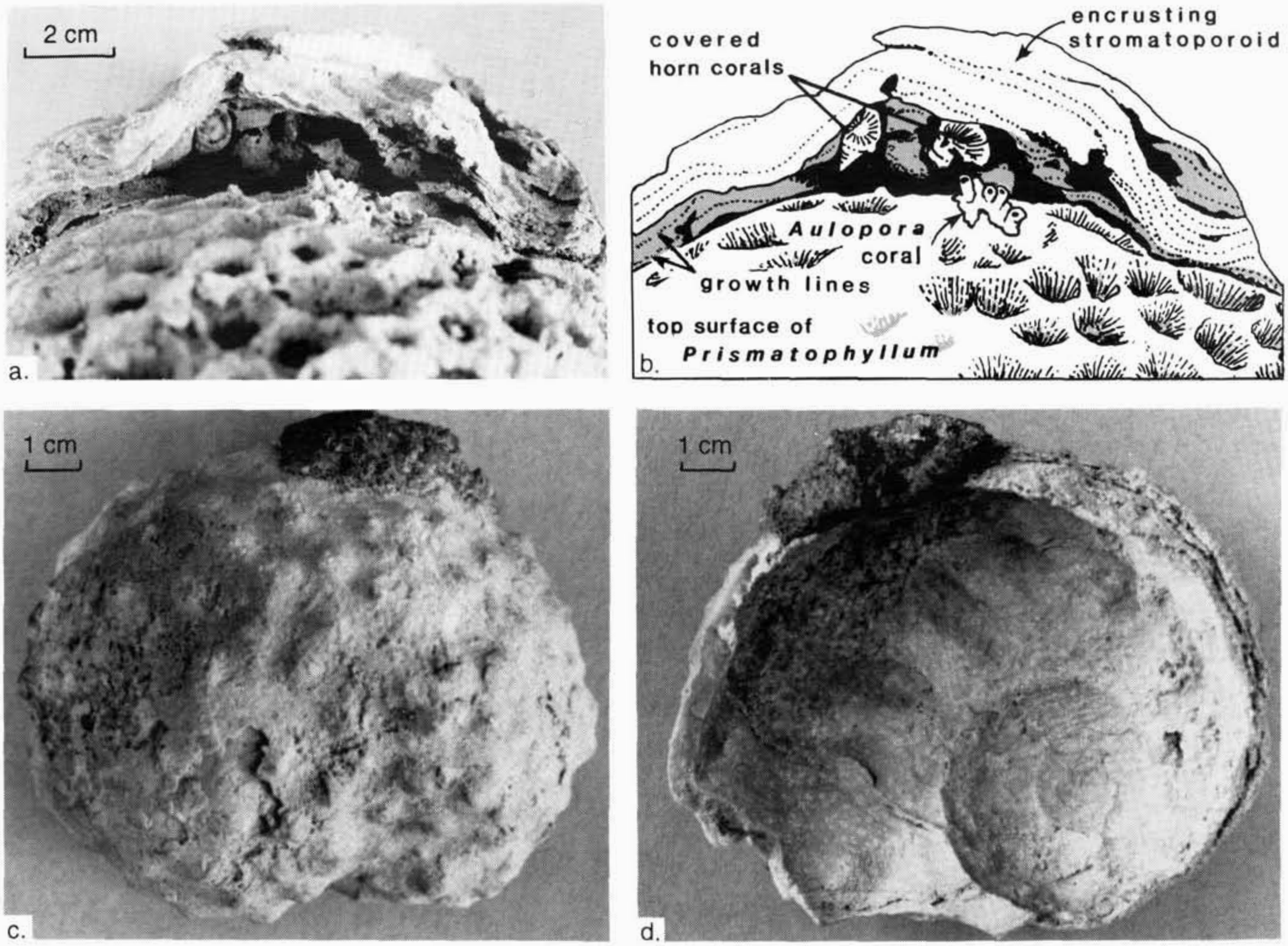


Figure 26. Photographs and illustrations of encrusting stromatoporoids. (a) Side view of a stromatoporoid that encrusted a *Prismatophyllum* coral. (b) Explanation of the photograph. (c) Top and (d) bottom view of a stromatoporoid that encrusted a snail; the shape of the snail coils is preserved in the mold formed by the base of the stromatoporoid fossil.

(Fig. 30b). The shells are usually found in groups or clusters, which is probably the way the animals lived on the ancient seafloor.

Paraspirifer (PAIR-a-SPEAR-eh-fir) is another type of brachiopod that is common only in the uppermost part of the Jeffersonville Limestone. *Paraspirifer acuminatus* is usually wider than it is long, with a deep V-notch in the shell (Fig. 30c). The V-notch demonstrates the difference in the two valves of the brachiopod shell. One valve, called the pedicle or ventral valve, has a bulge or rib at the center of the shell, whereas the other shell, called the brachial or dorsal valve, has an indention or trough that fits into the bulge. *Paraspirifer acuminatus* shells are often much larger than *Brevispirifer gregarius*

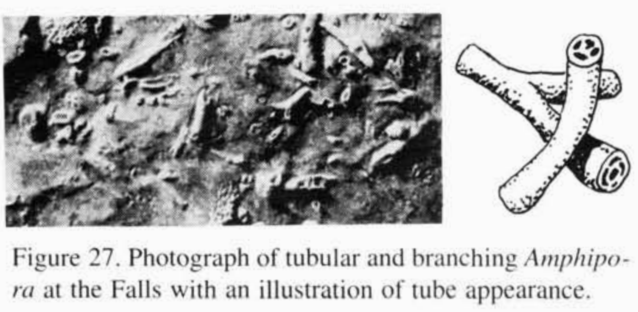


Figure 27. Photograph of tubular and branching *Amphipora* at the Falls with an illustration of tube appearance.

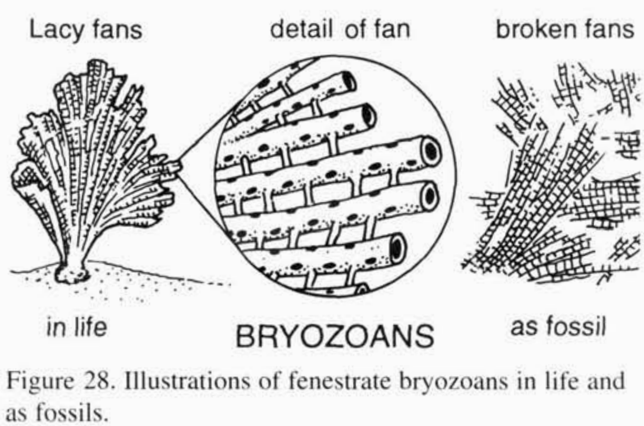


Figure 28. Illustrations of fenestrate bryozoans in life and as fossils.

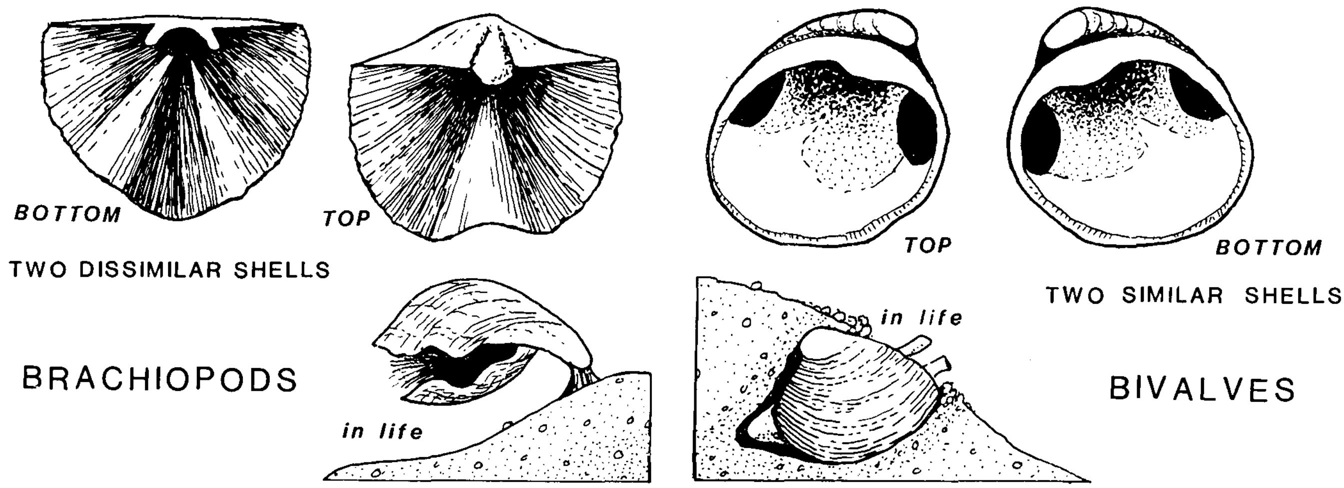


Figure 29. Illustration of the differences between brachiopods and bivalves (pelecypods) (*from* Greb, 1989).

shells; some shells are nearly 5 cm (2 in.) across (Fig. 30c).

Many other types of spiriferid brachiopods at the Falls are less common than *Paraspirifer* or *Brevispirifer*. These other kinds of spirifers are characteized by long, wing-like shells (Figs. 30d–e). Long, winged shells would have been an advantage to a brachiopod trying to rest on an unstable, fine-grained seafloor.

Another way brachiopods adapted to soft, muddy seafloors was to make broad, flat shells. *Stropheodonta* is an example of a brachiopod that had a flat shell (Fig. 30f). These shells are common in the *Paraspirifer* and fenestrate bryozoan-brachiopod zones of the upper Jeffersonville Limestone.

Other types of brachiopods that existed at the Falls are harder to find. Some were rounded with a point at the center of the hingeline, like *Athyris* (a-THY-ris) (Fig. 30g) and *Atrypa* (A-tri-pah) (Fig. 30h). *Atrypa* shells can be found in the fenestrate bryozoan-brachiopod and *Paraspirifer* zones of the Jeffersonville Limestone and in the overlying Sellersburg Limestone (Conkin and Conkin, 1976). *Atrypa* can be differentiated from *Athyris* by its fine ribbing.

Pelecypods

Pelecypods are the group of animals that includes the modern clam. They have two identical shells rather than two different shells (Fig. 29). Although pelecypods are one of the most common types of shelled animals living today, they were uncommon in the Devonian seas, and are much rarer then brachiopod shells at the Falls of the Ohio. pelecypod shells are most common in and above the *Brevispirifer gregarius* zone at the Falls, and can be seen in the orange beds near the dam (Figs. 5–6, 7h). In the orange beds pelecypod fossils look like spoon-shaped groups of orange and white crystals (Fig. 31a). In other levels of the upper Jeffersonville Limestone and in the overlying Sellersburg Limestone they may look more like modern clams, such as *Paracyclas* (pear-ih-SIKE-less) (Fig. 31b).

Pelecypod shells are often recrystalized because the living pelecypods had shells made out of the mineral aragonite, as have clams today. Aragonite is not as stable as calcite, which is what brachiopod shells are made of. The calcite in brachiopods is similar to the minerals in the lime mud in which they were buried, so brachiopod shells were directly fossilized into the limestone bedrock. In contrast, the aragonite in the pelecypod shells was often dissolved when they were buried, leaving only molds of the original shells. If silica-rich water flowed through the rock (Fig. 8), the molds were filled with quartz crystals or other minerals.

Rostroconchs

Another example of a shelled fossil from the Falls is the shell *Hippocardia* (HIP-o-CAR-dee-uh) (Fig. 31c). *Hippocardia* belonged to the Rostroconchia (rah-stra-CONK-ee-uh) class of molluscs. They once were considered a type of pelecypod, but because of details beyond the scope of this report are now classified separately. *Hippocardia* was very clam-like, but had a shell with strong ribs and a wing-like shape similar to the spiriferid brachiopods. However, *Hippocardia* can be differentiated from the spiriferid brachiopods by both the upper and lower shells or valves of the shells looking the same; valves of a brachiopod shell would look different from each other. The reason many rostroconchs, pelecypods, and brachiopods had similar-looking shells was because the animals adapted to living in similar environments.

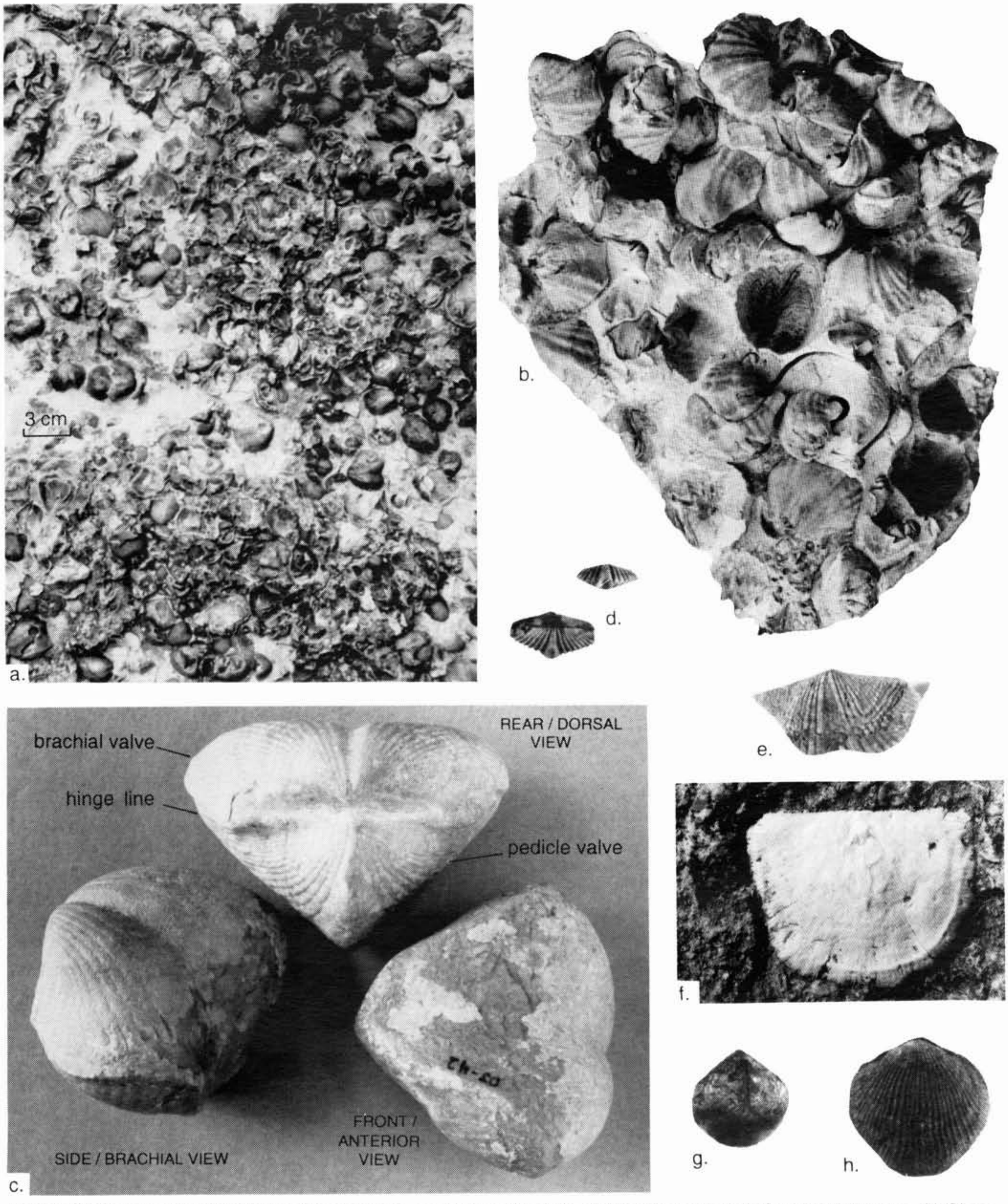


Figure 30. Photographs of fossil brachiopod shells. (a) Cluster of *Brevispirifer gregarius* shells from near the dam. (b) Close-up of *Brevispirifer* cluster showing the shape of some of the shells. (c) Various orientations of large *Paraspirifer* shells removed from the surrounding bedrock. (d) Small, spirifer shells. (e) Larger spirifer, *Platytrachella*. (f) *Stropheodonta* in bedrock. (g) *Athyris*. (h) *Atrypa*.

Gastropods

Pelecypods and rostroconchs are classes of the phylum Mollusca. Another class of molluscs found at the Falls is Gastropoda, which includes snails. Snails are not very common in many zones of the Jeffersonville Limestone, but some are large enough to be found by the amateur fossil hunter willing to look for them. A gastropod that occurs in the fenestrate bryozoan-brachiopod and *Paraspirifer* zones (Figs. 5–6) at the Falls is *Platyceras* (plat-IH-sir-as). These fossil snail shells may be only slightly coiled or they may be tightly coiled, as many modern snail shells are. *Platyceras* had many spines that stuck out from the snail's shell for protection from predators (Figs. 32a–b). In most fossils the spines are broken off, but in rare specimens some of the spines are preserved.

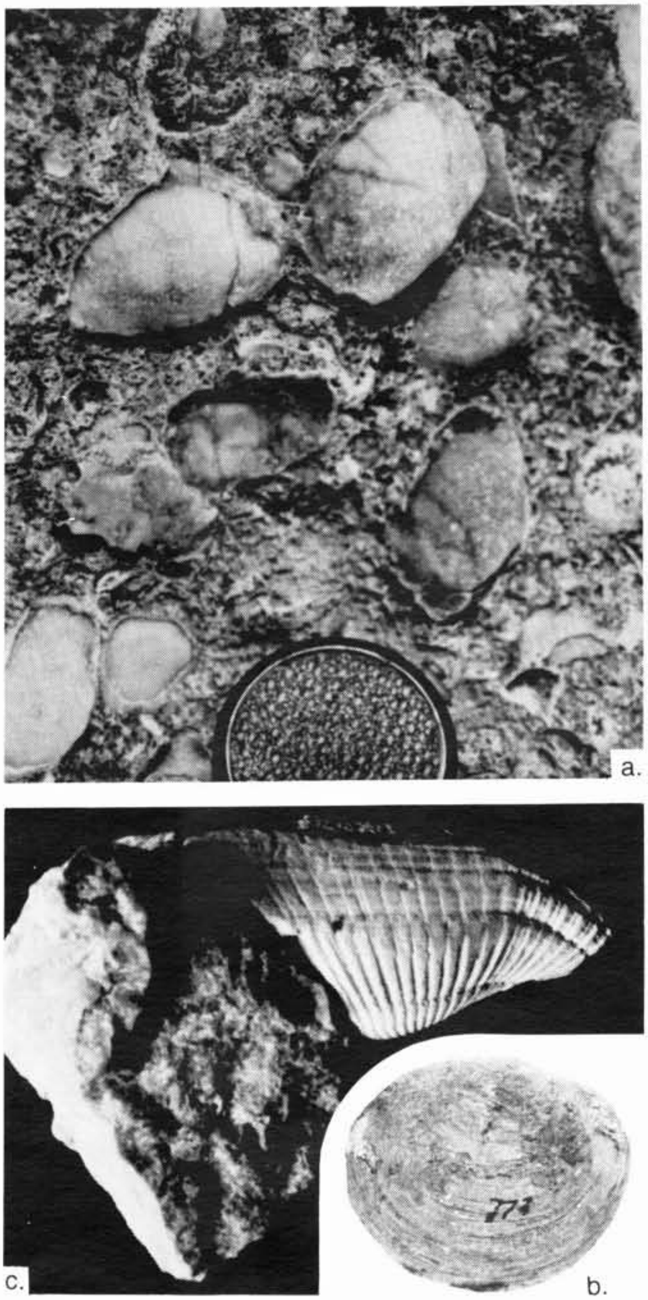


Figure 31. Photographs of fossil pelecypod and rostroconch shells. (a) Group of crystallized pelecypod fossils in the bedrock of the upper orange beds (*Brevispirifer* zone) near the dam. (b) *Paracyclas* clam shell. (c) The rostroconch *Hippocardia*.

Another type of gastropod fossil at the Falls is the snail *Turbonopsis* (TUR-bow-NOP-sis). Some of these snails were as large as a fist (Fig. 32c). *Turbonopsis* had an aragonite shell, so its fossils are often recrystallized. Near the dam, in the orange-colored *Brevispirifer gregarius* zone (Figs. 5–6), beautifully preserved coils of white crystals (like the fossil snail on the cover of this booklet) are actually the preserved remnants of *Turbonopsis* shells. Please do not try to remove these fossils from the beds. They are fragile, and collecting is prohibited by law.

Many of the *Turbonopsis* shells at the Falls are covered by stromatoporoids, as shown in Figures 26c and 26d. The stromatoporoid fossils do not normally cover the opening of the shell where the snail lived. This may indicate that the stromatoporoids lived on the shell while the snail was alive. The stromatoporoids would have benefited from this arrangement by being carried around to different food sources by the snails. They may even have eaten food left over or stirred up by the snails. In turn, the stromatoporoid covering would not have harmed the snail and would have been a type of camouflage that helped the snails blend in with their environment (Fig. 32b).

Other Fossils

Echinoderms

Echinoderms (ee-KYN-oh-dermz) are a group of animals that includes the modern starfish and sea urchin. Most have skeletal plating that acts like armor around the soft bodies of the echinoderm animals. Two kinds of echinoderm fossils, crinoids and blastoids, are found at the Falls, although whole specimens of either are rare.

Crinoids and blastoids were made up of a stalk or stem that was attached to the seabed or the hard surface of another animal. The stems were comprised of ring-shaped skeletal plates stacked like beads on top of each other and connected by soft tissues (Fig. 33a). When the animals died the soft tissues rotted and the stems commonly broke apart into hundreds of tiny rings. These ring-shaped fossils are often called Indian beads when they are separated from the bedrock. The ring-like

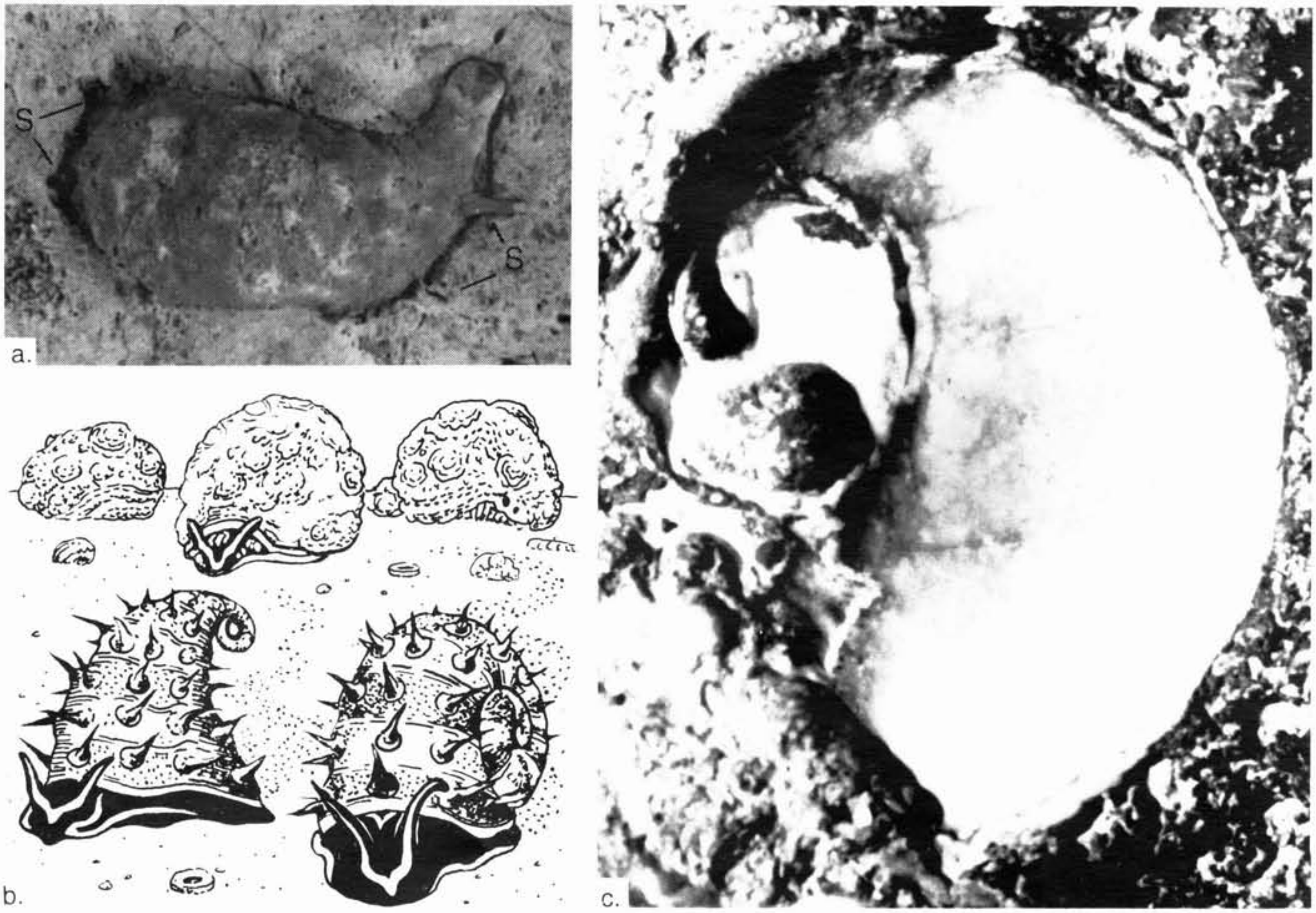


Figure 32. Gastropod fossils at the Falls. (a) Photograph of *Platyceras* snail fossil with broken ends of spines (S). (b) Illustrations of how snails may have protected themselves in the seas at the Falls. Coiled and uncoiled *Platyceras* snails with spines, and camouflaged *Turbonopsis* snails encrusted with stromatoporoids (middle backround). (c) Photograph of large, recrystallized *Turbonopsis* snail fossil in the orange beds (*Brevispirifer* zone) near the dam.

plates of crinoids and blastoids are common throughout the Jeffersonville and Sellersburg Limestones.

In life, the stems of the crinoids and blastoids supported a crown or calyx that had arms or tentacles for filtering microscopic food particles out of the sea (Fig. 33a). Because the arms and tentacles make crinoids look like flowers, they are often called sea lilies. However, crinoids are animals, not plants. They still live in the sea today, although they are not as common as they were in the Devonian seas. The crinoid calyx is usually cone shaped and branches upward into a series of arms (Figs. 33b–c). In rare specimens, the filter-feeding tentacles on the ends of the arms may be preserved as impressions in the bedrock (Fig. 33c).

Blastoids have a stem, like crinoids, but rather than a cone-shaped calyx, they have a rounded or bulbous calyx (Fig. 33d). Also, the blastoid calyx has no branches, but a star-shaped impression on its top. The filter-feeding tentacles came out of this star-shaped mark (Fig. 33a). The blastoid *Elaeacrinus* (el-EE-a-KRYN-us) can be found at the Falls, but since most are less than 1 cm (0.4 in.) in diameter, they are difficult to find.

Trilobites

Another animal that lived in the shallow seas around Louisville during the Silurian and Devonian Periods was the trilobite. Trilobites were distantly related to modern horseshoe crabs and belong to the phylum Arthropoda. Trilobite fossils look similar to the pill bugs or "rolly-pollies" you might find under a rock in your backyard. Both are types of arthropods. Arthropods commonly have a hard exterior skin or shell to protect them like a suit of armor. Trilobites had a segmented shell that let them bend or roll up into balls for protection. They could shed or molt this skin as they grew. The rolled trilobites in Figure 34 are examples of *Phacops* (FAY-cops). Complete

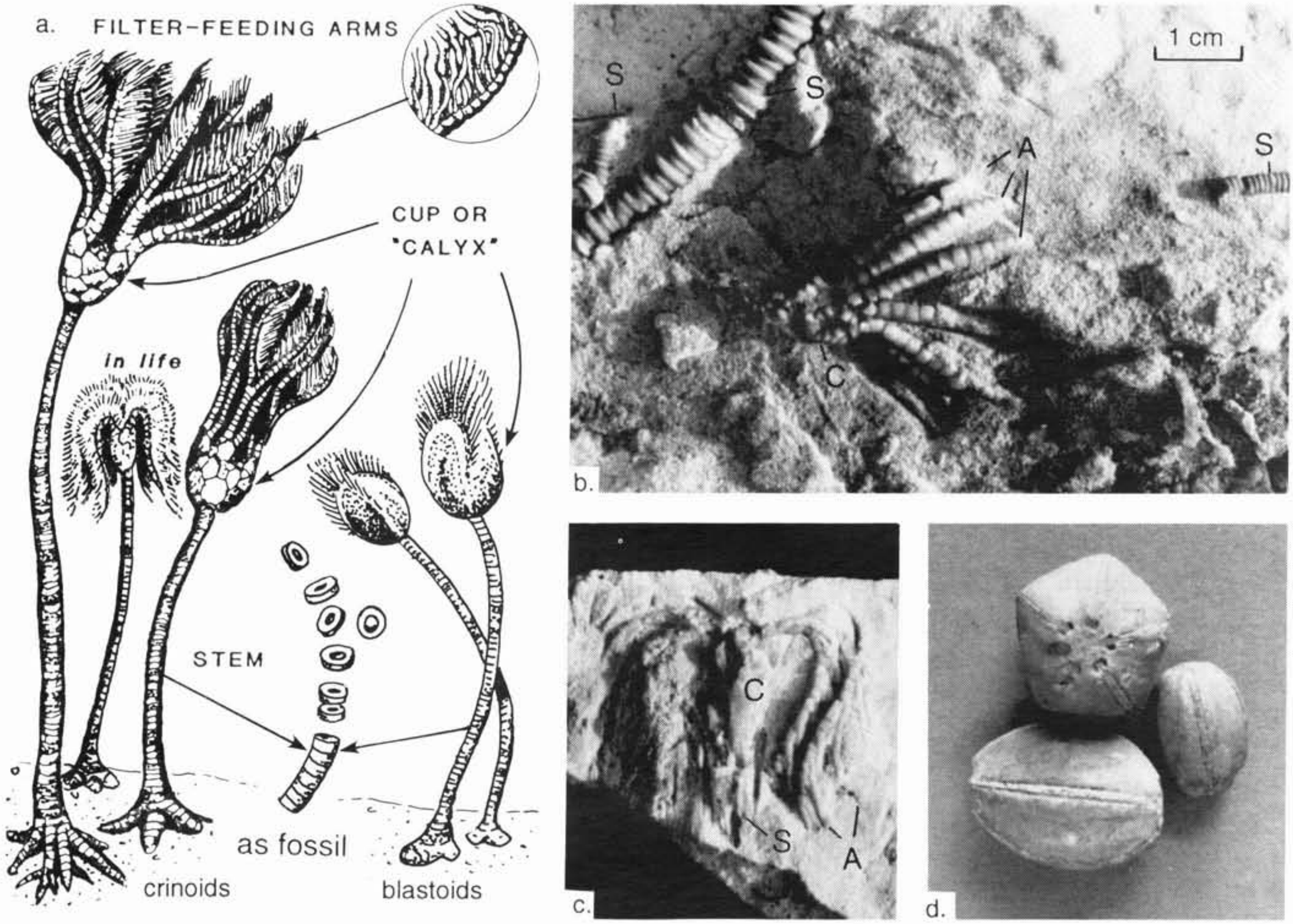


Figure 33. Echinoderm fossils of the Jeffersonville Limestone. (a) Illustration of crinoids and blastoids in life position. (b) Photograph of crinoid stems (S) and calyx (C) with partial arms (A). (c) Photograph of crinoid calyx with indentations from the original feathery tentacles on the arms. (d) Different views of calices of the blastoid *Elaeacrinus*.

trilobite fossils are very rare at the Falls, but broken fragments of trilobite molts can be found throughout the Jeffersonville Limestone, especially in the *Brevispirifer gregarius* zone, and in the overlying Sellersburg Limestone.

Vertebrate Remains

All of the fossils described to this point are the remains of invertebrate animals; they lacked backbones. Vertebrate animals have backbones. The remains of vertebrate animals such as fish and sharks have been found in bone beds at the Falls. These beds are concentrations of bones and broken fossil debris that overlie irregular bedding surfaces in the upper Jeffersonville Limestone. Bone beds have been found at the base of the fenestrate bryozoan-brachiopod and *Paraspirifer* zones and within the *Paraspirifer* zone (Conkin and Conkin, 1973, 1980, 1984; Conkin and others, 1973). The irregular surfaces may have been cut during ancient storms or changes in Devonian sea level. Fossil teeth, bony plates, and bony spines of primitive fish were concentrated in several of these layers at the Falls. The pieces are usually orange, maroon, or blue-black; very small; fragmented; and sometimes polished. Most are so small they are unrecognizable to all but the serious scientist. Often they are so fragmented it is impossible to tell what kind of Devonian fish they came from, although they can be compared to other known Devonian fish such as the jawless ostracoderms, early jawed placoderms, or primitive sharks (Fig. 35). However, in some cases, plate-like bones are large enough that you can see the bony grain of the fossils. The bony plates in Figure 35 are from a type of placoderm fish called an arthrodire. Arthrodires grew to lengths of 10 m (30 ft.), and had heads that were completely covered in bony armor (Fig. 35).

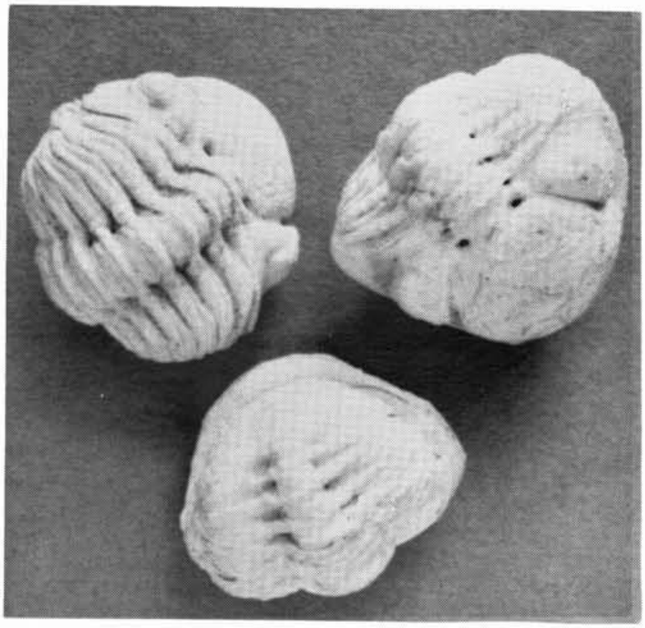


Figure 34. Photographs of rolled *Phacops* trilobites from northern Jeffersonville in the Falls area.

SUMMARY

The fossils at the Falls of the Ohio can be used to reconstruct what the Devonian seas of Louisville and southern Indiana were like between 380 and 400 million years ago (*see* cover illustration). When scientists find different kinds of fossils in the same layer, or different fossils encrusting each other, they can piece together the way animals of the Silurian and Devonian seas interacted. With a little puzzle-solving ability, the scientists can reconstruct the fossils at the Falls of the Ohio to show what the ecosystems of the ancient seas were like millions of years ago.

The lower part of the coral zone of the Jeffersonville Limestone developed on the eroded remains of the Louisville Limestone. Initially, small horn corals, colonial coral mounds, and stromatoporoids took a foothold on the seafloor of the Falls area (Fig. 36a). The corals thrived in the tropical Devonian seas, just as corals thrive in tropical seas of the Bahamas today. At certain times tabulate corals constituted the bulk of the corals growing on the seafloor; at other times rugose corals were abundant. Given time, the small pioneering corals and stromatoporoids grew larger and clustered into groups of corals and stromatoporoids (Fig. 36b). As the corals grew, the older parts of their skeletons and the skeletons of animals that died provided a hard surface for smaller corals and other animals to grow on (Fig. 36c). When these animals died their skeletons were overgrown with branching corals and stromatoporoids until large mounds of corals and other animals dotted the seafloor. Large associations of corals and other animals may have formed bioherms, which are similar to but smaller than true reefs (Fig. 36d).

Branching corals in the lower coral zone tend to be less fragmented than branching corals in the upper coral zone, which may indicate that during deposition of the upper coral zone the coral bioherms had grown upward to depths at which they were affected by wave energy (Perkins, 1963). The shallowing effect led to the destruction and ultimate burial of the coral zone (Fig. 36e).

The broken fragments of the coral zone were colonized by the organisms of the *Amphipora* zone (Fig. 36f). During deposition of this zone, stromatoporoids became much more abundant than corals (Fig. 6). Abundant mat-like stromatoporoids, branching *Amphipora* stromatoporoids, and abundant broken fossils are evidence that this zone was deposited in shallowing, lagoonal waters (Perkins, 1963; Powell, 1970; Droste and Shaver, 1975).

The upper surface of the *Amphipora* zone at the Falls is irregular and contains small scours filled with fossil debris from the overlying *Brevispirifer gregarius* zone (Conkin and others, 1973; Conkin and Conkin, 1973, 1976). This erosional surface documents a change in seafloor conditions, possibly a large storm or another change in sea level. The net effect of the change was further shallowing of the Jeffersonville seas and the development of a new community of marine animals better suited to the new seafloor.

During deposition of the *Brevispirifer gregarius* zone, large *Turbonopsis* snails and clusters of brachiopods spread across the seafloor in relatively calm tropical waters (Fig. 36g). Small corals also lived on the seafloor, but there were not as many of them and they were not as large as the corals that formed the coral zone. There were also clams, echinoderms, and bryozoans, but they were not as large or abundant as they would become.

Bone beds at the top of the *Brevispirifer gregarius* zone provide evidence for yet another major change in the Jeffersonville seas that destroyed much of the *Brevispirifer* community and eroded into the underlying seafloor (Fig. 36h). The net effect of this change was a deepening of water in the Falls area. Fish bone fragments indicate that arthrodires and other primitive fish swam in these seas. Many of the fish may have lived in much deeper water to the southwest and only floated into the Falls area when they died. Other fish may have sought the shelter of the seas in the Falls area as protection against large arthrodires and primitive sharks that patrolled the deeper waters, just as fish do in the seas today.

Figure 35. Illustration of the types of Devonian fish that could have lived in the Falls area, with a top (T) and bottom (B) view of a piece of arthrodire bony plating from the Beechwood Member of the Sellersburg Limestone. The top view shows bubbly ornamentation (Or), and the bottom view shows the grain of the bone.

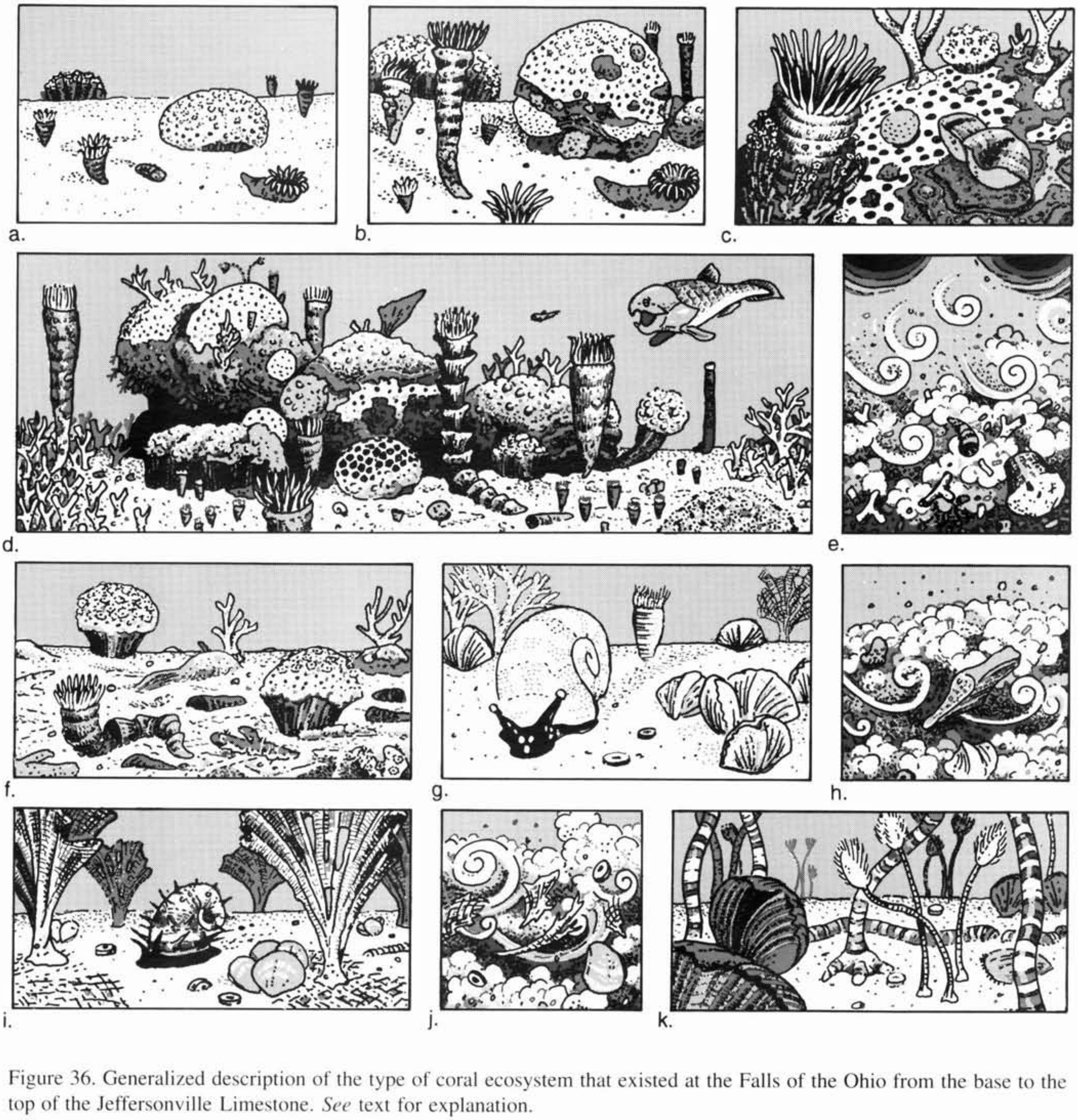


Figure 36. Generalized description of the type of coral ecosystem that existed at the Falls of the Ohio from the base to the top of the Jeffersonville Limestone. *See* text for explanation.

The types of marine animals that lived in the seas of the fenestrate bryozoan-brachiopod zone were slightly different than the animals of the *Brevispirifer gregarius* zone. *Brevispirifer* brachiopods were replaced by a wide suite of other brachiopods such as *Atrypa* and *Strophedonta.* Bryozoans, which had been only small components of earlier communities, became widespread until the seafloor at the Falls was probably covered by thickets of delicate fans (Fig. 36i). The fragile nature of the bryozoans indicates continued deepening of the seas during this time, since these animals probably could not survive long in shallow waters affected by wave energy (Perkins, 1963).

During deposition of the *Paraspirifer acuminatus* zone, several storms or changes in sea level resulted in multiple erosive surfaces and bone beds in the upper Jeffersonville Limestone (Fig. 36j). The seafloor conditions that followed these events were similar to those preceding them, as evidenced by the small amount of difference between the fossils of the fenestrate bryozoan-brachiopod and *Paraspirifer acuminatus* zones (Perkins, 1963; Conkin and Conkin, 1976). Large *Paraspirifer* brachiopods increase in the upper Jeffersonville Limestone, which may indicate that this brachiopod was better suited to the upper Jeffersonville seas than the other brachiopods in the Falls area (Fig. 36k). Crinoid fossils also increase, which may indicate that they were able to out-compete the bryozoans that filled the same ecological niche.

Hence, the fossil beds at the Falls of the Ohio illustrate that each major change in the Devonian environment was followed by a change in the types of animals that lived on the seafloor. New groups of animals, better adapted to the new environment, continuously moved into the Falls area to fill the ecological niches left by the animals that had preceded them, or new niches created by the new environment. This type of change is called ecological succession and it still happens in the seas today. The ecological succession documented at the Falls occurred across a time span of millions of years and led to the different fossil zones in the Jeffersonville Limestone. The beds that make up the zones were buried and the hard parts of the animals that had thrived on the sea bottom became the famous fossil beds we see today.

The fossil beds of the Falls of the Ohio are a wonderful natural resource that can be used for recreational and educational purposes. The beds have survived the repeated drowning and draining of the continent by inland seas, the glaciers of the Ice Ages, and the steady erosion of the Ohio River (which will eventually destroy the fossil beds). Having survived for so long, it is not too much to ask that this important site be preserved. Since the scientific importance of the beds was first recognized, untold numbers of fossil specimens have been taken from the bedrock. Some are kept in museums, but many have been lost and will never be seen again. Even with laws protecting the fossils, vandalism still occurs. Please help to protect the fossil beds so that future generations can look and wonder at the striking evidence of days long past.

EDUCATIONAL IDEAS FOR GROUPS AT THE FALLS

The Falls of the Ohio State Park offers educational groups many opportunities. If you are a teacher or leader of a group that wants to visit the Falls and would like a tour of the fossil beds, you are encouraged to call the State Park in advance to reserve a time for your visit and to check on river levels. The Visitors Center contains many exhibits and dioramas that can be used to supplement classroom information. Meeting rooms and a library are also available for groups to use. Call Falls of the Ohio State Park at (812) 945–6284 to make your plans. You can also check with the Park for ideas to increase your group's educational experience. Following are some ideas that incorporate some aspect of geology.

Treasure Hunt/Fossil Identification

Make a trip to the Falls a treasure hunt. After walking through the fossil exhibits at the Visitors Center, let members of your group see how many different kinds of fossils they can identify in the fossil beds. You can use the photos in this book as a guide. Give all members of your group a piece of paper or a copy of this book, a pen or pencil, and let them write down the different types of fossils they find.

The level of identification can be adjusted for age and experience. For example, fossil novices or young children might get one point for finding a shell, a horn-shaped coral, or a mound of coral or stromatoporoid. For more experienced individuals, or classes that have had fossil identification as part of a geology course, distinguishing between brachiopods and pelecypods, or identifying different types of brachiopods and corals might be more appropriate. After 10 or 20 minutes gather everyone together and find out what they have found. Have each individual lead the group to a different kind of fossil on his or her list so that everyone can see the widest variety of fossils.

Biggest Coral Contest

Another version of the treasure hunt is to have members of your group try to find the largest coral. You'll need rulers for each individual. From the shore on the north flat (*see* map on p. 6) give everyone 2 to 5 minutes to run out on the north flats and find the longest horn coral, or the widest mound of coral or stromatoporoid. Then have a judge walk around and measure each fossil to see who found the largest fossil!

Fossil Drawing

Groups of young children or art classes might like to use the fossil beds as an outdoor classroom. Many fun things can be done at the Falls with some drawing paper, colored pencils, crayons, or paints. You could have members of the group identify the fossils in an area along the shore. Then have members draw the fossils as they may have looked in life. Dioramas in the Visitors Center and the illustrations in this booklet will give students an idea of what the different fossils looked like in life.

A variation on this exercise is to go to the fossil beds first, play this game, and then go to the dioramas in the Visitors Center. This makes the students use their imaginations without relying on preconcieved notions about what the fossils looked like when they were alive. A horn coral could become a horn on a cow or a dinosaur depending on the imagination of the artist. Then when your group tours the Visitors Center the students can compare their ideas to what the fossils actually looked like in the dioramas.

Fossil Mapping

Let your group discover how the types of fossils changed at the Falls through time, as in Figure 36 on page 32. Your group will need graph paper, a pencil, and a copy of this book. Walk down the stairs to the fossil beds and out onto one of the fossil beds (*see* the map on p. 6). When everyone is gathered at the same rock bed, have each student spread out so that each has a 2- or 3-foot-square area of exposed rock to look at. Give everyone 5 minutes to count the fossils in his or her area. For a simple exercise, have students count only the number of shells. For a slightly more complex lesson, have them count the number of shells, horn-shaped corals, mounds of coral, branching corals, etc., in their areas (*see* Fig. 6 on p. 7 for major groups). Then have each student keep track of his or her count individually, or you can add up the number of fossils everyone found in Bed 1 and keep a master count. Then walk down to the next ledge and repeat the procedure. You can do the counts for as many ledges as time allows. Try to space out the beds to include the uppermost ledge and the north flats in order to see a major change in the types of fossils.

When you have done counts for the number of beds you have chosen, have the students make graphs of their data. This can be done along the shore at the Falls, in a classroom in the Visitors Center (if reserved in advance), or back in school. In the case of shell counting, have each student write "number of shells" along the horizontal axis of a piece of graph paper and "bed number" (1 for top, 2 for bed below 1, etc.) on the vertical axis. Then have each student fill out the graph with the data they collected. In this way students combine the fun of the treasure hunt with a practical lesson in data collection and graphing. You can make a master graph of the sum of everyone's data to show how the sum of data may be different than any one student's individual data.

ACKNOWLEDGMENTS

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* intended for non-scientists

APPENDIX A

Measured Sections

Following are descriptions of geological sections in the Falls area made by the authors. For descriptions of the same intervals by other authors, *see* Powell (1970), Kepferle (1974), and Conkin and Conkin (1976, 1980).

Geologic Section 1

This section is a composite of beds exposed at the Falls of the Ohio and Cane Run Creek. The type section of the Jeffersonville Limestone is the rock ledges at the Falls of the Ohio, New Albany Quadrangle, Clarksville, Clark County, Indiana, and Louisville, Jefferson County, Kentucky. However, the upper 2 m (6 ft.) of the Jeffersonville Limestone (*Paraspirifer acuminatus* zone) is not well exposed in these beds. The upper Jeffersonville Limestone and overlying Silver Creek Member of the Sellersburg Limestone are exposed in a section northwest of the mouth of Cane Run Creek, New Albany Quadrangle, Clarksville, Clark County, Indiana, and Louisville, Jefferson County, Kentucky. Also, in the fall of 1988, the top of the Louisville Limestone was exposed at river level northwest of the mouth of Cane Run Creek.

Sellersburg (North Vernon) Limestone

Silver Creek Member (0.6 m, 2 ft.)

Dolomitic limestone or limy dolomite, light-bluish- to greenish-gray, argillaceous, fine-grained. Predominantly mudstone. Unfossiliferous. Poorly exposed at the Cane Run Creek Section.

Jeffersonville Limestone (10.7 m, 35 ft.)

Paraspirifer acuminatus zone (1.8 m, 6 ft.)

Limestone, light-yellowish-brown, fossiliferous, with crinoidal matrix. Some chert near the middle of the unit. Wackestones and packstones predominate. *Paraspirifer acuminatus* common to abundant, usually preserved as isolated pedicle valves. Also, abundant fenestrate bryozoans, brachiopods (*Paraspirifer, Atrypa*, *Stropheodonta*, *Rhipidomella*), and snails (*Platyceras*). Fossils in this zone are generally similar to those in the underlying zone but with abundant *Paraspirifer.*

Bryozoan-brachiopod zone (1.8 m, 6 ft.)

Limestone, light-brownish-gray, fossiliferous, coarse-grained, crinoidal, with white chert stringers and nodules. Predominantly grainstones and packstones. Abundant fenestrate bryozoans, crinoids (*Dolatocrinus*), and brachiopods (*Atrypa*, *Stropheodonta*). Common to uncommon blastoids (*Elaeacrinus*); snails (*Platyceras*); small, rugose horn corals (*Siphonophrentis*); rugose colonial corals (*Eridophyllum*, *Prismatophyllum*); and tabulate corals (*Favosites*).

Brevispirifer gregarius zone (1.4 m, 4.5 ft.)

Limestone, light-gray to light-brownish-gray, fossiliferous, with a 20-cm-thick (8 in.), orange to brown, cherty, silicified zone near the top. Predominantly packstones and grainstones, with some wackestones. Abundant brachiopods (*Brevispirifer gregarius*), small horn corals (*Zaphrenthis*, *Heterophrentis*), rugose colonial corals (*Eridophyllum*), tabulate corals (*Favosites*, *Pleurodictyum*), snails (*Turbonopsis*), clams, stromatoporoid mounds and crusts, and crinoid debris.

Amphipora ramosa zone (2.6 m, 8.5 ft.)

Limestone, light- to medium-brownish-gray, fossiliferous. Some cherty layers. Predominantly packstones and grainstones. The limestone contains solution cavities along the Indiana shore and in the islands area on the Kentucky side of the river. Abundant to common *Amphipora ramosa*. Corals common to abundant, including large (2 m, 6 ft.), tabulate coral heads (*Emmonsia emmonsi*); small to medium (*Favosites*), rugose colonial corals (*Prismatophyllum*, *Syringopora*); rugose horn corals (*Siphonophrentis*, *Heliophyllum*, *Heterophrentis*); also common stromatoporoid crusts, mats, and mounds.

Coral zone (3 m, 10 ft.)

Limestone, medium-gray, fossiliferous. Packstones and grainstones predominate. Abundant solitary and colonial corals, stromatoporoids, fenestrate bryozoans, crinoids, brachiopods, etc. Corals include large tabulate corals (*Emmonsia*, *Favosites*), branching tabulate corals (*Alveolites*, *Cladopora*, *Thamnopora*), large rugose horn corals (*Siphonophrentis*), and small rugose horn corals (*Aulacophyllum*, *Scenophyllum*). For a more complete listing of corals, *see* Stumm (1964).

Louisville Limestone (0.3 m, 1 ft.)

Limestone, light- to medium-gray, fossiliferous. Mostly packstones. Fossils include colonial corals (*Halysites*, *Heliolites*) and small mound-shaped stromatoporoids. The uppermost part of this unit is exposed only at low water along the north bank of the Ohio River along the north flats area and rarely northwest of the mouth of Cane Run Creek. The base of the unit is not exposed in the immediate area.

Geologic Section 2

The Sellersburg Limestone is exposed west of the Falls area along the north shore of the Ohio River at Clark Park, New Albany Quadrangle, Clarksville, Clark County, Indiana, north of the hydroelectric plant.

New Albany Shale

Blocher Member (0.3+ m, 1+ ft.)

Shale, black, fissile, unfossiliferous. Weathers gray. Poorly exposed on hillside.

Sellersburg (North Vernon) Limestone (5.3 m, 17.5 ft.)

Beechwood Member (0.75 m, 2.5 ft.)

Limestone, light-gray, abundantly fossiliferous, coarse-grained, crinoidal. Packstones and grainstones predominate. Unit weathers tan to buff. Fossils include crinoids, corals, and brachiopods. Irregular contact at base of the member is marked by argillaceous quartz sand with phosphatic nodules, marcasite, and fish bone fragments.

Silver Creek Member (4.6 m, 15 ft.)

Dolomitic limestone to limy dolomite, light-bluish- to greenish-gray, argillaceous, fine-grained. Predominantly mudstone. Unfossiliferous, burrowed mudstones in lower 3.3 m (11 ft.) of the unit. Cherty and fossiliferous in the upper 1.3 m (4 ft.). Distinctive conchoidal weathering forms lens-shaped rock fragments and scalloped surfaces along the river's edge. Irregular contact at the base of the member is marked by a sandy, pyritic, glauconitic horizon containing phosphate nodules.

Jeffersonville Limestone (0.3 m, 1 ft.)

Limestone, light-gray, fossiliferous, with abundant silicified *Paraspirifer acuminatus* brachiopod fossils. Uppermost part of this formation only exposed at low water levels.

Geologic Section 3

The New Albany Shale and unconsolidated Quaternary deposits are exposed along the north shore of the Ohio River between the mouth of Silver Creek and the K. and I. T. railroad bridge, New Albany Quadrangle, New Albany, Floyd County, Indiana. This is the type section of the New Albany Shale.

Unconsolidated Quaternary Deposits

Varved, light-gray, sandy silts and bluish-gray clays with partially carbonized leaf and stem fossils fill a channel-form scour (245 m; 800 ft.) partially exposed west of the mouth of Silver Creek. Kepferle (1974) reported C-14 ages of the fossils at 2,840 $\pm$250 years.

New Albany Shale (6+ m, 20+ ft.)

Blocher Member (6+ m, 20+ ft.)

Shale, dark-gray to black, fissile, essentially unfossiliferous. Weathers light to medium gray. Abundant marcasite nodules and crystals.

APPENDIX B

Fossil Names and Locations

UKDGS = University of Kentucky Department of Geological Sciences collections

RTHC = R. T. Hendricks private collection

Figure 4. *Thamnopora* sp.? (originally *Favosites limitaris*), $^1/_3$ original size, from Davis (1885, plate 30).

Figure 13. (a) *Heterophrentis simplex*, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC. (b) *Zaphrenthis phrygia*, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC. (c) *Siphonophrentis elongata (giganteas)*, in bedrock, upper coral zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (d) *Siphonophrentis* sp., in bedrock, *Amphipora ramosa* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (e) *Siphonophrentis* sp., in bedrock, *Amphipora ramosa* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (f) *Scenophyllum conigerum*, lowermost coral zone, Jeffersonville Limestone, Cane Run Creek Section, Clark County, Indiana, RTHC.

Figure 14. (a) *Heliophyllum ethelanum*, previously *Cyathophyllum ethelanum*, from Davis (1885, plate 80, no. 3), found in Louisville, Kentucky. (b) *Blothrophyllum decorticatum*, from Davis (1885, plate 98, no. 2), found in Louisville, Kentucky. (c) *Heliophyllum verticale*, previously *Cyathophyllum detextum*, from Davis (1885, plate 88, no. 3), Falls of the Ohio.

Figure 15. (a) *Aulacophyllum* sp., lower coral zone, Jeffersonville Limestone, Cane Run Creek Section, Clark County, Indiana, RTHC.

Figure 16. (a–b) *Eridophyllum* sp., in bedrock, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky.

Figure 17. (a) *Prismatophyllum* sp., in bedrock, coral zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana. (b–c) *Prismatophyllum* sp. with encrusting *Aulopora* sp., *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, RTHC.

Figure 19. (a) *Pleurodictyum* sp. tabulae, in bedrock, coral zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (b) *Favosites turbinatus*, top view, upper *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC. (c) *Favosites turbinatus*, side view in bedrock, upper coral zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky.

Figure 20. (a) *Emmonsia emmonsi*, in bedrock, *Amphipora ramosa* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky.

Figure 21. (a–b) *Emmonsia ramosa*, in bedrock, upper coral zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky.

Figure 22. (a) *Alveolites* sp., lower coral zone, Jeffersonville Limestone, Cane Run Creek Section, Clark County, Indiana, RTHC. (b) *Thamnopora* sp., lower coral zone, Jeffersonville Limestone, Cane Run Creek Section, Clark County, Indiana, RTHC. (c) *Trachypora* sp., Jeffersonville Limestone, Falls of the Ohio, UKDGS. (d) *Cladopora rimosa*, Jeffersonville Limestone, Falls of the Ohio, from Davis (1885, plate 59, no. 2).

Figure 23. (a–b) *Pleurodictyum* sp. in bedrock, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana.

Figure 24. (a) *Syringopora* sp., in bedrock, *Amphipora ramosa* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (b–c) *Halysites* sp., Louisville Limestone, Falls of the Ohio, Clark County, Indiana.

Figure 25. (a–b) Stromatoporoids from the upper coral zone, Jeffersonville Limestone, Falls of the Ohio.

Figure 26. (a–b) Stromatoporoid encrusting *Prismatophyllum* sp. coral, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC. (c–d) Stromatoporoid mold of *Turbonopsis* snail, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC.

Figure 30. (a) *Brevispirifer gregarius*, in bedrock, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (b) *Brevispirifer gregarius*, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKDGS. (c) *Paraspirifer acuminatus*, *Paraspirifer acuminatus* zone, Jeffersonville Limestone, Scott County Stone Company, Scottsburg, Indiana, RTHC. (d) *Spirifer hobbsi*, dorsal and pedicle views, Jeffersonville Limestone, Falls of the Ohio, UKDGS 6879. (e) *Platyrachella fornacula*, Jeffersonville Limestone, Falls of the Ohio, UKDGS 6878. (f) *Stropheodonta* sp., in

bedrock, bryozoan-brachiopod zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana. (g) *Athyris virrata*, Jeffersonville Limestone, Falls of the Ohio, UKDGS 2905. (h) *Atrypa reticularis*, Jeffersonville Limestone, Falls of the Ohio, UKDGS 6882.

Figure 31. (a) Silicified bivalves, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky. (b) *Hippocardia* sp., coral zone(?), Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, RTHC. (c) *Paracyclas elongata*, Sellersburg Limestone, Clark County, Indiana, UKDGS 772.

Figure 32. (a) *Platyceras dumosum*, in bedrock, base of the bryozoan-brachiopod zone, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana. (c) *Turbonopsis shumardi*, in bedrock, *Brevispirifer gregarius* zone, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky.

Figure 33. (b) Crinoids, *Brevispirifer gregarius* zone, Jeffersonville Limestone, from abandoned stone quarry northeast of Charlestown, Indiana, given to Dr. Frank Ettensohn for UKDGS. (c) Crinoid, *Brevispirifer gregarius* zone, Jeffersonville Limestone, from abandoned stone quarry northeast of Charlestown Indiana, RTHC. (d) *Elaeacrinus* sp., bryozoan-brachiopod zone, Jeffersonville Limestone, Cane Run Creek Section, Clark County, Indiana, RTHC.

Figure 34. *Phacops* sp., upper Silver Creek Member of the Sellersburg Limestone, along Utica-Sellersburg Road northeast of Jeffersonville, Indiana, RTHC.

SELECTED PUBLICATIONS AVAILABLE FROM THE KENTUCKY GEOLOGICAL SURVEY

GENERAL–INTEREST PUBLICATIONS

Progression of Life, by Stephen F. Greb, 1988, poster, 18 x 22 inches $4.75

Special Publication 13 (Ser. XI), **Guide to "Progression of Life," with Notes on the History of Life in Kentucky**, by Stephen F. Greb, 1989, 44 p. $6.00

Special Publication 8 (Ser. XI), **The Geologic Story of Kentucky**, by Preston McGrain, 1983, 74 p. $2.50

Special Publication 4 (Ser. IX), **Geology of the Natural Bridge State Park Area**, by A. C. McFarlan, 1954, 31 p. $1.50

Special Publication 6 (Ser. X), **The Geologic Story of Diamond Caverns**, by Preston McGrain, 1961, 24 p. $1.50

Special Publication 11 (Ser. X), **Geology of the Cumberland Falls State Park Area**, by Preston McGrain, 1955; reprinted with minor revisions 1966, 33 p. $1.50

Special Publication 12 (Ser. X), **Geology of the Carter and Cascade Caves Area**, by Preston McGrain, 1954; reprinted with minor revisions 1966, 32 p. $2.50

Special Publication 13 (Ser. X), **The Geologic Story of Bernheim Forest**, by Preston McGrain, 1967, 26 p. $1.50

Special Publication 24 (Ser. X), **Scenic Geology of Pine Mountain in Kentucky**, by Preston McGrain, 1975, 34 p. $1.50

Special Publication 16 (Ser. XI), **Roadside Geology Along Interstate Highway 75 in Kentucky**, by Donald C. Haney and Martin C. Noger, 1992, 37 p. $5.75

Special Publication 17 (Ser. XI), **Roadside Geology Along Interstate Highways 71 and 65 in Kentucky**, by Donald C. Haney and Martin C. Noger, 1992, 44 p. $5.75

Special Publication 16 (Ser. X), **Water in Kentucky**, by R. A. Krieger and others, 1969, 51 p. $1.50

Special Publication 12 (Ser. XI), **Caves and Karst of Kentucky**, ed. by P. H. Dougherty, 1985, 196 p. $12.50

Special Publication 14 (Ser. XI), **The Great Central Mississippi Valley Earthquakes of 1811–1812**, by Ronald Street and Otto Nuttli, 1990, 14 p. $3.00

Special Publication 15 (Ser. XI), **A Guide to Kentucky Place Names** [rev. ed.], by Thomas P. Field, 1991, 268 p. $15.00

Special Publication 25 (Ser. 10), **Topography of Kentucky**, by Preston McGrain and James Currens, 1978, 76 p. $3.00

Geologic Map of Kentucky, scale 1:500,000 (1 inch = 8 miles), compiled by Martin C. Noger, 54 x 24 inches, ... $6.00

Rocks and Minerals of Kentucky, by Warren H. Anderson, 65 p. (Anticipated publication by early 1994.)

RECENT TECHNICAL PUBLICATIONS

Bulletin 2 (Ser. XI), **Geology and Stratigraphy of the Western Kentucky Coal Field**, by Stephen F. Greb, David A. Williams, and Allen D. Williamson, 1992, 77 p. $8.00

Bulletin 3 (Ser. XI), **Stratigraphic and Structural Framework of the Carboniferous Rocks of the Central Appalachian Basin in Kentucky**, by Donald R. Chesnut, Jr., 1992, 42 p. $12.00

Bulletin 4 (Ser. XI), **Gas Exploration in the Devonian Shales of Kentucky**, by Terence Hamilton–Smith, 1993, 31 p. $4.00

A complete List of Publications is available on request from the Kentucky Geological Survey.

Fossils I Have Seen at the Falls

Fossil Name	Size	Looks Like What	Area Found in (Use Figure 5)	Date Seen

Siphonophrentis
(x 1)
horn coral

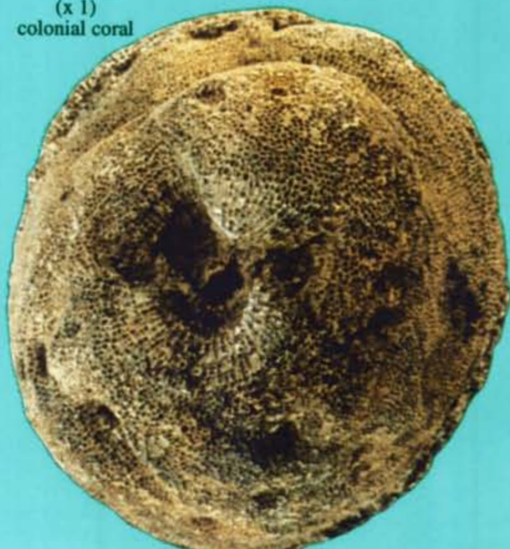
Loxonema
(x 1)
snails

"fossil hash"
Upper Coral Zone
(x 0.5)

Crystallized
Turbonopsis
(x 1)
snail

Heterophrentis
(x 1)
horn coral

Favosites
(x 1)
colonial coral



Atrypa
(x 1)
brachiopod

Paraspirifer
(x 1)
brachiopod

Thamnopora
(x 1)
colonial coral

Brevispirifer
(x 1)
brachiopods

Striatopora
(x 1)
colonial coral

Placoderm bone
(x 1)
fish