Educational Series No. 6

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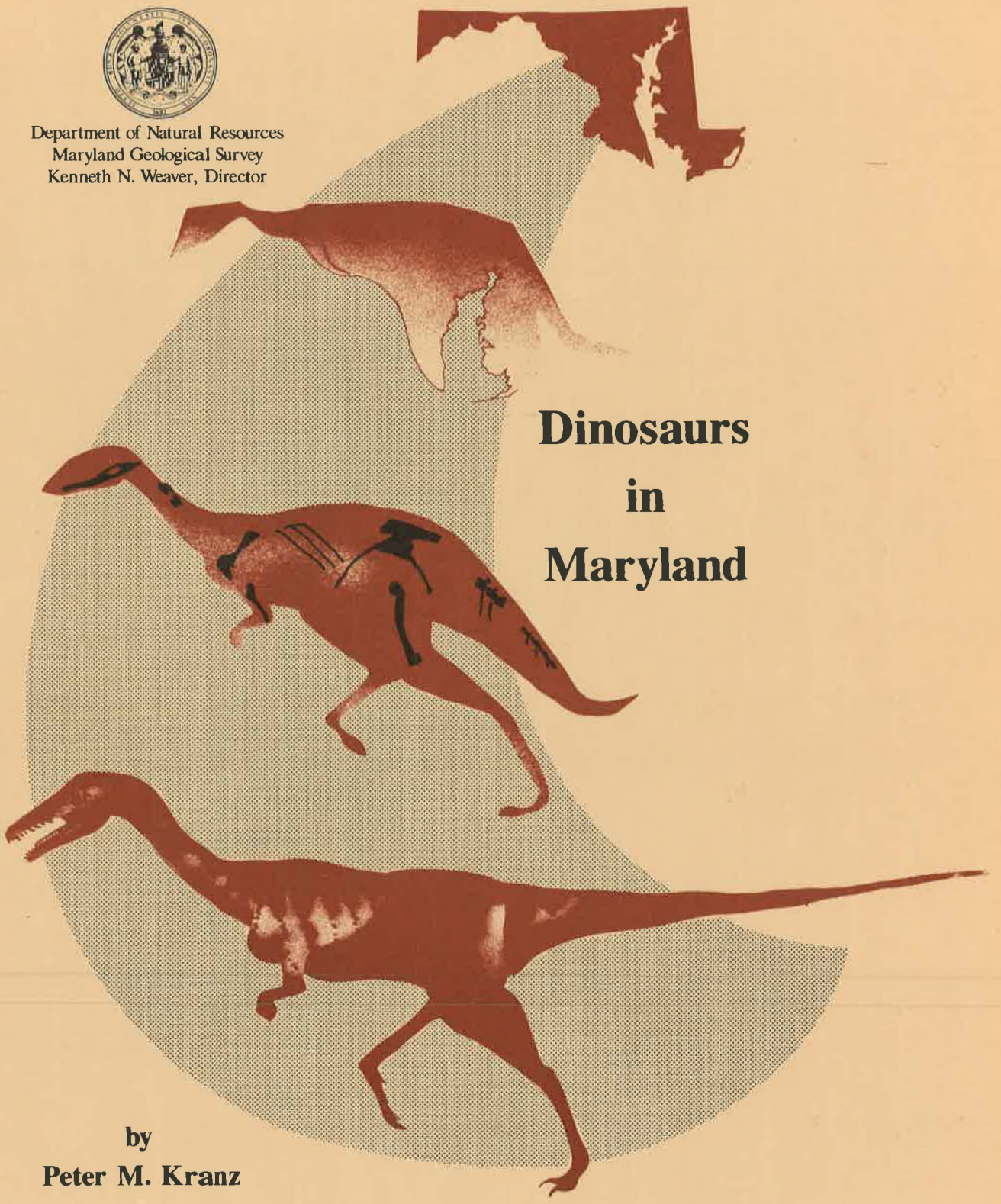
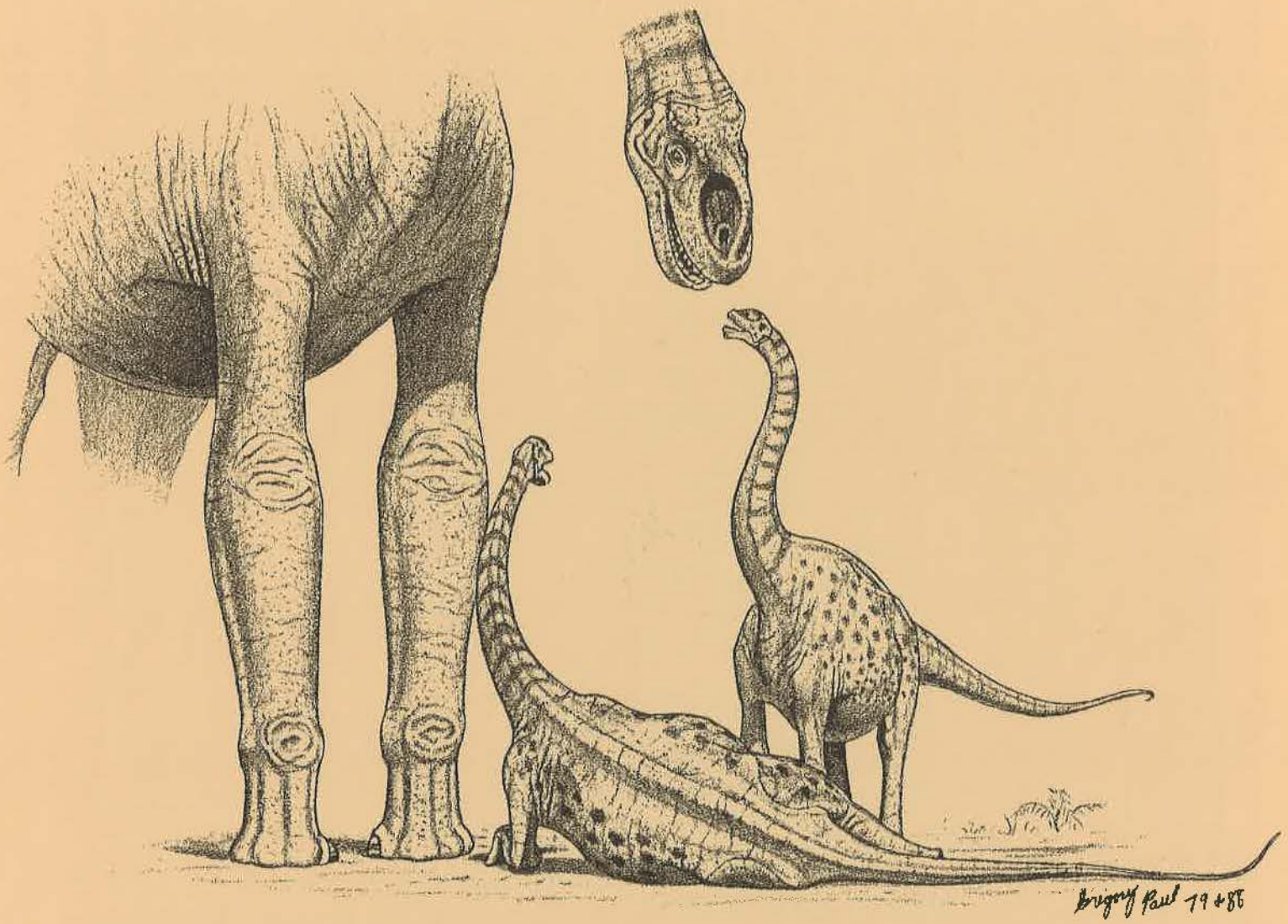


Dinosaurs in Maryland

by
Peter M. Kranz



Astrodon, Maryland's most common dinosaur.

Department of Natural Resources
MARYLAND GEOLOGICAL SURVEY
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Dinosaurs in Maryland

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1989

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Cover art by M. Sandra Nelson, of Nelson Geo-Graphics Services.

Original drawings for Frontispiece and Figures 5, 7, 9, and 12 by Gregory S. Paul.

Figure 4: Redrawn from Bibbins, A., 1895, *Notes on the Paleontology of the Potomac Formation*: Johns Hopkins University Circulars, No. 121, October 1895.

Figure 8: Negative No. 335199, photo by R. E. Logan, Courtesy Department of Library Services, American Museum of Natural History.

This booklet is dedicated to the school children of Maryland and the National Capital Area—the most important link from our past to our future.

PREFACE

In doing this revision of *Dinosaurs in Maryland*, I found myself falling prey to a malady common to scientists—the desire to write *the* definitive work. As my research continued, however, I gave up any such notions. After all, if it were ever possible to publish "The Whole Truth," science would be a very boring pursuit. Because once "The Truth" were written down, there would be nothing further to do. Fortunately, the world is not that way, and science is eternally fascinating.

What I hope to do in this booklet is to provide some sense of the current state of knowledge and opinion about dinosaurs in Maryland. I will attempt to present what is known as well as what is yet to be discovered. Throughout, I hope to inject the all-important human element into my presentation. The story of dinosaurs in Maryland is surely as much history (a continuing one at that) as it is science. I further encourage the reader to view this booklet as a jumping-off point, a way to become involved in the processes of science and history as others have done before.

Please contact me at the address given below or in care of the Maryland Geological Survey if you have found some vertebrate fossil remains, would like to look for dinosaurs, or have a question or correction. To the extent that it is possible, I will try to keep this booklet updated and revised. Remember, most fossils are found by amateurs, not professionals.

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I have always maintained that my best ideas have come from other people. Therefore, I must first give general and necessarily anonymous recognition to the public, my students, and my colleagues.

Turning now to the specific, I gratefully acknowledge the following particular contributions: Mario, my auto mechanic, who told me I would write a book before I even conceived of this one; Bob Finnie, who gave me the magic feather; Mary Ann Parmley, who helped put together the proposal for this booklet; Marianne Kyriakos and Peggy Blake, whose skillful editing made my prose readable; Marian Flynn, who conceived the cover design, and Sandy Nelson, who executed it; Greg Paul, who drew the magnificent and scientifically accurate renditions of the dinosaurs; Ms. L. Gray and Ms. C. Dove, who typed the original manuscript; and Robbie Scharfe, a great children's librarian, who read the manuscript to make certain that a large part of the intended audience would find the work readable and interesting.

Among my colleagues, Hans-Dieter Sues checked the text for scientific errors, but bears no responsibility for any that remain; Scott Wing did the same for the plants cited and illustrated; and John Ostrom aided in the early research for the project.

And finally, I must thank the Maryland Geological Survey for the faith and interest to see the booklet through to publication. The Survey's financial support, including the publication costs, was indispensible. Also, several of the Survey's geologists critically reviewed the manuscript and made crucial contributions, which included preparation of the tables and most of the figures, final editing, and word-processing.

INTRODUCTION

Why are people today so interested in dinosaurs? This is a question frequently asked by the public. Oddly enough, it does have an answer. Since the last writing of *Dinosaurs in Maryland* (1973) there has been a real increase in public interest as well as scientific interest in dinosaurs, what Robert Bakker has called a "dinosaur renaissance." Bakker, along with many other scientists, has begun to take a new, serious look at dinosaurs. Prior to this "renaissance," dinosaurs had become, at least as far as the general public was concerned, the property of young children, who like them because they were big, mean, and had long, funny names their parents couldn't pronounce.

To a large extent, young children still are the group most often thought of when dinosaurs are mentioned. But interest in dinosaurs by older folks has become a lot more fashionable of late because paleontologists have revised their view of dinosaurs from slow-moving, stupid, beasts to active, intelligent, extremely successful animals.

WHAT IS A DINOSAUR?

"Dinosaur" is a term freely used and, more often, misused by the public. A dinosaur was not *any* four-legged creature that lived long ago. Neither was a dinosaur a flying reptile, or pterosaur, frequently referred to incorrectly as a bird. Nor were marine reptiles (Fig. 10) like plesiosaurs, icthyosaurs, and mosasaurs swimming dinosaurs. And of course, the famous finback reptile *Dimetrodon* of Permian time was not a dinosaur either.

Although it is difficult to get a precise definition of a dinosaur that all paleontologists will accept, a general description is not too hard to provide. The first dinosaur to be recognized as a giant extinct reptile was *Iguanodon*, found in England in 1822 by Mary Ann Mantell, a fossil hunter and the wife of Dr. Gideon Mantell, who later described it. In 1842, the noted British anatomist Sir Richard Owen, oddly an opponent of Darwin's Theory of Evolution, gave the official name "Dinosauria" to *Iguanodon* and two other extinct giant reptiles, *Megalosaurus* and *Hylaeosaurus*. From that time forth, dinosaurs have been a fixture in the public consciousness. Whether seen as failures or successes, they have often appeared in our cartoons, our advertising, and as toys.

The generally accepted features of a dinosaur today are that it was a reptile belonging to the Subclass Diapsida (two holes in the skull behind the eyes), Superorder Archosauria (ruling reptile), and either the Order Saurischia (reptile-hipped) or Ornithischia (bird-hipped). The major relationships among dinosaurs and related species are depicted in Figure 1. Dinosaurs generally had but one type of tooth, although the teeth of one dinosaur may be quite different from the next. Mammals, by contrast, have a variegated dentition including cutting, tearing and chewing teeth. A dinosaur usually had longer hind limbs than forelimbs, reflecting its bipedal ancestry. *Brachiosaurus*, a close relative of our most common local dinosaur, is a noted exception.

Dinosaurs were basically land dwellers; they did not fly nor did they do a lot of swimming. Swamps were not popular with them, contrary to common belief. As land dwellers, one of their most important features was a fully erect gait (see Figs. 5 and 8). They did not sprawl, but walked with their legs straight under their bodies. This fact is reflected in their hip joints, which were tight cylinder joints, and in their trackways, which were narrow—in some cases even pigeon-toed—with little sign of tail dragging.

They had high skulls and generally deep rib cages. Many walked on two legs. Some of the very large ones were four-legged; however, even the biggest may have been able to rear up on their hind legs when trying to reach high vegetation. There were many more plant-eaters than meat-eaters. They generally laid hard-shelled eggs, but some may have borne live young.

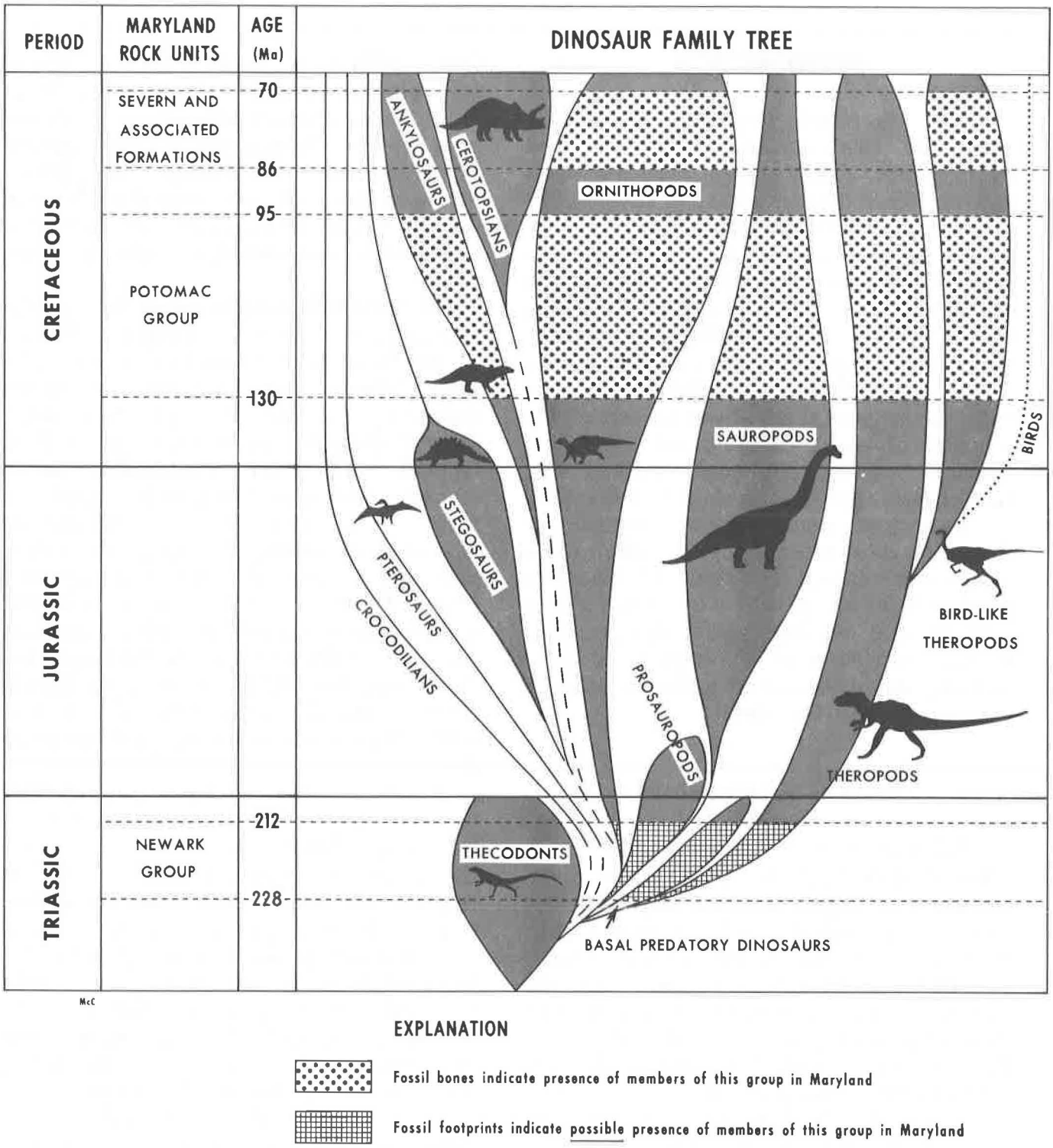


Figure 1. Dinosaur family tree.

DINOSAUR HISTORY

The position of dinosaurs in geologic time is illustrated in Figure 2. In this chart you may have noticed many unfamiliar words and names. They are, however, not as confusing as they may at first appear. Geologists and paleontologists have very simple rules for assigning names. In general, one tries to give a name that is descriptive of the animal, plant or rock. Frequently, a rock layer will be named for the place where it was first described or most commonly found.

Thus, we see that dinosaurs lived during the *era* known as Mesozoic (meaning "middle life"), which consists of three *periods*: Triassic (three-part rock system) 245-208 mya (million years ago); Jurassic (Jura Mountains) 208-144 mya; and Cretaceous (chalk) 144-66.4 mya. In Maryland, dinosaur fossils are found in rock units known as the Newark Group, the Potomac Group, and the Severn Formation (named for Newark, New Jersey, the Potomac River, and the Severn River, respectively). The fact that these units cover much but not all of the Mesozoic, or "dinosaur time," should not be taken to mean that there were no dinosaurs living here during the missing time periods, but only that rock units from those time periods were buried, removed by erosion, or never deposited. Furthermore, outcrops of rocks containing dinosaur fossils are not restricted by state boundaries; thus, a dinosaur from rock units in a neighboring state or the District of Columbia may occasionally be mentioned.

A list of dinosaurs and the rock units in which they were found in Maryland is presented in Table 1.

Dinosaur Hunters

It is true that amateurs are responsible for most fossil discoveries, a fact that will be discussed at length later in this booklet. There are, however, several scientists who figure prominently in the history of Maryland's dinosaur discoveries. Three of the great pioneers were John Bell Hatcher, Arthur Bagnold Bibbins, and Othniel Charles Marsh.

Dinosaur remains were undoubtedly found in North America in prehistoric times. Historically, their tracks, though not recognized as dinosaurs' at the time, were catalogued by Pliny Moody in 1800. The bones of a hadrosaur were found in New Jersey and described

Scientific Name	Common Name	Rock Unit
Archeornithomimus affinis	Ostrich dinosaur	Arundel (LK)
Astrodon altus	Brachiosaur	Arundel (LK)
Astrodon johnstoni	Brachiosaur	Arundel (LK)
Astrodon nanus	Brachiosaur	Arundel (LK)
"*Coelophysis*"	Small carnivore	Gettysburg (UTr)
"*Coelurus gracilis*"	Small carnivore	Arundel (LK)
"*Dryptosaurus medius*"	Large carnosaur	Arundel (LK)
"*Dryptosaurus potens*"	Large carnosaur	Arundel (LK)
"*Hadrosaurus foulkii*"	Duckbill dinosaur	Severn (UK)
Ornithomimus antiquus	Ostrich dinosaur	Severn (UK)
Priconodon crassus	Armored dinosaur	Arundel (LK)
"*Tenontosaurus* sp."	Ornithopod	Arundel (LK)

"Quotes" around names indicate uncertain identification in Maryland.
UK: Upper Cretaceous. LK: Lower Cretaceous. UTr: Upper Triassic.

Table 1. List of Maryland dinosaurs.

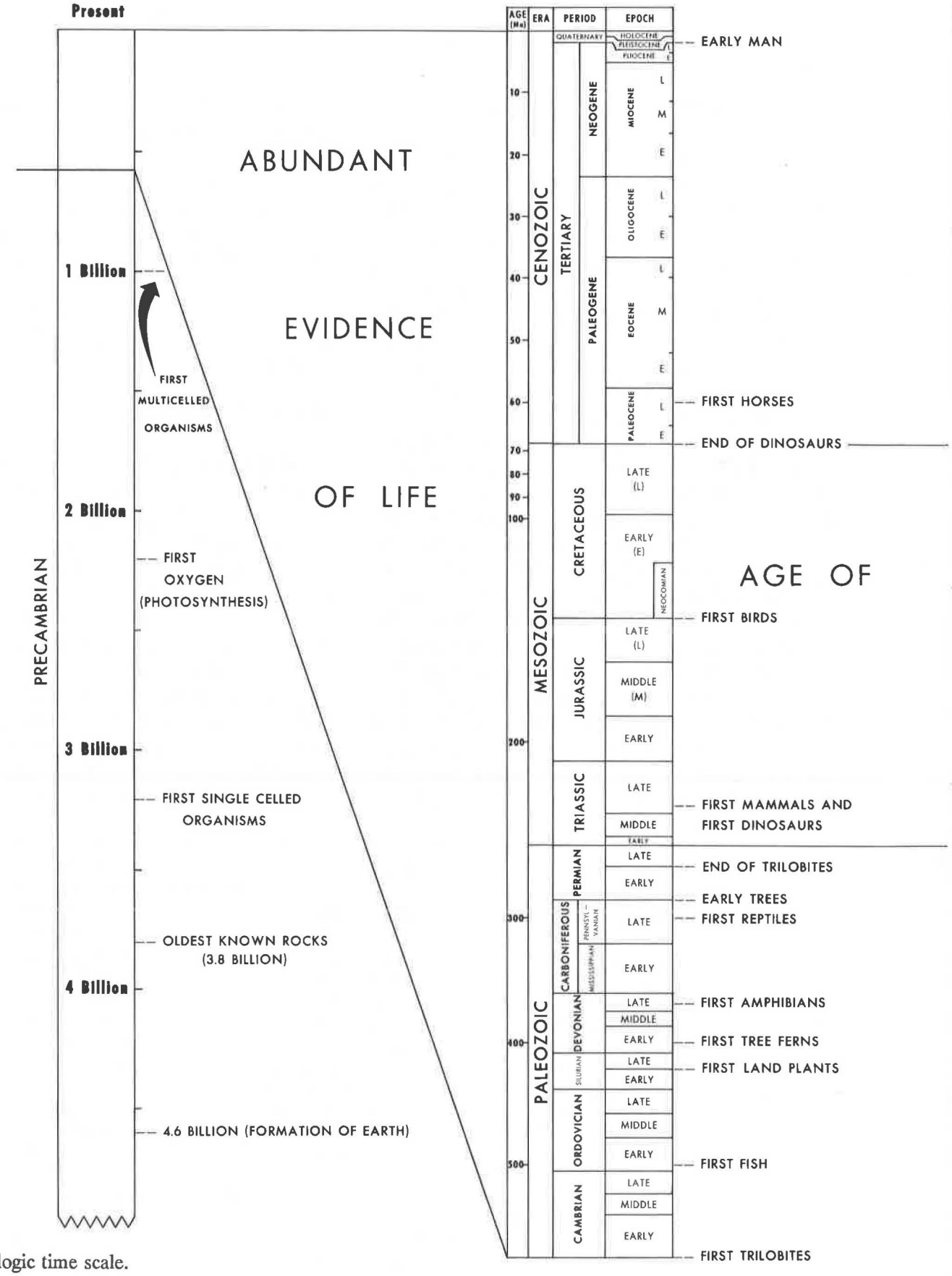


Figure 2. Geologic time scale.

MARYLAND ROCK UNITS

DINOSAURS

AGE (Ma)	ERA	PERIOD	EPOCH	STAGE	
70	MESOZOIC	CRETACEOUS	LATE	MAASTRICHTIAN	Severn and Mt. Laurel Sand; Matawan Formation (and equivalents); Magothy Formation
80				CAMPANIAN	
				SANTONIAN	
				CONIACIAN	
90				TURONIAN	
				CENOMANIAN	
100			EARLY	ALBIAN	Patapsco Formation; Arundel Clay; Patuxent Formation — POTOMAC GROUP
110				APTIAN	
120			NEOCOMIAN	BARREMIAN	
				HAUTERIVIAN	
130				VALANGINIAN	
140				BERRIASIAN	
150		JURASSIC	LATE	TITHONIAN	
				KIMMERIDGIAN	
160				OXFORDIAN	
170			MIDDLE	CALLOVIAN	
				BATHONIAN	
180				BAJOCIAN	
				AALENIAN	
190			EARLY	TOARCIAN	
				PLIENSBACHIAN	
200				SINEMURIAN	
				HETTANGIAN	
210		TRIASSIC	LATE	NORIAN	Gettysburg Shale; New Oxford Formation — NEWARK GROUP
220				CARNIAN	
230			MIDDLE	LADINIAN	
				ANISIAN	
240			EARLY	SCYTHIAN	

MPK McC

by Professor Joseph Leidy in 1858. These bones, which are on display at the Philadelphia Academy of Natural Sciences, were part of the first mounted dinosaur skeleton in the U.S. In 1859, a scant year after the New Jersey hadrosaur was discovered, Dr. Christopher Johnston described some dinosaur teeth that were found at an iron mine near Bladensburg, Maryland. These teeth were given the name *Astrodon* (star-tooth) by Dr. Johnston and were formally described and named *Astrodon johnstoni* by Professor Joseph Leidy in 1865. The teeth currently are housed at the Peabody Museum of Yale University, New Haven, Connecticut. The find and identification are truly remarkable when one considers that dinosaurs were recognized as a formal group only 17 years earlier, and in England, at that. This rapid recognition of dinosaurs in North America is early evidence of the power these creatures seemed to exert on our imaginations from the very first.

The teeth made their way to Yale, and it is there that we pick up the story of Maryland's dinosaurs. One of the most noted of all American paleontologists, Othniel Charles (O.C.) Marsh, dispatched his most famous and enthusiastic, although somewhat eccentric, bone collector, John Bell Hatcher, to Maryland to recover dinosaur bones. Hatcher arrived here in 1887. The following excerpts from his diaries may give the reader some sense of what dinosaur hunting as well as the hunter were like:

December 1887,

22 Several pieces of bones and Sequoia cones. Commenced work with Engine and cars.
23 1 large femur, 1 vertebra and 1 phalanx, several Sequoia cones.
24 Men laid off for Christmas.
25 Sunday
26 Celebrating Christmas.
27 I went to work but the men did not come.
28 Rained.
29 I went to work but no one came.
30 2 limb bones, 1 vertebra, several Sequoia cones.
31 Snowed.

January 1888,

1 Sunday.
2 New Year.
3 One piece of skull with four teeth, 4 metatarsals, 1 phalanx, and several pieces of bones. 16 Sequoia cones.
4 2 pieces of skulls, metapodial (3) bones, 1 radius, several pieces of bones, Sequoia cones &c.
5 1 femur, 2 metapodial bones, 2 phalanges, 2 vertebrae, several pieces of bones and Sequoia cones.
6 3 phalanges, 2 vertebrae, 2 metapodial bones, 1 piece of skull, several pieces of bones, Sequoia cones &C.
7 2 vertebrae, 1 phalanx, several pieces of bones, Sequoia cones &c.
8 Sunday Prof. Marsh arrived at Washington.
9 1 limb bone, 1 tooth, 3 sequoia cones. Commenced snowing about noon.
10 Accompanied Marsh to Good Hope Hill.
11 Accompanied Marsh to Muirkirk and Contees and Hanover.
12 Packed two boxes of fossils at office of Survey to be shipped to New Haven.
13 Rained.
14 Went to Beltsville, Muirkirk and Contees, found nothing but piece of vertebra from new locality at Contees.
15 Went to Marlboro, Md., visited marl banks and found many shells and three teeth.
16 In Washington.
17 Went to Muirkirk to see Mr. Coffin.
18 Went with Prof. Marsh to Balto. and saw Prof. Uhler of Peabody Institute and with him we went to Johns Hopkin's and saw Tyson's cycads from the Potomac and from thence we went to Federal Hill. Note the strong similarity between the section of sandstone at iron ore and paint bank of Mr. Hobb's at Hanover and that at Federal Hill, Balto.
19 Two sacral vertebrae.
20 Went to Mt. Vernon and White House Bluff. Spent the evening with Prof. Marsh and took dinner with him.
21 Part of turtle. Prof. Marsh returned to N. Haven.
22 Sunday.
23 Went to the State Agriculture College of Maryland. Nothing there of interest.
24 Went to Muirkirk and Jessup's, at the first place got one metapodial bone and some other fragments.
25 Snowed.
26 1 tooth, 1 limb bone, several pieces of bones, Sequoia cones &c. Cold and windy and snow drifting badly.
27 1 tooth, several vertebrae, limb and feet bones and Sequoia cones.
28 Several bones.

Hatcher found hundreds of bones and teeth, which are now housed at the National Museum of Natural History, Smithsonian

Institution, Washington, D.C. With a few exceptions, virtually all of the dinosaurs known from Maryland were found by him in the years 1887-1888. These bones were shipped to Marsh at Yale, who then described them. They were all, of course, new to science. In addition to dinosaurs, one species of turtle and one of crocodile were discovered.

The work of Marsh and Hatcher inspired a young local geologist and budding paleontologist, Arthur Bagnold Bibbins, to look for bones. He reported on his findings in 1895 while a graduate student at the Johns Hopkins University. Over the next several decades, Bibbins collected and recovered most of the additional bones and teeth in the Smithsonian's current collection of Maryland dinosaurs. Comments on his collecting methods follow (from *Recent Discoveries of Cycadean Trunks in the Potomac Formation of Maryland*, by Lester F. Ward):

> In appointing Mr. Bibbins curator of the college the right step has been taken to further these ends. A post-graduate of Johns Hopkins at the time of his appointment, Mr. Bibbins has been trained to the best scientific work. He is naturally endowed in a high degree with true scientific instincts as well as with practical judgment and good sense. It is these qualities which have led him to adopt an entirely new method in searching for scientific material. Knowing the rarity of fossil cycadean trunks and their great value to science, he set himself the task of trying to secure some of these for the college museum. But, instead of undertaking a hopeless and aimless quest, as has been done by geologists and collectors in the past, he chose to avail himself of the knowledge of the inhabitants of the districts in which the cycads were believed to occur. Supported by the Woman's College, which furnished him the means of transportation and met the small expense of his work, including an occasional *pour boire* to some needy farmer or miner who possessed information of great value, and usually gave it freely, he proceeded to visit the houses of the native population, and placing himself on a level with their powers of understanding, he was able to interrogate a large number of persons in such a way that they could not fail to comprehend his meaning. Having secured one specimen, he carried it about in his wagon and showed it to all whom he met. His surprise was great to find that a large proportion of the inhabitants of the iron ore districts had at some time in their lives seen similar things and were able to recognize them. In some cases a person to whom he would show his specimen would reply at once that there was such a stone in his barnyard or near his house, and by a very little negotiation he was able easily to secure it. By far the greater number, in fact nearly all, of the specimens were thus found in the possession of the people. Many of them could remember having ploughed them out of their fields, or taken them from their ore pits; others there were that had lain so long around farm houses whose occupants had several times changed that it was impossible to trace them to their original source, but usually even in such cases there was a tradition lingering in the family with regard to the peculiar stones. The reason why they were so universally picked up and brought to the house or the workshop or the barnyard or laid up in some conspicuous place seems to be that their peculiarity was instantly recognized. A countryman knows every stone that he has seen about his place, and if there be one which differs markedly from all others, especially if it has a certain symmetry of form or shows unusual and regular markings, he at once distinguishes it, is impressed by its appearance, and probably, at first at least, couples with the notion of its strangeness some vague idea of its possible utility or money value. He therefore invariably picks it up and sequestrates it in some way. After many years, finding that there is no demand for it, that no one knows any use to which it can be put he eventually loses interest in it, and it is pushed aside, forgotten, and perhaps covered up in some obscure corner. So that in addition to the specimens that Mr. Bibbins actually obtained, there remain quite a number which are known to exist, but which for the present cannot be found.
>
> Mr. Bibbins always frames his questions with skill, taking care not to ask leading ones, realizing that the desire to please is liable to color the answer and make it conform to what it is supposed he desires to have said. He therefore always takes pains to induce these people to tell what they know independently of any suggestion on his part.
>
> As an illustration of the accuracy with which such persons often observe and remember facts, may be mentioned a case in which one of these traditional lost specimens was being inquired after from an octogenarian who remembered seeing it some forty years before, and when asked if the "holes" in the stone were "round" he replied "No, they were sort o' three-cornered," a remark which rendered it certain that the object was really a cycad.

Since the early part of the twentieth century, when local iron mining ceased, very few dinosaur bones have been recovered from Maryland and its environs. This is, for the most part, due to a lack of knowledge about

modern excavation methods using large machines have removed workers from close contact with the ground. Two noteworthy but isolated discoveries took place in Washington, D.C. In 1898, some men digging a sewer at First and F Streets, S.E., found the remains of a carnosaur ("*Dryptosaurus*," or a related species). Workers found a very large legbone from *Astrodon*, a brachiosaurid, while building the McMillan Water Filtration Plant at First and Channing Streets, N.W. in 1942. There have been other finds at other locations, but much needs to be done. The bones are still here, but few people are looking for them!

Earth History and Maryland Geology

Dinosaurs no longer walk the earth—they are in it! For this reason it is necessary for the reader to understand something of the local geology. In a later section on searching for dinosaurs, there will be a more complete discussion of some of the practical aspects of the local geology as it relates to dinosaurs.

The Earth, along with other planets and the sun, is currently believed to have formed from a mass of gas, dust and ice about 4.6 billion years ago. As it evolved during the next billion years, rain from the atmosphere and water vapor from the interior produced seas on its surface. During subsequent earth history, the amount of land covered by the seas has fluctuated continuously. Each time the seas have receded from the land, they have left new deposits containing fossils. The "layer cake" earth they have produced can be "read" by geologists and paleontologists (see geologic column, Fig. 2). Rivers, streams and lakes also have added their sediments to the "cake."

About half a billion years ago, Maryland was covered with a shallow tropical sea. Later, the sea receded and left coal swamps. Finally, about 225 million years ago, much of Maryland was land—some of it very low and flat. In some aspects, these land areas looked very much like the traditional image people have of "dinosaur time," a broad plain cut by rivers and covered with tropical vegetation, and accompanied by volcanic and seismic activity, all indicative of the significant changes that the Earth was undergoing at this time. The super-continent, Pangaea, which had formed about 100 million years earlier, was beginning to break up. By the end of "dinosaur time," some 165 million years later, this break-up would be more or less complete, leaving the continents much as they are today.

The rocks that formed during this early period—the Late Triassic, about 230-208 mya— are called the Newark Group and are present today in a very narrow belt in western Montgomery, Frederick, and Carroll Counties (see geologic map, Fig. 3). They accumulated in two of an extensive system of low-lying inland basins that extend from Nova Scotia to North Carolina. The rocks on the eastern edge of the basins are almost 20 million years older than those on the western edge. The beds dip, or tilt, to the west where they abruptly terminate at a boundary fault along the base of the Blue Ridge. Red sandstones and shales make up the bulk of the rocks, which are occasionally interrupted by igneous dikes of dark diabase, or traprock. Locally, one finds black or gray shales, which mark the sites of former ponds. The fossils tend to be located on the western edges in the dark shales. Most common are fish and plant debris. Bones and teeth of reptiles are rare, but three-toed dinosaur footprints are common in some layers.

To the east, much older crystalline rocks across Baltimore, Harford and parts of Cecil Counties are devoid of fossils, as are similar rocks to the west (Blue Ridge and Middletown Valley). Fossils reappear in rocks in the Hagerstown and Hancock areas, but are from a time much earlier than that of the dinosaurs. No dinosaur remains are known to exist in Maryland west of the Triassic rocks of the Gettysburg and Culpeper Basins.

Traveling eastward, one eventually leaves the Piedmont and enters the flat Coastal Plain. Here again is the land of the dinosaurs, 144-97.5 mya (Early Cretaceous). This area comprised a broad river system covered with

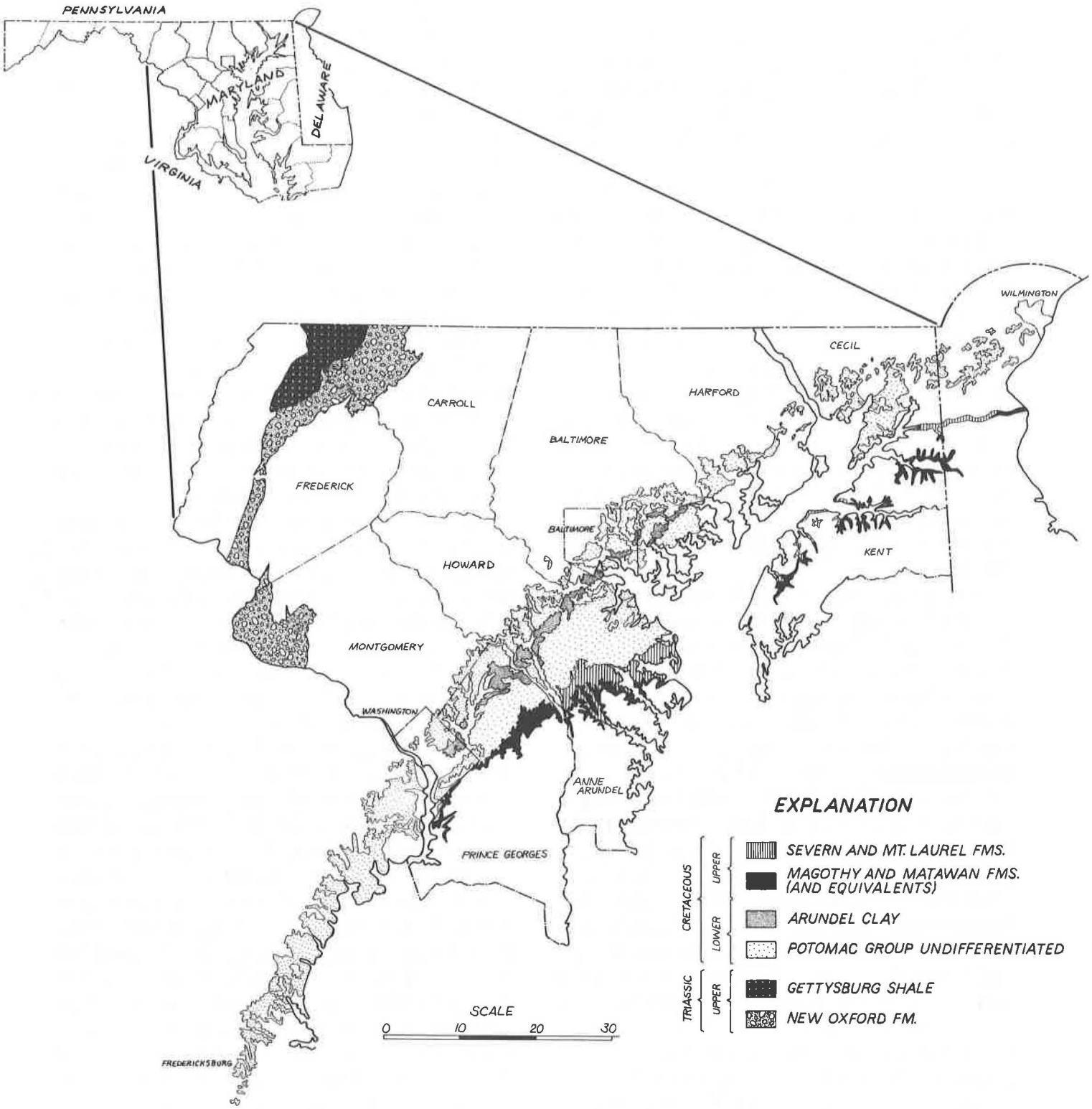


Figure 3. Geologic map of the Mesozoic rocks in Maryland.

coniferous trees, tree ferns and an occasional early angiosperm. In some ways it resembled today's Mississippi Delta area. The Coastal Plain is distinguished from the Piedmont in that its sediments have yet to be consolidated into rock.

The sediments that abut the Piedmont on the east are called the Potomac Group, which is divided into three formations. The oldest, the Patuxent, is composed primarily of sand and gravel, with occasional clay. The middle, the Arundel, and the source of most of Maryland's dinosaur bones, is primarily gray clay, which contains large amounts of iron ore and fossil wood. The youngest, the Patapsco, is dominated by brightly colored clays and sands. In the past, the Arundel Clay was extensively mined for its iron ore and brick clay. Most of the dinosaur bones were found during these mining operations. Even today the Potomac Group is still mined to a limited degree.

The Potomac Group beds, like all the beds of the Maryland Coastal Plain, slope gently to the southeast. Thus, the oldest sediments are at the western edge where the Fall Line is formed by the contact of the Coastal Plain sediments and the Piedmont rocks, and the sediments become progressively younger southeastward. (The Fall Line is defined as the line connecting points along rivers where waterfalls and rapids first prevented the further progress of ocean-going ships up the coastal rivers. Many large cities like Philadelphia, Baltimore, Washington and Richmond are located on the Fall Line.) Like the Newark Group rocks in the Gettysburg and Culpeper Basins, the Potomac Group is part of a much larger belt running in a southwesterly direction from Nova Scotia to Georgia. In Maryland, it extends from the eastern edges of Montgomery, Howard, Baltimore, Harford and central Cecil Counties to near the western shore of the Chesapeake Bay (see geologic map, Fig. 3).

On the eastern edge of the Potomac Group sediments is an extremely narrow strip of marine sediments from the Late Cretaceous (Upper Maastrichtian) about 70 mya, which crop out in Prince George's, Anne Arundel, Kent and Cecil Counties. It is a black clayey sand and highly fossiliferous, especially in Prince George's County. Because of its marine origin, however, dinosaur bones are only a rare "washed-in" fauna. Nevertheless, it was in an associated marine unit in New Jersey that the first dinosaur found in North America, mentioned earlier, was unearthed. Also quite abundant in this formation are marine reptiles, often mistaken for dinosaurs by the public. As with the previously discussed sediments, the Severn Formation, as it is known locally, is part of a much larger system that extends from Long Island to Alabama and up the Mississippi Valley. The western portions of this formation in Maryland appear to have been formed nearer to shore than some of the eastern parts.

The most famous fossiliferous marine sediments of the Coastal Plain are southeast of and younger than the Severn Formation. Most notable is the Chesapeake Group, which includes the sediments at the Calvert Cliffs. These formations are of no interest to the dinosaur hunter, as they were all deposited following the end of Mesozoic time after dinosaurs became extinct.

One final point needs to be made here about geology in general. People often recognize the law of superposition, which states that older rocks or layers are buried beneath younger ones, but fail to understand that these older layers can be and are exposed at the surface. This occurs through processes like folding, tilting, and faulting, accompanied by erosion. Thus, contrary to the common misconception that paleontologists dig for dinosaurs the way one might dig for gold, paleontologists in fact look for places where nature has exposed dinosaur-bearing layers at the surface. The geologic map shown in Figure 3 indicates the surface locations of all these beds in Maryland.

THE DINOSAURS OF MARYLAND

As indicated in the preceding section,

dinosaur remains are distributed in three different rock units in Maryland. Dinosaurs of the very earliest and latest types are found here. In fact, Maryland has dinosaur forms represented throughout much of their approximately 160 million-year history. The reader is cautioned, however, that this is not to suggest that dinosaurs in Maryland were anywhere nearly as abundant or diverse as they were in other parts of the U.S. or the world. They were not.

Dinosaurs of the Newark Group (Late Triassic, 228-212 mya)

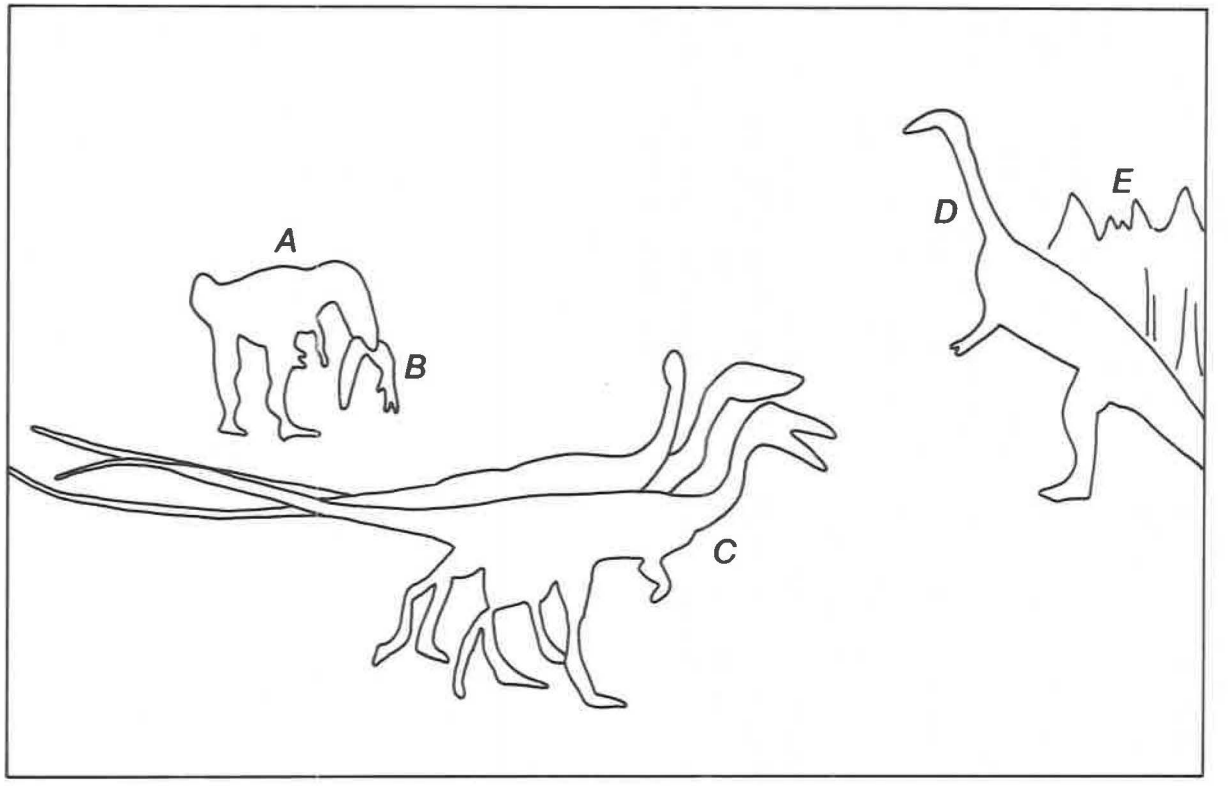
Dinosaur bones and teeth have been reported from beds of this age outside of Maryland. To date, however, neither has been found in Maryland. Bones of fish and other vertebrates have been found in our State, and there is no reason that dinosaur bones should not eventually be found. The dinosaurs of Maryland in this time period are known solely from their tracks (Fig. 4).

It is very difficult to identify an unknown creature from its tracks alone. Therefore, the tracks, or *ichnofaunas*, have been assigned their own species names. It may be possible to make some good guesses about the dinosaurs that lived here from the bones and teeth found in nearby states, as well as track morphology. We are necessarily less certain about these dinosaurs than some of the later ones.

In 1895, James A. Mitchell, a graduate student at Johns Hopkins University, reported upon and drew pictures of dinosaur footprints from a quarry north of Emmitsburg. The current location of the original fossil footprints from which he drew the pictures is unknown. The quarry, however, still exists, although it is overgrown. Most of the tracks are reported to be of a three-toed type, about 3 inches in length, with about a one-foot stride. Such a dinosaur would be about 4 feet long and 20 pounds in weight. A good candidate might look something like *Coelophysis* (Fig. 5).

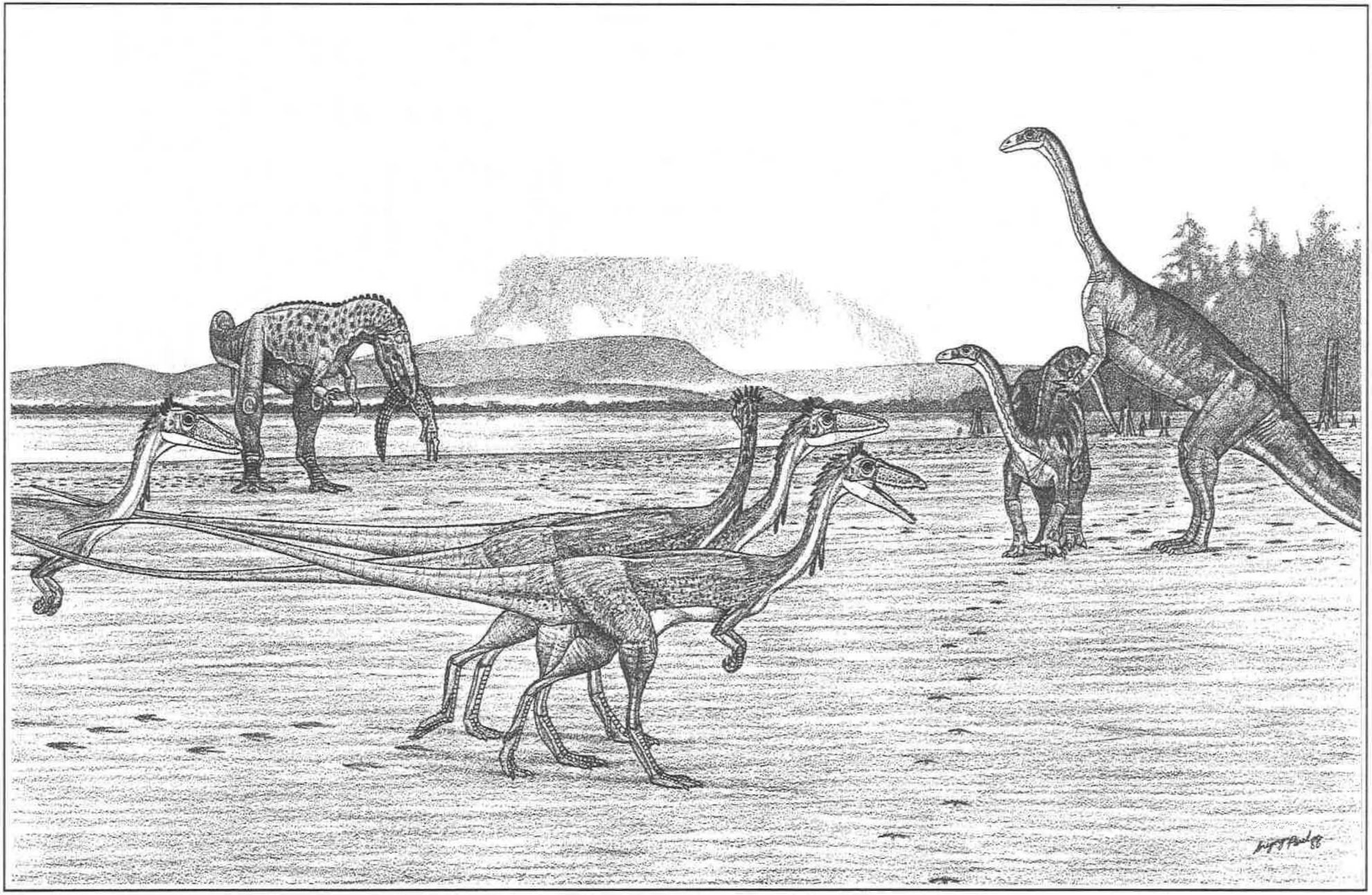
There have been two other rare tracks

Figure 4. Dinosaur footprints in Triassic sandstone from Frederick County.



A, carnosaur; B, phytosaur; C, "*Coelophysis*"; D, prosauropod; E, cypress.

Figure 5. Dinosaurs of the Late Triassic Newark Group.



reported, also three-toed; one is about 1 inch long, the other a webbed foot. What these are is difficult to say without studying the actual specimen.

From nearby locations in Virginia, larger three-toed prints, some greater than 12 inches long, have come to light. Such creatures presumably lived in Maryland. They may have been similar to the carnosaur in Figure 5.

If one goes yet farther afield to the Connecticut Valley, dozens of track varieties have been recorded. Here, too, there are very few bones to associate with the tracks. All that one can say with certainty is that there were a variety of dinosaurs living in the eastern United States, including Maryland, during the Late Triassic and Early Jurassic periods, 230-187 mya. Perhaps the greater interest currently being shown in these rocks may lead to a better understanding of the dinosaur fauna.

Dinosaurs of the Potomac Group (Early Cretaceous, 130-95 mya)

The record of Jurassic and very early Cretaceous time, if it exists at all in Maryland, is apparently buried. The dinosaur story resumes in the middle of Early Cretaceous times. It is from the clays of the Potomac Group that most of the dinosaur bones have come. It is of interest that many of these bones were found 100 years ago in 1887-1888 by John Bell Hatcher. They were recovered from sedimentary iron mines. In 1894-1896, Arthur Bagnold Bibbins also made a significant collection while a graduate student at the Johns Hopkins University. Since that time, there have been only isolated finds. This case of limited discovery is in large degree due to the cessation of iron mining, but also to the fact that few people are aware that the bones are there. Recently, bones have been recovered from the Potomac Group because people have been encouraged to look for them.

The dinosaurs of the Potomac Group are the best known, most abundant, and first ones found in the State. In 1859, only about 17 years after the name "dinosaur" had been coined, Philip Tyson, the State Agricultural Chemist, made available to Dr. Christopher Johnston, a local physician, a strange tooth that he had found in a mine "near Bladensburg" (Fig. 6). Dr. Johnston described this tooth in the American Journal of Dental Science in 1859 and named it *Astrodon*, or "star tooth" (Fig. 7 and Frontispiece). In 1865, the famous pioneer of American paleontology, Dr. Joseph Leidy, formally named and described the fossil as *Astrodon johnstoni*, making it the first sauropod dinosaur described from North America. This dinosaur was discovered almost simultaneously with Leidy's most famous find, *Hadrosaurus foulkii*, dug up in New Jersey and considered to be the first dinosaur found in North America.

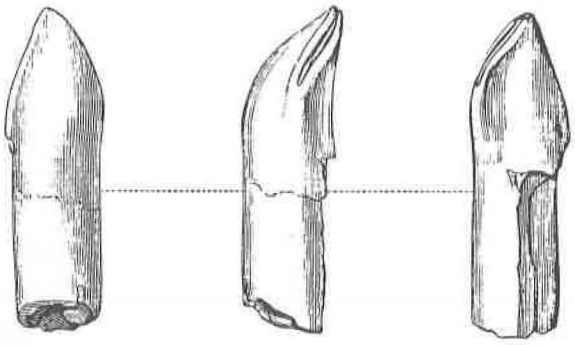


Figure 6. Tooth of *Astrodon johnstoni*. Outer, side and inner views of tooth (natural size).

Astrodon's history has not been a simple one. John Bell Hatcher is said to have commented that "no two bones or fragments of all that material collected from the Potomac beds in Maryland were found in such relation to one another as to demonstrate that they belonged to the same individual." Such fragmentary, disarticulated remains naturally led to confusion and controversy. There are hundreds, perhaps thousands, of *Astrodon* bones in the collections of the Smithsonian. Despite this fact, exactly what kind of dinosaur *Astrodon* was and what it looked like has been debated for many years. It is currently believed to be a brachiosaurid. In the past it was called a morosaur by O.C. Marsh, and a

brontosaur by Gilmore on at least one occasion. Some of the published life-restoration pictures are different from either.

It is not always easy to differentiate the skeleton of a juvenile reptile from an adult. This has led to confusion about the true size of *Astrodon*. If the known bones are truly those of an adult, then it is one of the smallest sauropods known, with some individuals only 10 feet long. On the other hand, a leg bone found in 1942 at the McMillan Reservoir in Washington, D.C., was from an animal of considerable size—certainly more than 40 feet long.

The animal was definitely vegetarian, but as with all dinosaurs it is difficult to be specific about the exact diet. *Astrodon* probably browsed the conifers, cycads and low-growing plants. It probably was a forest dweller. Although its bones have been recovered from river deposits, if current ideas are correct, it did not spend its time in the water.

Taxonomically, there is great confusion about *Astrodon*. It has been known in the past as *Pleurocoelus* and some paleontologists have even suggested that it is synonymous with *Brachiosaurus*. At present, it is thought that *Astrodon* and *Pleurocoelus* are synonymous, with *Astrodon* having precedence. Although it is probably a brachiosaurid, it is not *Brachiosaurus*. Where else it is found and how many species exist are areas of greater uncertainty. It may be found in Texas in the Comanchean beds and in Montana in the Cloverly Formation. There are three species recognized in Maryland: *Astrodon nanus*, *Astrodon altus*, and *Astrodon johnstoni*. The latter two, however, are known from very limited material.

As uncertain and limited as the *Astrodon* material is, it is far more abundant than that of any other dinosaur in the Potomac Group. The other plant-eating dinosaurs known from present collections consist of an ankylosaur, *Priconodon crassus*, known from six teeth (now seven because of an amateur's recent discovery of the largest and best preserved tooth) and presumed to be a nodosaur; and an iguanodontid, perhaps *Tenontosaurus*, known from a single tooth fragment (USNM 244564). *Dryosaurus grandis*, another herbivorous dinosaur, which was believed to have existed in the Potomac Group, has been shown by Gilmore to be the remains of *Archeornithomimus affinis*.

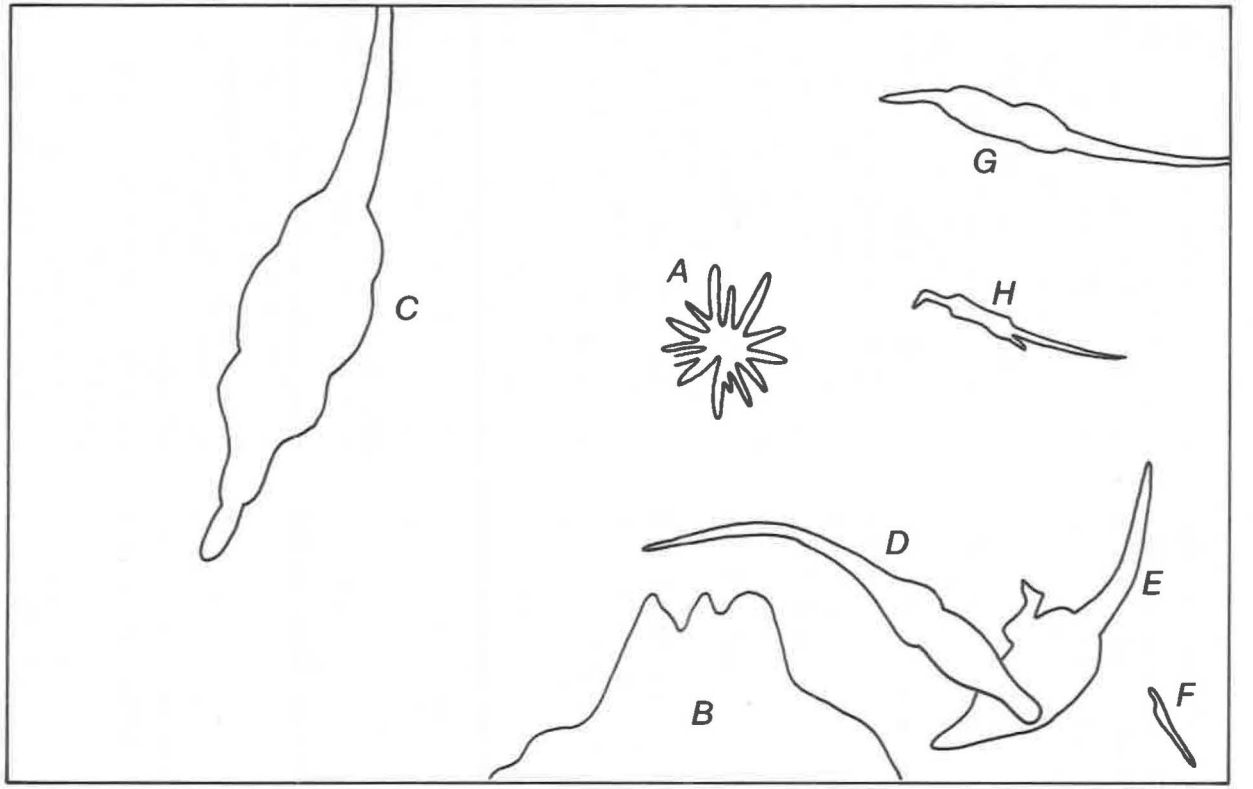
Nodosaurs are armored dinosaurs that walked on all fours and are presumed to have been low browsers. These animals are known only from Cretaceous times, with one possible exception. *Priconodon crassus* is estimated to have been about 20 feet long (Fig. 7).

The iguanodontid tooth fragment mentioned earlier may be that of *Tenontosaurus* (Fig. 7). There is also a caudal (tail) vertebra (USNM 8508) in the U.S. National Museum, which may belong to this same creature, but this is uncertain. If the animal can be shown to be *Tenontosaurus* or if future finds confirm its existence in the Potomac Group, then it would be known from the eastern U.S., as well as the West. *Tenontosaurus* was 21 feet long and weighed about one ton.

Although herbivorous dinosaur remains dominate the Arundel (Potomac) fauna, making up more than five times as much material as all other forms, several carnivorous dinosaurs are also represented. "*Dryptosaurus*" (Fig. 7) is the largest and most impressive of them. It was a carnosaur about 20 feet long, and may have been a close relative of the tyrannosaurs. Marsh had previously identified these bones as *Allosaurus*, believing the Potomac Group to be of Jurassic age. Later, R.S. Lull called them *Creosaurus*. "*Dryptosaurus*" had once been called *Laelaps*, the leaping hunting dog of mythology. Indeed, it is pictured leaping in Charles Knight's illustration (Fig. 8).

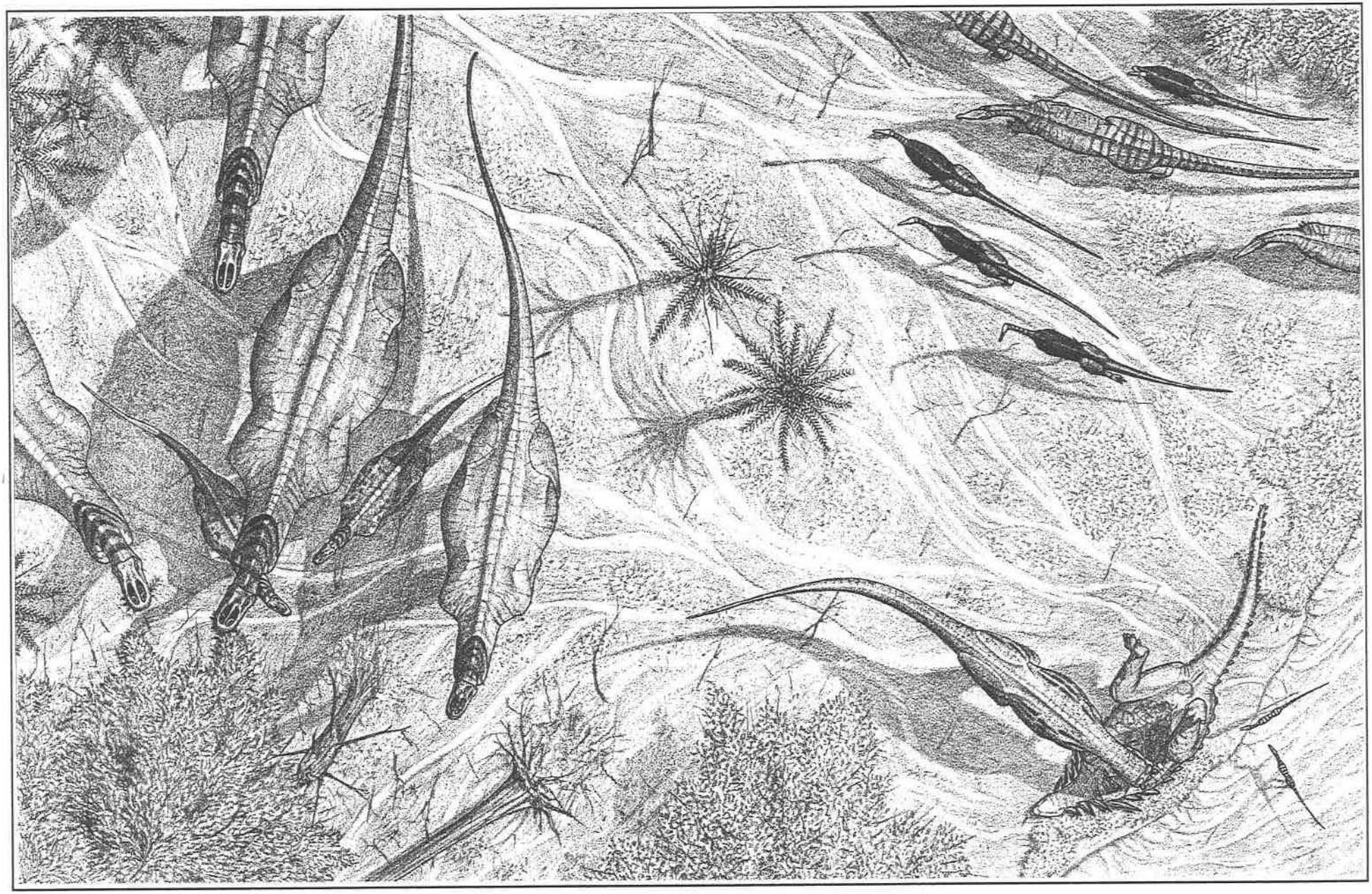
One other story, which may be apocryphal, is that E.D. Cope, the paleontologist who proposed the name *Laelaps*, did so because he liked to think of his dinosaur attacking the slow-moving plant eaters described by his archrival, O.C. Marsh.

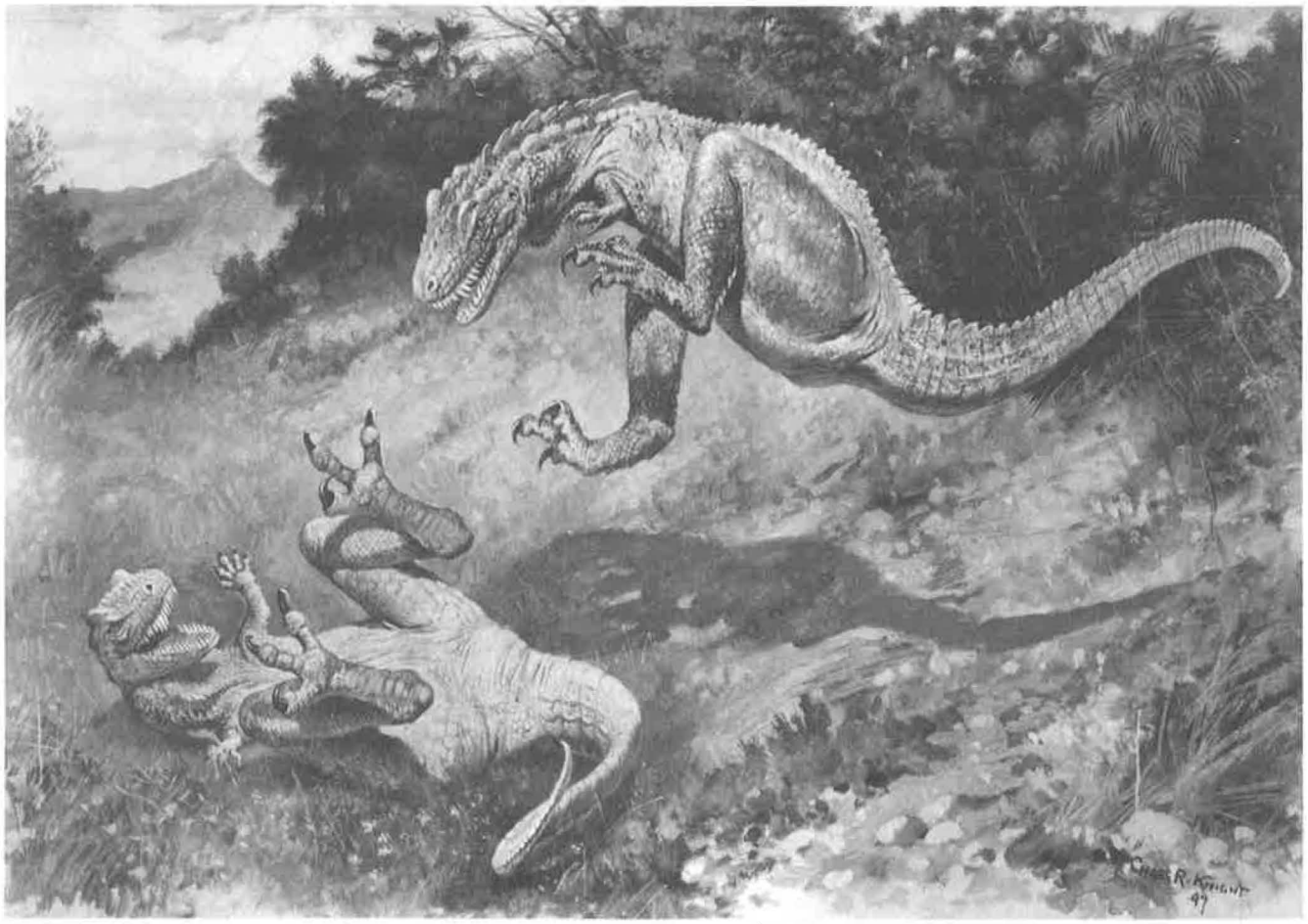
Nothing resembling a complete skeleton of "*Dryptosaurus*" has ever been found, but it is represented by many bones and teeth. There



A, cycads; **B**, conifers; **C**, *Astrodon*; **D**, "*Dryptosaurus*" (carnosaur); **E**, *Priconodon* (nodosaur); **F**, "*Coelurus*"; **G**, "*Tenontosaurus*"; **H**, *Archeornithomimus*.

Figure 7. Dinosaurs of the Early Cretaceous Potomac Group.





(Courtesy of the American Museum of Natural History)

Figure 8. "*Dryptosaurus*" (from a painting by Charles R. Knight).

are believed to be at least two species known from this area: the more common being "*Dryptosaurus*" *medius*, and a larger species, "*Dryptosaurus*" *potens*, known from a large vertebra and bone fragments found by workers digging a sewer on Capitol Hill in Washington, D.C., in 1898.

Archeornithomimus affinis, an ostrich dinosaur (Fig. 7), has a curious history in that it was not originally recognized by Marsh as part of the Potomac Group fauna. In 1911, Lull assigned its bones to *Dryosaurus grandis*, a herbivore. Only in 1920 did Charles Gilmore of the U.S. National Museum recognize them as bones from an ornithomimid. Ornithomimids were the fastest of the dinosaurs, perhaps able to run faster than modern-day horses. They were about 11 feet long.

Archeornithomimus affinis is known only from foot bones. Its diet may have included seeds, plants, fruit and eggs, as well as meat, but this is mostly speculation. Much of what is understood about this animal is by analogy with ostriches and their kin because they have a similar body form and are similarly toothless.

Coelurus gracilis was a typical small meat-eating dinosaur, in some ways very similar to *Coelophysis* (Fig. 5). They were about 6 feet long, could run swiftly, and probably fed upon smaller creatures. Some scientists believe they may have been scavengers. Coelurosaurs are particularly interesting because they are thought to be close relatives of bird ancestors. The *Coelurus* from the Potomac Group is very poorly known, being based largely on a claw and a few broken bones.

As mentioned previously, because the

preservation of Potomac Group dinosaurs is so infrequent and so few people are looking for them, there is much yet to be learned about this interesting group of eastern North American dinosaurs. Several bone fragments were recovered from some of the historic localities near Muirkirk, Maryland, in 1973 by area resident Marion "Pete" Rath and recently by the author and his students. Though none of these finds has yet added significantly to our knowledge of the fauna, in early 1989 the author tentatively identified what may prove to be a new species. Perhaps renewed searches of the clays will bring new species to light.

Dinosaurs of the Severn and Related Formations (Late Cretaceous, 86-70 mya)

Dinosaur remains in the Severn Formation and other Upper Cretaceous units are scarce indeed. This is mostly attributable to the fact that these formations are marine. Despite their marine origin, however, these beds have yielded some dinosaur bones among which is the first and perhaps most famous dinosaur find in Eastern North America. The New Jersey *Hadrosaurus* was found in one of these marine deposits. The reason that dinosaurs, which were terrestrial animals, ended up in the marine deposits of the Late Cretaceous is that these deposits were laid down quite near the shore where dinosaur carcasses and bones could be carried into the sea by rivers in flood. Such bones have been found in these deposits largely because they are so frequently hunted for the abundant marine fossils they contain.

Little is known about the land in these times because so few terrestrial deposits of the Upper Cretaceous have been identified in Maryland. We can presume it was a warm, forested lowland, based on some of the vegetation which has also been found in these deposits. To date, only one dinosaur has been given a formal name: *Ornithomimus antiquus*, although remains of others have been found (Fig. 9).

On the basis of the sparse material—a few broken leg bones—*Ornithomimus antiquus* cannot be said to be significantly different from the one described earlier from the Potomac Group. It was probably about 11 feet long.

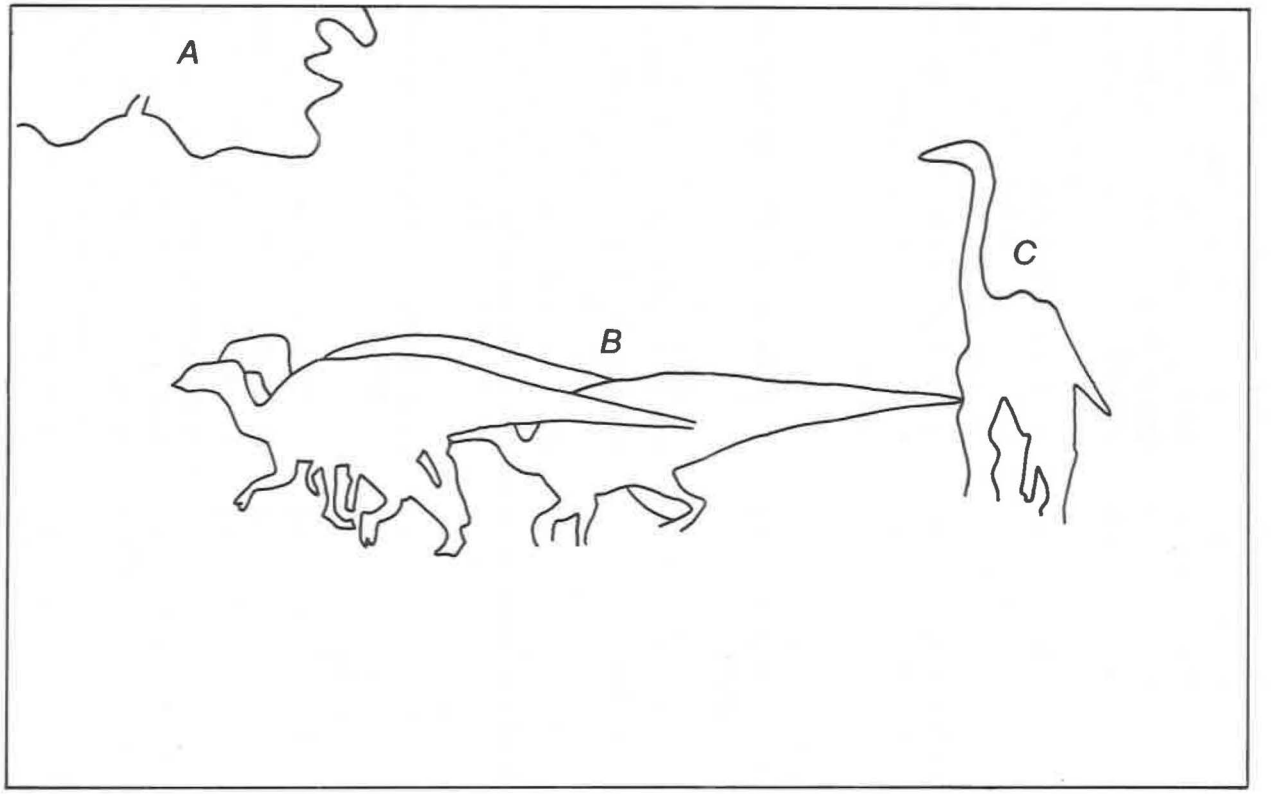
Hadrosaur remains include some broken leg bones and a recently discovered tooth. They may perhaps best be compared with the New Jersey specimen, *Hadrosaurus foulkii*. This creature was what is commonly called a duck-bill dinosaur. Hadrosaurs frequently walked or ran on their much larger hind legs (Fig. 9). They had a mouth full of grinding teeth and lived mostly by browsing on conifers and other vegetation. Hadrosaurs are currently believed to have been completely terrestrial, and not aquatic as often pictured. Adults may have been 26-32 feet long, and weighed more than a ton.

MARYLAND'S DINOSAUR WORLDS

Each of the three major dinosaur periods in Maryland (the Late Triassic of the Newark Group, the Early Cretaceous of the Potomac Group, and the Late Cretaceous of the Severn and related formations) was unique in character and biota. In this section, a brief image of each one will be presented.

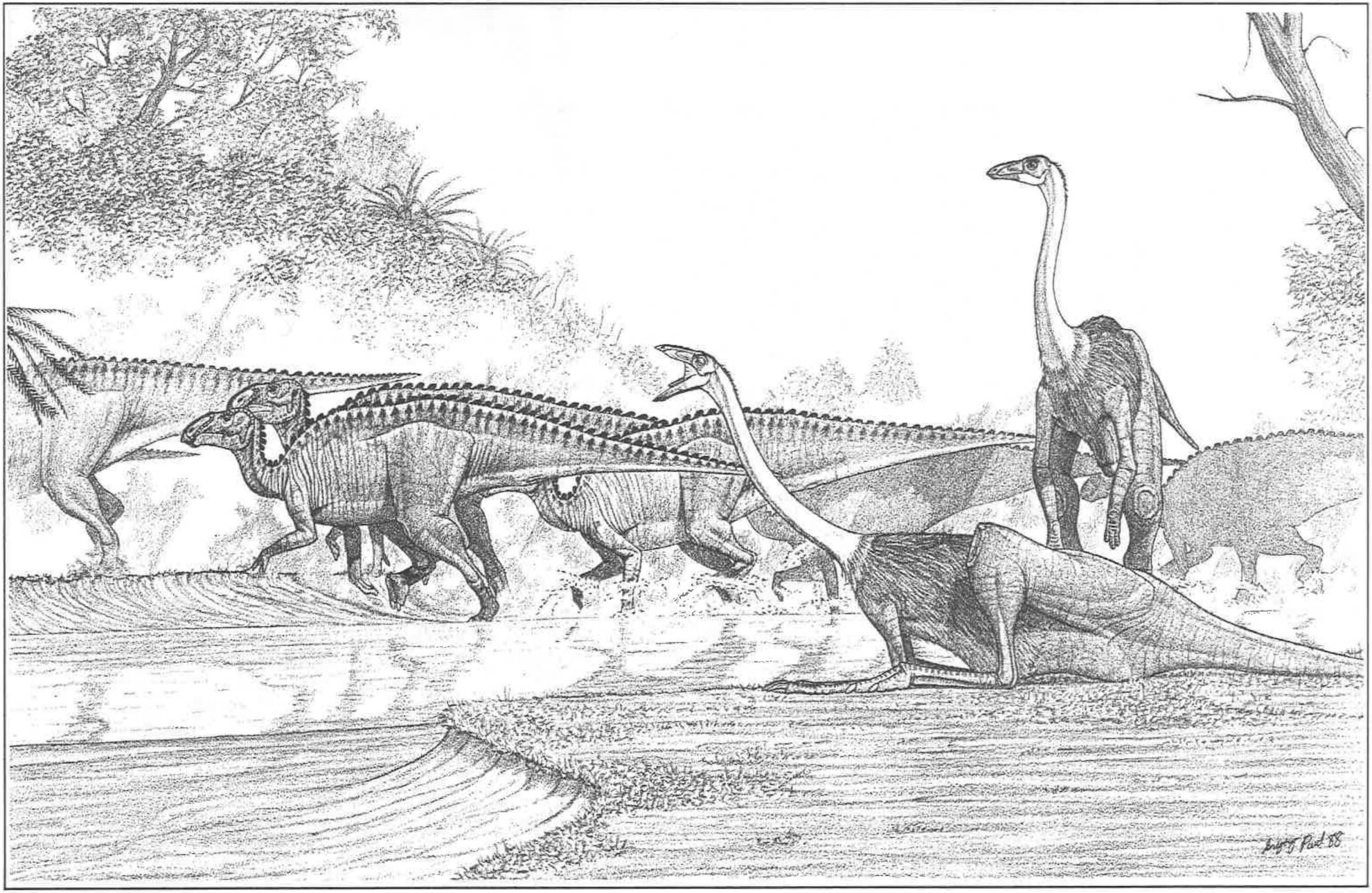
The Late Triassic World of the Newark Group

During this time period, life forms and environment (Fig. 5 and Table 2) can be considered similar to the well-known environments of the Connecticut Valley. The environment in Maryland was close to the popular image of "dinosaur times." The land was a low, forested alluvial plain dotted with lakes and volcanic fissures. The word "jungle" has been deliberately avoided, because it conjures images in people's minds of vines, palms and broad-leafed plants, none of which existed for most of dinosaur time. The kind of plants then abundant were mostly conifers, but included monkey puzzles, ferns, treeferns, cycads, cycadeoids, bennettitales, ginkgoes and horsetails (Fig. 5).



A, deciduous tree; B, hadrosaur (duckbill dinosaur); C, *Ornithomimus antiquus* (ostrich dinosaur).

Figure 9. Dinosaurs of the Late Cretaceous Severn Formation.



Living side by side with the dinosaurs (*Coelophysis*? prosauropods? *Dilophosaurus*?) were many strange creatures, hangers-on from earlier periods. There may have been some mammal-like reptiles and a strange reptilian "tank" known as *Doswellia*. Actual finds in Maryland are scarce, but they do include a phytosaur and a gavial-like archosaur, found south of Poolesville in Montgomery County (Fig. 5). Much is yet to be learned about Early Mesozoic life in Maryland.

The Early Cretaceous World of the Potomac Group

Here one finds an interesting split. The Potomac Group beds begin with the Patuxent Formation in a time before the origin of angiosperms (flowering plants) and end with the Patapsco Formation when angiosperms were beginning to become well established.

In the middle of the Potomac Group lies the Arundel Formation, to which nearly all of the dinosaurs of the Potomac Group can be attributed (*Astrodon*, "*Dryptosaurus*," *Ornithomimus*, *Priconodon*, *Coelurus* and *Tenontosaurus*). The Potomac Group, therefore, is far more important for its plant fossils than its limited dinosaur fauna (Fig. 7 and Table 3). This stems from the fact that almost all our food crops and most of the vegetation of today, which includes broad-leafed trees and grasses, are angiosperms.

Exactly what the vegetation was like during this time is difficult to say because it was undergoing these major changes. The land was a low-lying, delta-like region, not unlike southern Louisiana today, but the vegetation was quite different. There were still coniferous trees like *Araucaryoxylon*, a monkey puzzle, as well as ferns, treeferns, cycads, cycadeoides, bennettitales, ginkgoes, horsetails, and clubmosses (Figs. 10 and 11). In addition, the early ancestors of broadleaf trees, like magnolias, cottonwoods, and sycamores were growing in the area. Grasses, which did not become abundant until about 20 million years after dinosaur times, were, of course, not important. There were also some early water plants like water lilies appearing at this time. Prior to the Late Cretaceous, there was little or no evidence of floating vegetation in fresh water. Thus, many of the illustrations showing earlier Jurassic behemoths like *Apatosaurus* wading in swamps munching soft water-plants are erroneous.

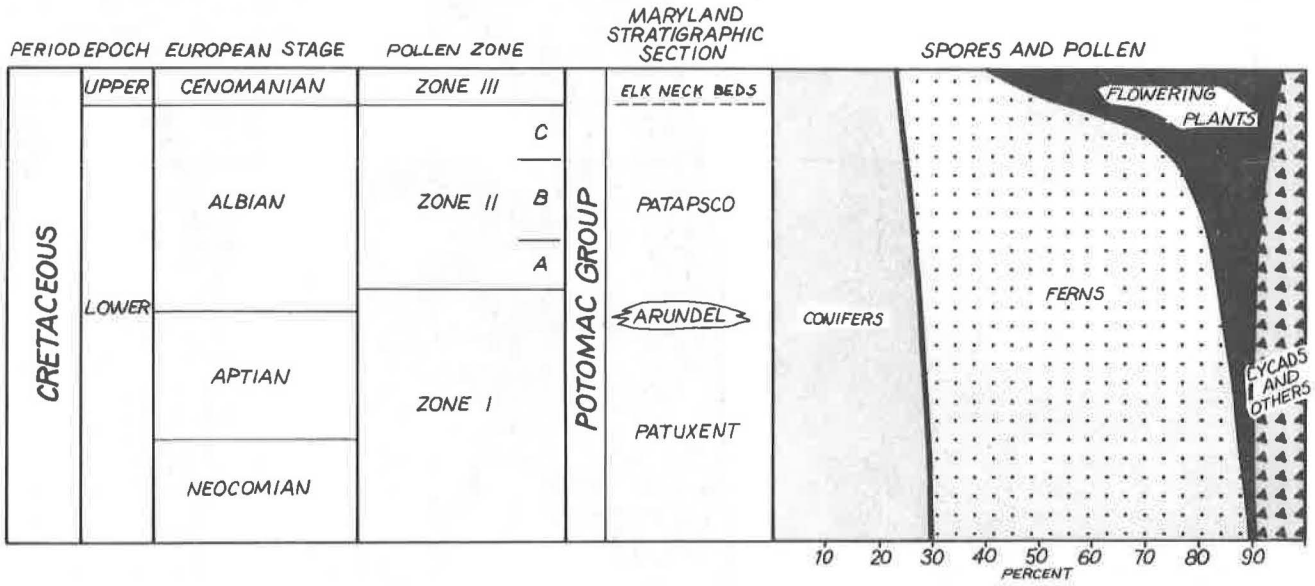


Figure 10. Evolution of Cretaceous flora.

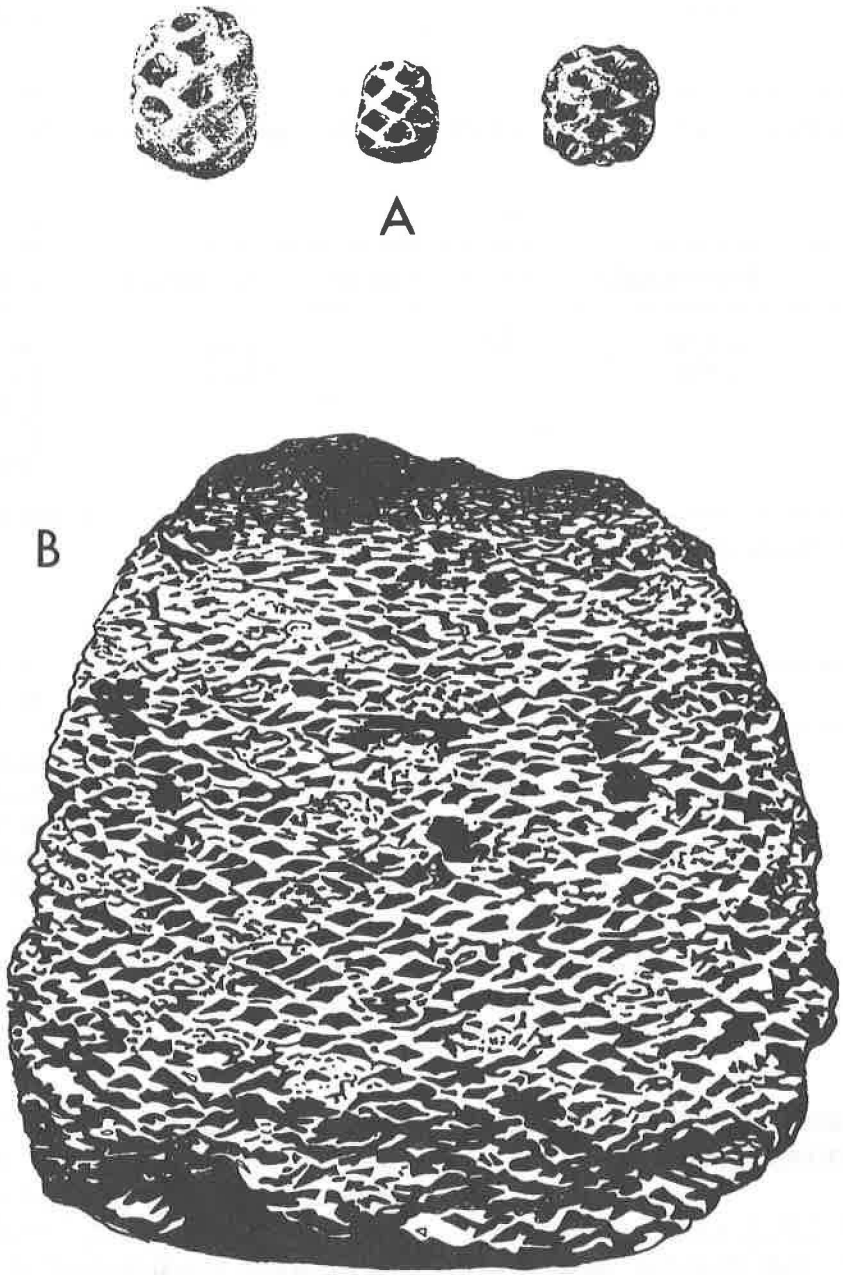


Figure 11. Examples of Early Cretaceous flora found in the Arundel Clay. **A,** Sequoia cones (shown natural size); **B,** Cycad trunk (shown about 1/3-size).

Dinosaurs	Other Reptiles	Other Vertebrates	Invertebrates	Plants
Coelurosaurs Ornithopods Prosauropods Theropods	*Doswellia* Phytosaurs	Fish	Clams Worms	Conifers Ferns Horsetails

Table 2. Some representative life forms of Late Triassic through Early Jurassic time.

Dinosaurs	Other Reptiles	Other Vertebrates	Invertebrates	Plants
Ankylosaurs Brachiosaurs Coelurosaurs Iguanodontids Ornithomimids Theropods	Crocodiles Turtles	Fish	Clams Snails	Conifers Cycads Early angiosperms Ferns Horsetails

Table 3. Some representative life forms of Early Cretaceous time.

Dinosaurs	Other Reptiles	Other Vertebrates	Invertebrates	Plants
Hadrosaurs Ornithomimids	Turtles Mosasaurs Plesiosaurs Crocodiles	Sawfish Sharks "Salmon" "Tarpon"	Ammonites Nautiloids Clams Snails Belemnites Scaphopods Crabs	Early angiosperms Conifers Ferns Horsetails Cycads

Table 4. Some representative life forms of Late Cretaceous time.

The Late Cretaceous World of the Severn and Related Formations

By the Late Cretaceous, angiosperms (flowering plants) had become well established. Unfortunately, Maryland has no known terrestrial deposits from this time. Therefore, knowledge of the land vegetation is basically from washed-in fragments found in marine deposits. The same is true of the animal land life. Other than the scant dinosaur remains (*Ornithomimus* and a hadrosaur), little is known of the land animals. One can assume that the fauna was similar to that of other areas where the land life is better known, and that it probably contained a variety of dinosaurs, reptiles, amphibians, birds, some small mammals, and insects (Fig. 9 and Table 4). The land probably also was host to vestiges of the previously described floras, which were in decline while the angiosperms were ascendant. Cottonwoods, sycamores, willows, magnolias and other deciduous trees were becoming dominant, as were shrubs, vines, and herbaceous plants. True grasses were still not common.

In these Late Cretaceous sediments there is an abundance of marine fossils, including a large variety of invertebrates such as bivalves, snails, and ammonites (a squid-like creature with a shell) (Fig. 12). Ammonites are noteworthy not only because they were so abundant throughout dinosaur times, but also because they became extinct along with the dinosaurs. In contrast, the Late Triassic and Early Cretaceous sediments in Maryland are of continental origin and, therefore, do not contain any information about ocean life during those times.

In all, the fossil record of Maryland's dinosaur world spans a time period of about 155 million years, reaching almost from the time of the coal swamps of the Paleozoic to the jungles of the Cenozoic. Maryland has as diverse or more diverse a history during this time of great life changes as can be found in many larger states and countries.

BONE HUNTING AND THE ROLE OF THE AMATEUR

As noted earlier, some museum curators have estimated that 90 to 95 percent of the fossil specimens in museums are there as a result of discoveries by amateurs—not professionals. However, they do not mean that amateurs excavate and recover most of the important specimens. This is the work of the professional.

The reason amateurs make such a significant contribution is simply that there are so many more of them than professionals. It is often true, as well, that many amateurs spend more hours in the field and search with greater enthusiasm than many professionals, who are often preoccupied with curatorial and administrative duties. Not surprisingly, some of the most important soldiers in the ranks of the amateurs are children. They tend to have more free time and will investigate locations adults might not. Anyone can make a contribution!

The primary difficulty faced by the amateur is lack of information. How do you know where to look? How do you know if what's been found is important? And what do you do if you have a find of uncertain importance?

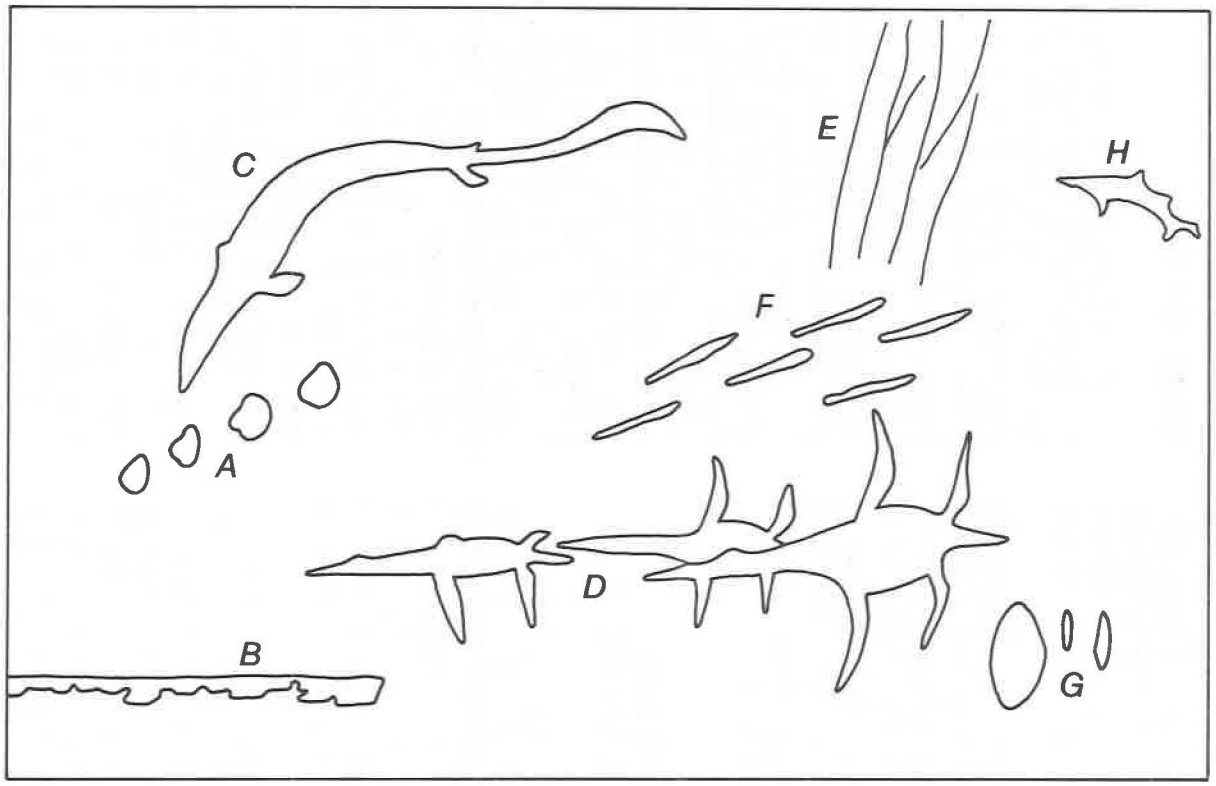
The following outline is intended to guide the amateur through these and other questions.

Where to Look

Before you can decide where to look, you must first decide what it is you are looking for. In almost every case, fossils are found in sedimentary rocks (i.e., water-laid, layered rock). Therefore, the most important questions are the age of the rocks and whether they were deposited under marine or fluvial conditions. This information can be found on geologic maps. (See Map Sources, p. 32.)

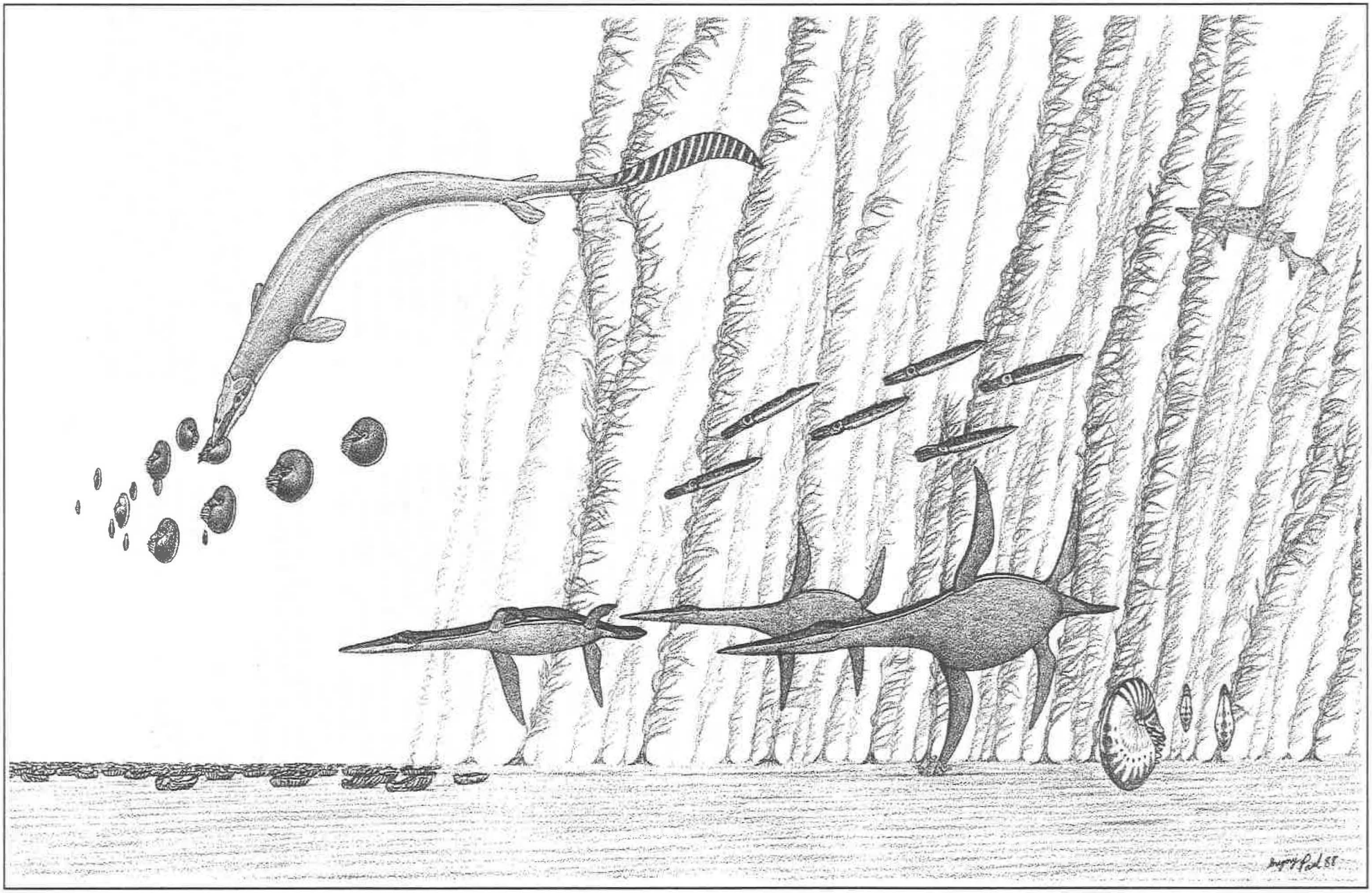
As has already been noted, dinosaurs were land dwellers that lived during the Mesozoic Era (about 245 to 66 million years ago). You should, therefore, look for rocks deposited by rivers during that time period. In Maryland, this includes the Triassic rocks (Newark Group) of the Gettysburg and Culpeper Basins, found in Montgomery, Frederick, and Carroll Counties, and the Lower Cretaceous clays (Potomac Group), which form a wide northeast-southwest band that passes through the cities of Baltimore and Washington. Because of their close proximity to the ancient shoreline, dinosaur bones have also been found in the marine deposits of the Upper Cretaceous Severn Formation.

The Triassic basins are part of a much larger Triassic-Jurassic rift system extending from Nova Scotia to the Carolinas. The sedimentary rocks of these basins are a mixture of sandstones and shales, ranging in color from red to black. The red shales and sandstones occasionally contain dinosaur and other tracks, with sporadic white to reddish bones. The bones in these beds are often difficult to see. When looking for tracks, it is generally best to look for interbedded shales and sandstones, because tracks are best preserved as impressions in mud infilled and cast by the overlying sand. The black and gray



A, *Sphenodiscus* (ammonite); **B**, *Exogyra* (oyster); **C**, mososaur; **D**, pliosaur; **E**, kelp; **F**, belemnites; **G**, *Placenticeras* (ammonite); **H**, shark.

Figure 12. Marine life of the Severn Formation.



layers are the remains of ponds. In places they contain large amounts of organic materials like plants and fish skeletons. Occasionally, a dinosaur, reptile, amphibian or their tracks are preserved in one of these ponds. When a creature is preserved in pond sediments, it is often complete. Bones found in such deposits tend to be black in color.

The Lower Cretaceous Potomac Group, like the rocks in the Newark Group, is part of a much larger system that stretches from Nova Scotia to Georgia. It consists of clays, sand, and gravel, with sporadic sedimentary iron ore. Although few living persons have found dinosaur bones *in situ* in the Potomac Group, there are historical descriptions of the stratigraphic position of the bones. A typical account follows:

Muirkirk and Contee. Tyson was the first to direct attention to animal remains in the Potomac Formation, and the observations which he placed on record in 1860 have been amply confirmed by the results of recent work—with a single exception: no cetacean or other mammalian fossils have lately been seen. It seems probable that Tyson mistook some of the huge dinosaurian bones occasionally found in the section to which he refers, for bones of whales; an error which might easily occur.

In 1887 collections were made by Marsh from one of the mines of the Muirkirk region, under the auspices of the United States Geological Survey, resulting in the discovery of 'a new genus of Sauropods, and other new Dinosaurs.'

During the summer of 1894 the writer's attention was directed to additional saurian fossils which had been found in the same mine explored by Marsh, and at various other points apparently yet unexplored. Several of these new localities were examined with some care in the hope both of adding to our knowledge of the species already known and of the discovery of additional forms. Though the work was attended by much difficulty, a considerable collection was obtained in a comparatively short time.

The fossils have been placed in the hands of Professor Frederic A. Lucas, of the United States National Museum for study.

The collection comprises:

Lamellibranchs	2 species.
Gasteropods [*sic*]	1 species.
Bryozoa (doubtful)	1 species.
Fish	2 species.
Crocodile	1 species.
Turtle	1 species.
Dinosaurs:	
Allosaurus	1 species.
Pleurocoelus	1 species.
Priconodon	1 species.
Astrodon (tooth)	1 species.

It also includes a number of forms yet undetermined.

Among the more interesting fossils of the collection may be mentioned a tibia, probably of *Allosaurus*, which measures ten inches in width, and thirty-two inches in length, exclusive of the ends, which are lacking. In the same beds ("brown charcoal clay") and at about the same level, were found fragments of other bones of similar dimensions, and a tooth . . . probably belonging to the same individual. Half a mile distant in a bed of similar character a single vertebra was found which is probably referable to the same species.

Among the rarest fossils of the collection is the tooth of *Astrodon* (*johnstoni* Leidy?). Tyson discovered the first two specimens of this tooth near Bladensburg, about 1859. Dr. Christopher Johnston made sections of one of them for microscopical study, and very briefly refers to them in a Note upon Odontology as the teeth of "*Astrodon*," a name which he coined descriptive of the appearance of the dentine in cross section. They were subsequently described by Dr. Leidy, who named the reptile *Astrodon johnstoni* in honor of Dr. Johnston. These teeth, with the one lately obtained . . . constitute the only known vestiges of this Dinosaur.

The character of the deposits about Muirkirk and Contee which contain the plant and animal remains has already been described.

The section is briefly as follows:

Quaternary.

1. Gravel, locally indurated . . . . . 10'

Potomac.

2. Arenaceous clay, containing silicified remains of Conifers, Cycads, and (occasionally) of Vertebrates . . . . . 15'
3. "Brown charcoal clay," containing "brown charcoal ore" and vertebrate remains . . . . . 10'
4. "Blue charcoal clay", containing "white charcoal ore," and vertebrate remains fewer in number but better preserved . . . . . 20'

The deposits of animal remains occurring in the vicinity of Muirkirk and Contee are mostly in the divide between the Patuxent and Potomac depressions, and are from a hundred to two hundred and sixty feet above sea level. The circumstance that they are considerably more abundant toward the upper limit, and pretty closely

associated (vertically) with the remains of Cycads suggests that these reptiles were most abundant about the time of the maximum Potomac submergence, which the presence of the Cycads would indicate to have probably been attended by the warm climate suited to animals of this class.

Patuxent. Near Patuxent, Anne Arundel County, on the estate of Mr. L. Welsh, three fragments of another huge (silicified) tibia were recently found. A fossil cycadean trunk, and considerable silicified coniferous wood have also been found on the surface of the same estate and hillslope.

Jessup. About 1886 a large femur (?) was taken from the iron mine of Dr. A.S. Linthicum of Jessup. This was given to the U.S. Geological Survey. Vertebrate remains have also been seen in the mines of the State House of Correction, near Jessup.

Hanover. The next point northward where they have been both reported and found is in the mines bordering the Deep Run depression, near Hanover. A large limb bone was found a few years since at a considerable depth, in one of the mines of Mr. P.R. Wilson, and Mr. C. Van Buren Smith of Wellham's Cross-roads has a silicified fragment of a huge dinosaurian tibia which appears to have come from this neighborhood.

The unusual abundance of silicified cycadean and coniferous vegetation in the valley of Deep Run has already been noticed.

Baltimore. During the past winter while making collections of plant remains from the shafts at Covington and Ostend streets, an impression was seen much resembling in outline and dimensions the track of a single toe of a Brontozoum-like Dinosaur. It occurred in the fossiliferous "slaty clay" near the plant bed. It was carefully removed, but being fragile, was destroyed in transportation.

Stemmer's Run. Vertebrate remains have lately been reported in the vicinity of Stemmer's Run. Independent of these rumors the character of the deposits north-east of Baltimore is such as leads us to expect to find in that section fossil remains, both vegetable and animal, similar to those occurring between Baltimore and Washington.

(From Johns Hopkins University Circular No. 121, *Notes on the Paleontology of the Potomac Formation*, by Arthur Bibbins, Oct. 1895)

There is a good deal of confusion about the Potomac Group finds. Although all of the dinosaur fossils have traditionally been ascribed to the Arundel Clay, the middle formation of the Group, there are those geologists who insist that the tripartite division of the Potomac Group has no validity. To be sure, dark-gray clay lenses are found in all three formations—Patuxent, Arundel, and Patapsco. The bones, which range from brown to red to black in color, are said to be found in these iron-bearing clays.

In addition, important plant fossil finds have been made in all formations, including cycad and bennettitales trunks in the Patuxent-Arundel and early angiosperms in the Patapsco.

Special Plant Deposits, Muirkirk and Contee. The iron ore of the Muirkirk region occurs to a considerable extent in an exceedingly tough blue clay impervious to water, and highly charged with lignite ("blue charcoal clay" of the miners). These beds are noteworthy on account of the abundance and excellent preservation of these lignitized vegetable stems and trunks, many of which will probably be found determinable. All of them lie horizontally and are much compressed. The stems also penetrate the masses of carbonate ore, which have evidently been formed about them as nuclei, and it is said that their abundance in the ore materially facilitates its reduction. These nodules of white ore are reported to contain occasional fern impressions, but none of these have yet come under the observation of the writer.

Among the more interesting fossils from the blue charcoal clay are the sequoian cones converted to siderite. According to Professor Ward the specimens hitherto obtained have mostly been secured from the so-called "old engine bank," where they are probably most abundant. They have lately been found at a number of other points in the region of Muirkirk and Contee. From the same beds casts of cones have also recently been obtained differing in species from those usually occurring. A perfect seed was also found and other determinable vegetable structures which will be described in a later paper.

Overlying the bed of "blue charcoal clay" there is frequently found a bed of "brown charcoal clay," which presents the appearance of having been produced from the former by weathering, though inclined to be less compact, considerably arenaceous and therefore pervious to water. The lignitized stems of these beds are much less perfectly preserved, and no cones have been seen in the same. The brown color of the clay has apparently been derived from the limonite produced by the weathering of the original masses of siderite. The vertebrate remains are considerably more abundant here than in the lower beds of "blue charcoal clay," though they too, are less perfectly preserved.

Above these beds of lignitic clay, and commonly forming the uppermost member, is usually found a bed of highly arenaceous clay destitute of lignite

and containing a considerable number of quartz and other pebbles. On the surface of this member, in close proximity to the lignitic clays above described, a cycadean trunk was recently found. This bed also contains fragments of silicified coniferous logs (the "petrified chips" of the miners), and one large highly silicified saurian bone was recently taken from the same member, near its contact with the lignitic clays below. It should be remarked that the Latchford mine near Contee, from which Mr. Tyson obtained one of the original cycadean trunks is about one mile north of the point where the trunk just mentioned was found. About the same stratigraphic relations exist there, and Tyson's cycad probably weathered out of this pebbly loam,(which here also contains much silicified wood), and rolled down upon the exposed surface of the iron-bearing clay, which until now has been regarded its original source.

(From Johns Hopkins University Circular No. 121, *Notes on the Paleontology of the Potomac Formation*, by Arthur Bibbins, Oct. 1895)

It seems wise, therefore, to hunt the entire Potomac Group for fossils rather than restrict your search to one formation.

The Severn Formation belongs to a belt of marine deposits that extend from Long Island to Alabama and up the Mississippi Valley. The fauna of the Severn Formation is almost exclusively marine, but because the Severn was deposited in the nearshore, especially in the parts of Prince George's County nearest Washington, D.C., occasional dinosaur bones have been found as washed-in elements. Marine reptiles like mosasaurs, plesiosaurs, crocodiles, and turtles are, of course, much more common.

When wet or fresh, the sediments appear black; when dry they are light gray. The sediments are mostly unconsolidated, but there are some moderate to large calcareous concretions which have abundant, though jumbled, fossil faunas. Because the teeth and bones are black, they are all but invisible in the fresh sediments. When the sediments have been washed by rains for a time, the bones and teeth become more apparent by their shiny or polished appearance.

What's Important

As a rule, any bone or tooth found in these formations should be considered important, especially if you are unfamiliar with the fauna. Bones and teeth, except for shark and fish teeth which tend to be flattened rather than conical like reptilian teeth, are generally rare to extremely rare in these formations.

What to Do With Your Find

The hardest decision for most amateurs is what to do with a find. *No one has any right to take it from you, not even a museum. However, permission should always be secured before collecting on any property but your own.*

Despite the ownership of the fossil by the finder, it is desirable that scientifically important specimens be donated to museums. As a matter of policy, museums do not buy specimens. Why, then, should you donate your specimens to a museum? Museums live forever; people do not. The first sauropod tooth found in North America at Bladensburg, Maryland, can still be studied and seen by anyone needing to do so in the Peabody Museum at Yale University, more than 135 years after its discovery.

The museum will not take all your fossils. Less than 10 percent of what is brought to the museum is important enough to be kept. What an amateur considers spectacular or valuable may not be important to a museum. A 5-inch shark tooth is an exciting find, but the museum may have its drawers full of even larger specimens. A small scrap of bone or tooth that is almost invisible may represent the presence of an entirely new group of animals in a fauna. Only the experts can tell you! But even the experts depend on you to provide some information, such as the location of your discovery. Knowing where the fossil was found is often very helpful, if not necessary, in identifying the specimen.

Local places to take finds follow:

Peter M. Kranz, Ph.D.
614 G Street, S.E.
Washington, DC 20003
(202) 543-1165 or (202) 547-3326

Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218
(301) 554-5525 or (301) 554-5522

Naturalist Center
National Museum of Natural History
Smithsonian Institution
Constitution Ave. at 10th St., N.W.
Washington, DC 20560
(202) 357-2804

EPILOGUE: WHAT HAPPENED TO THE DINOSAURS?

Many people wonder what became of this important group of animals that dominated the earth for some 160 million years. Did they all disappear without descendants, or are they still with us in some form? The traditional view is that they, along with more than half of the animal life on earth, became extinct at the end of the Mesozoic Era as a result of some single or group of catastrophes. Several hypotheses have been advanced to account for this extinction, but in recent years some scientists have been claiming evidence that an asteroid or comet collided with the earth at the end of the Cretaceous Period. The impact may have caused so much dust and smoke to enter the atmosphere that the sun was obscured for a time, producing a pronounced cooling and interruption of vegetative growth. The result was the rapid extinction of the dinosaurs, according to the theory. Other scientists view this scenario with caution, contending that other factors forcing climatic change may have played a role in the extinction. That an important extinction did occur is agreed upon; in fact, this extinction defines the end of the Mesozoic Era. It is worth noting that extinctions are the rule in nature. More than 99 percent of all the species that ever lived are now extinct.

Paleontologists generally agree that dinosaurs and birds are closely related because they share many common anatomical features. Birds have dinosaur ancestors. In a sense, then, the birds are their true descendants.

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Dr. Peter Michael Kranz was born on Long Island, New York and began haunting the Dinosaur Hall of the American Museum of Natural History as soon as he could walk. He earned his Ph.D. from the University of Chicago in 1972. Dr. Kranz has worked with museums, universities, and scientists throughout the world. He has collected dinosaurs and fossils on every continent in the northern hemisphere. Presently, his time is occupied with various aspects of science education, including teaching at all levels from pre-kindergarten to graduate school, making video and audio products, building exhibits, doing television productions, writing, and appearing at the occasional dinosaur birthday party.