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UNIVERSITY OF KENTUCKY, LEXINGTON
Donald C. Haney, State Geologist and Director

GUIDE TO "PROGRESSION OF LIFE"

WITH NOTES ON THE HISTORY OF LIFE IN KENTUCKY

Stephen F. Greb
Kentucky Geological Survey

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GUIDE TO "PROGRESSION OF LIFE"

(Poster Commemorating the Sesquicentennial Anniversary of the Kentucky Geological Survey)

WITH NOTES ON THE HISTORY OF LIFE IN KENTUCKY

Stephen F. Greb
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COVER: Scaled-down version of "Progression of Life" by Stephen F. Greb, published in 1988 by the Kentucky Geological Survey in commemoration of its 150th anniversary.

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Scaled–down, black-and-white copy of "Progression of Life." The original poster, which measures 18½ by 22 inches and is printed in full color on coated stock, is available for $5.95 per copy from:

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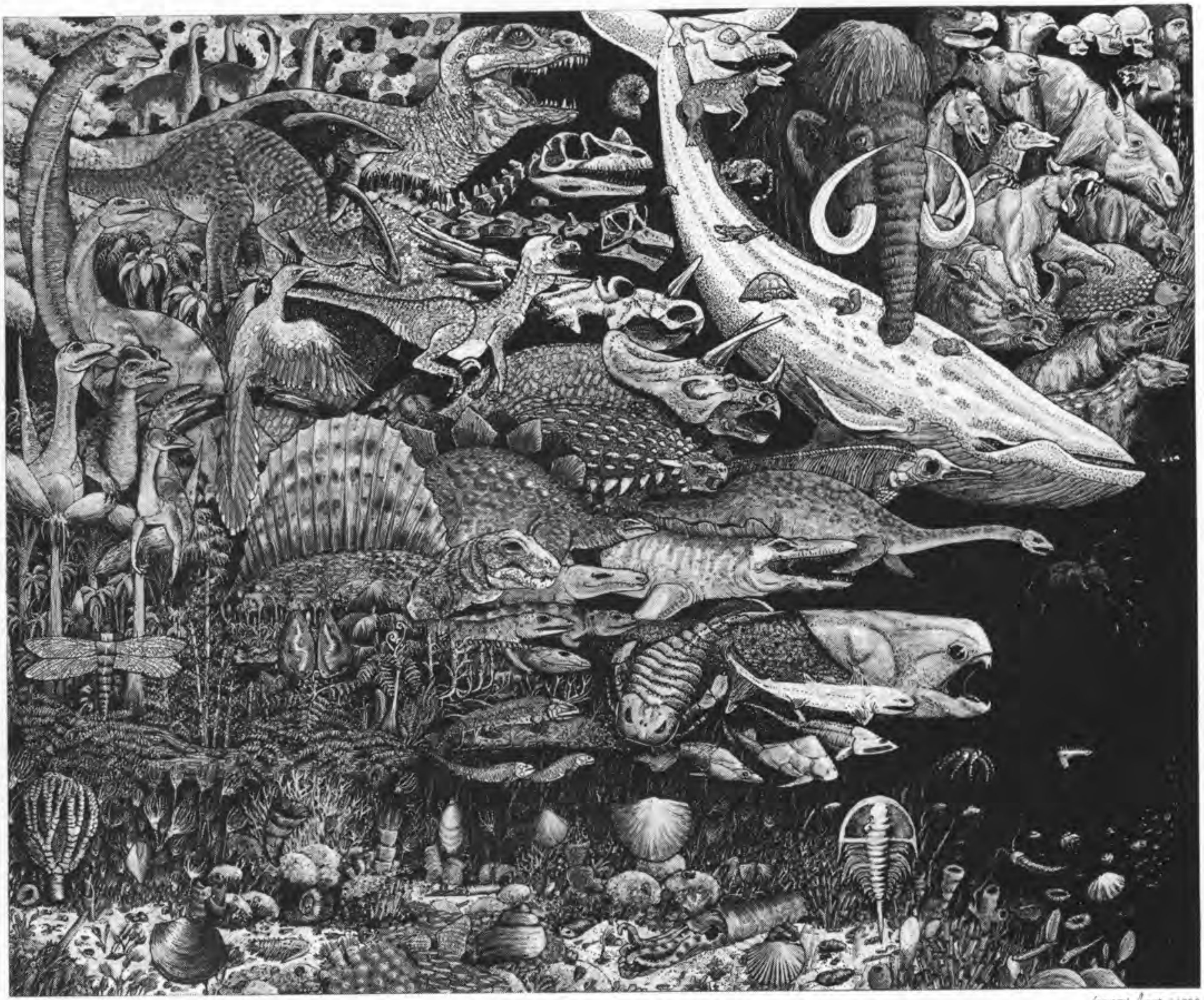

Kentucky Geological Survey

Stephen Greb ©1988

PROGRESSION OF LIFE

In Commemoration of the Sesquicentennial Anniversary
1838-1988

GUIDE TO "THE PROGRESSION OF LIFE"

Stephen F. Greb
Kentucky Geological Survey

INTRODUCTION

This booklet is meant to be used as an explanation of the various creatures illustrated on the "Progression of Life" poster, published in celebration of the Kentucky Geological Survey's one-hundred fiftieth anniversary (Fig. 1). The poster was constructed to illustrate the great diversity of life throughout geologic time. Restoration of ancient animals and plants is based upon the fossil record that has been preserved in the rocks. Many of the forms depicted on the poster lived in the area that is now Kentucky; however, some geologic rock units are missing in Kentucky due to erosion or nondeposition, and some of the older units are not exposed at the surface anywhere in the State (Fig. 2). Scientists are able to determine the life forms represented by the

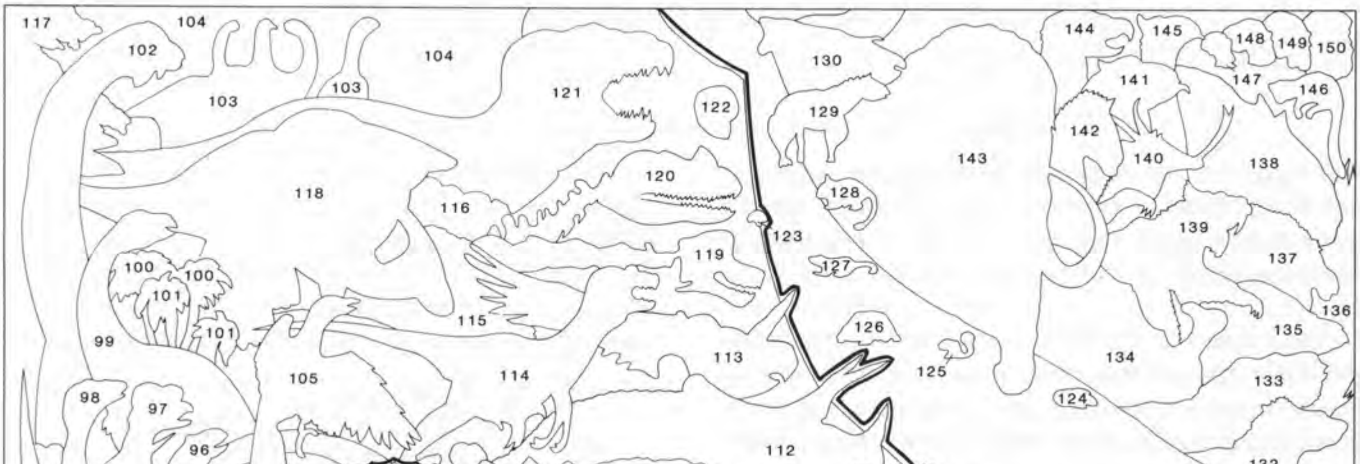

Figure 1. Reference diagram on back of "Progression of Life" poster for use in identifying individual animals and plants. Numbers on the diagram correspond to numbers used in the identification list.

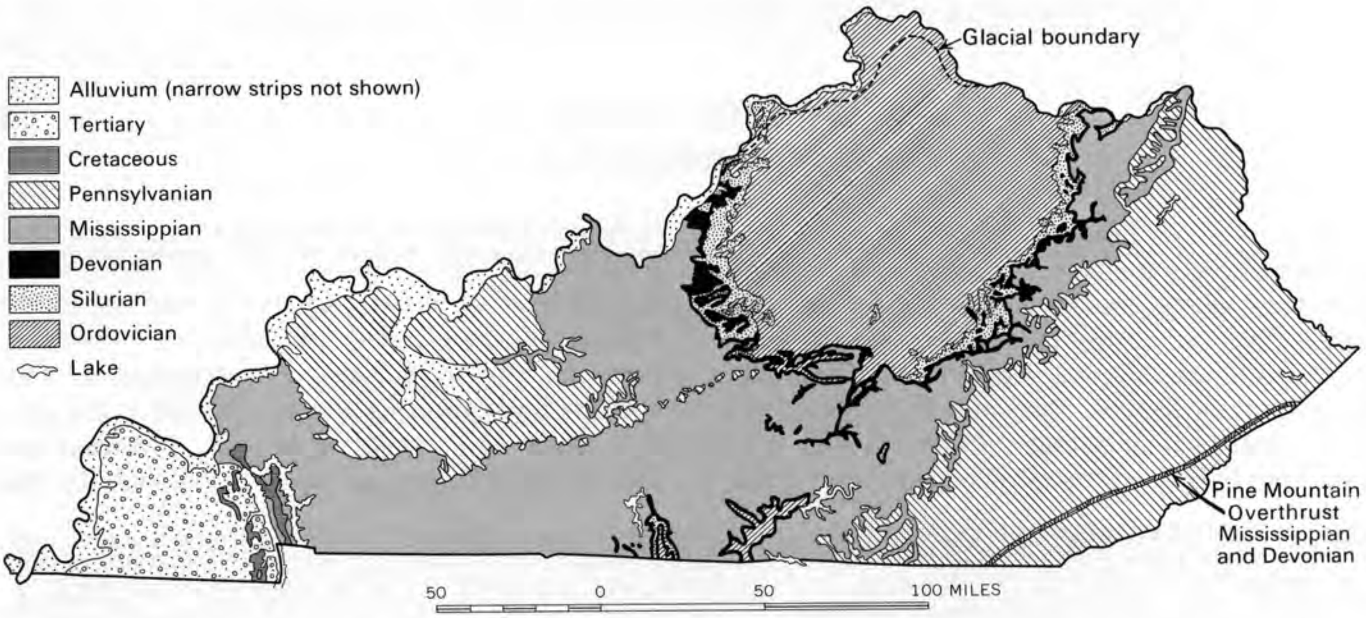

Figure 2. Rock units exposed at the surface in Kentucky.

missing rock units by studying units of the same age that have been preserved in other areas of the world. In this way a more complete understanding of the progression of life can be acquired.

The poster is divided into six broad sections, which are the same as the major headings in this booklet. Each organism pictured on the poster is discussed in this booklet (Fig. 3). The names of the organisms on the poster are capitalized and followed by a number in brackets that corresponds with the number of the organism on the legend of the poster. A pronunciation guide of many of the organisms discussed in the following pages is provided in the back of the booklet. The explanations are arranged by geologic age (Fig. 4), from the most ancient life to the most recent. In many cases, this arrangement corresponds to the numerical order of the organisms on the poster, but in some cases the explana-

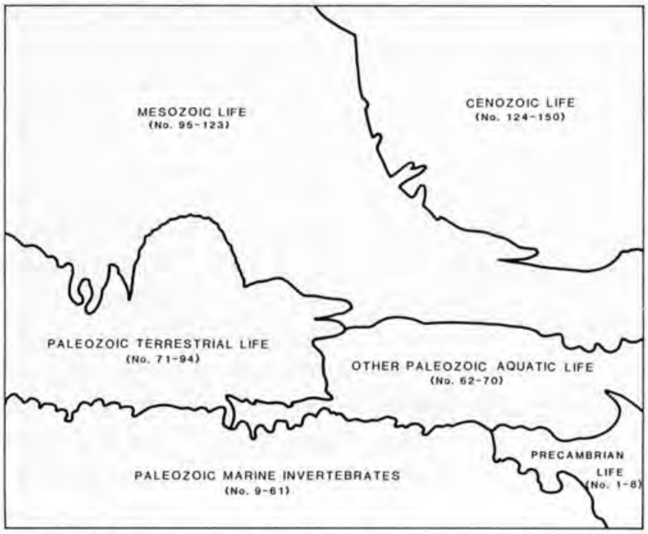

Figure 3. Subdivisions of "Progression of Life."

GEOLOGIC TIME SCALE

ERA	PERIOD		EPOCH	MILLIONS OF YEARS AGO	SYMBOL
CENOZOIC	QUATERNARY		HOLOCENE	.01	Qh
			PLEISTOCENE	1.6	Qp
		TERTIARY	PLIOCENE	5.3	Tpl
			MIOCENE	23.7	Tm
			OLIGOCENE	36.6	To
			EOCENE	57.8	Te
			PALEOCENE	66.4	Tpa
MESOZOIC	CRETACEOUS			144	K
	JURASSIC			208	J
	TRIASSIC			245	Tr
PALEOZOIC	PERMIAN			286	P
	PENNSYLVANIAN			320	Pa
	MISSISSIPPIAN			360	M
	DEVONIAN			408	D
	SILURIAN			438	S
	ORDOVICIAN			505	O
	CAMBRIAN			570	C
PRECAMBRIAN					PC

Figure 4. Geologic time scale.

tions are not in numerical order so that a more complete and more readable story could be told.

PRECAMBRIAN LIFE: "WITH A SINGLE CELL THE PROGRESSION BEGINS"

Precambrian Period [1–8]

The Precambrian Period includes the time from the beginning of the earth, 4.6 billion years ago, to the beginning of the Cambrian Period, only 570 million years ago. Thus, the Precambrian Period represents more than 85 percent of all geologic time! For the first quarter of this time there was no life on the planet. The earth was in the process of cooling down from its origin as a firey ball in space. Great volcanoes erupted clouds of gas. Rain from these clouds showered down on the planet for billions of years until large oceans and lakes formed. In these bodies of water, energy, high temperatures, and the proper alignment of chemical elements united to form the first cells. With these first cells the progression of life began.

The first known life forms were simple BLUE-GREEN ALGAE CELLS [1] (Fig. 5) and bacteria. As time progressed, mounds of algae called STROMATOLITES [3] became the most widespread fossils of the Precambrian. Algae were important because as plants they were able to take carbon dioxide out of the atmosphere and release oxygen. Over a period of more than a billion years these simple algae changed the poisonous gases of the early Precambrian atmosphere into a breathable oxygen-rich atmosphere in which other life could progress.

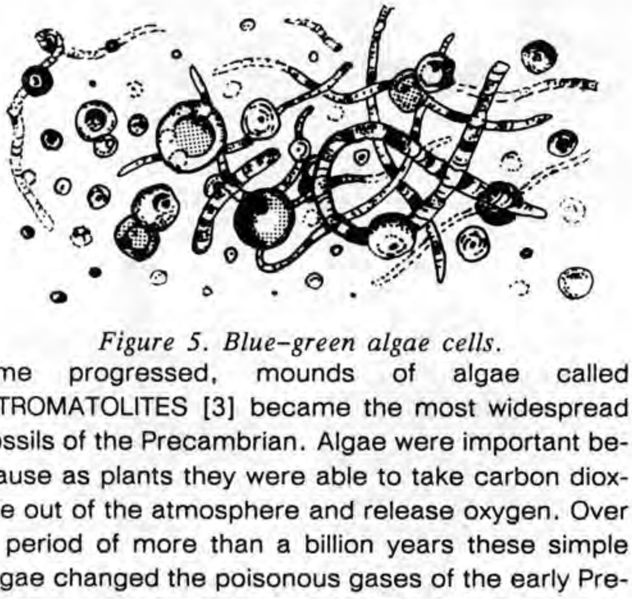

Figure 5. Blue-green algae cells.

At first the progression was slow. It took more than 2 billion years for the first single-celled organisms to combine into multicelled creatures called EUCARYOTES [2]. The first eucaryotes were little more than fungi and more complex bacteria, but the pattern for multicellular life had been set.

By 600 million years ago multicellular life had become widespread. An unusual find of fossils in Australia gave scientists a clue to what these primitive creatures were like. The EDIACARA ORGANISMS [4–8] include jellyfish, such as CYCLOMEDUSA [4] and BRACHINA [5]; marine worms, such as SPRIGGINA [6] and DICKINSONIA [7]; and many other organisms, such as the sea pen CHARNIODISCUS [8]. Scientists have been able to study the Ediacara organisms in great detail because the soft tissues of the organisms were preserved in the unusual Australian fossils. Most fossils are only the preserved hard parts of animals, such as bones, teeth, and shells. When the soft parts are preserved, scientists can derive a more complete picture of what the soft animals living in the hard shells looked like (Fig. 6).

PALEOZOIC MARINE INVERTEBRATES

Cambrian Period [9–18]

During the Cambrian Period shallow seas and oceans covered much more of the world than today. Most of the United States was under water. It was in these shallow seas that invertebrate (lacking a backbone) sea life first developed hard parts (shells and skeletons). When organisms develop a new ability or new mechanism that allows them to better survive, the organisms often become widespread in what is called an "adaptive radiation." Shells and hard parts were an adaptive innovation that offered needed protection to the soft-bodied invertebrates, and the beginning of the Cambrian is marked by a rapid "radiation" of shelled invertebrates across the world. Also, the explosion of animal life and development of shells at the beginning of the Cambrian may mark the point in the progression of life at which the oxygen level in the atmosphere and shallow seas finally reached the critical theshold to support abundant animal life.

Just as the fossils from the Ediacara hills of Australia told scientists much about life in the Precambrian seas, soft body parts preserved in the fossils of the BURGESS SHALE ORGANISMS [9–16] of Canada have told scientists much about life in the Cambrian seas. PEYTOIA [9] was thought to be a jellyfish, but is now recognized as the mouth parts to a predatory creature named *Anomalocaris*. This animal lived with other unusual creatures, worms, sponges, such as VAUXIA [11] and CHANCELLORIA [14]; and sea anemones, such as MACKENZIA [15.]

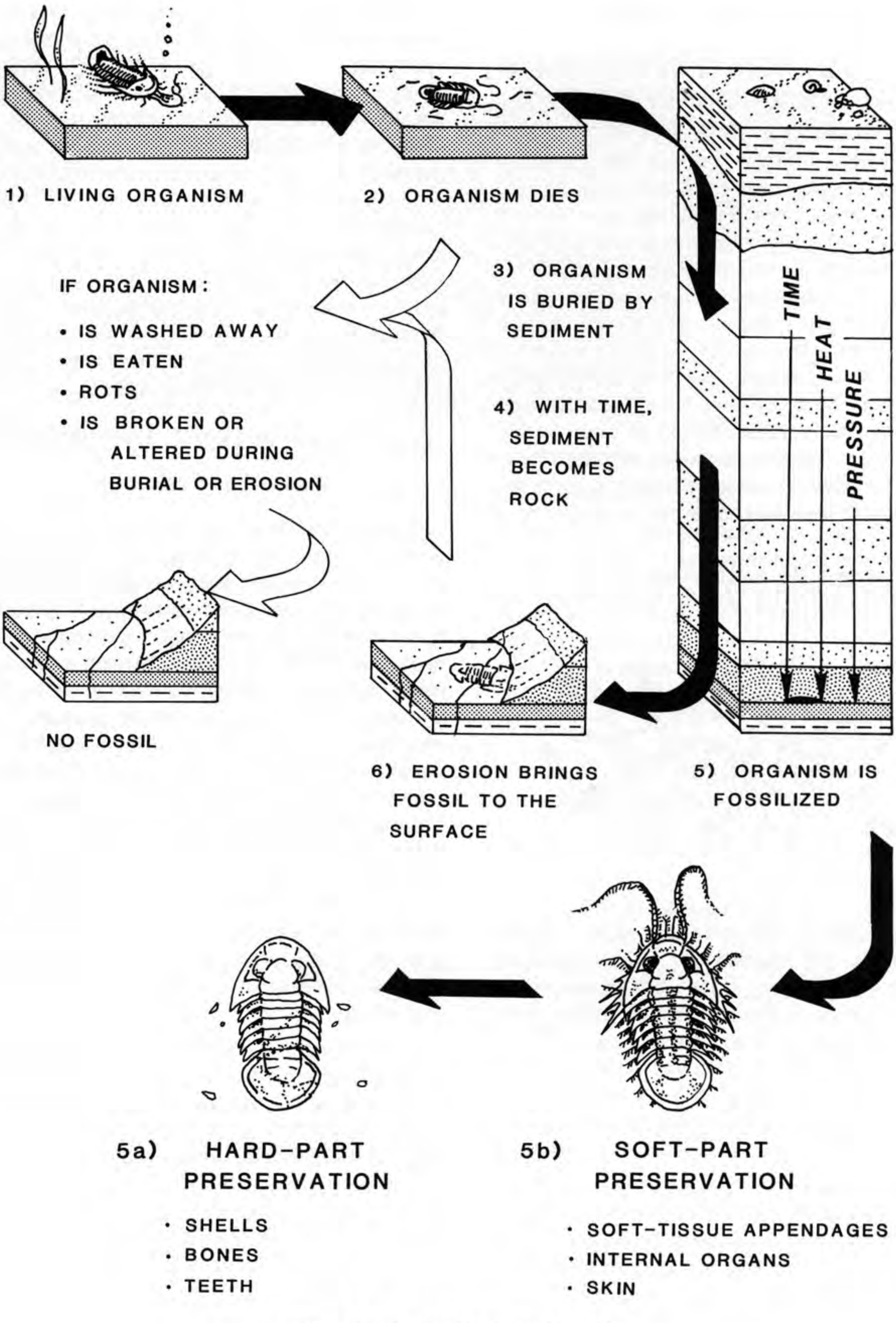

Figure 6. How a fossil is formed.

Another Burgess Shale organism called *Pikaia* was related to the LANCELETS [10]. Lancelets were creatures that resembled small eels. They are important because they appear to have developed a thin cord down the length of their bodies that may have been an early form of the backbone or vertebrae. Vertebrates would become important members of the animal kingdom. They include fish, amphibians, reptiles, birds, and mammals.

Another important group of organisms found in the Burgess Shale is arthropods, such as CANADASPIS [12]. Modern arthropods include crabs, scorpions, spiders, and insects. Arthropods became one of the most important groups of the Cambrian seas. The most common Cambrian arthropod was the trilobite (Fig. 7). All arthropods have a hard shell that they shed as they grow. The discarded shell is called a molt. Fossil trilobite molts are so common in Cambrian-age rocks that some people call the Cambrian the "Age of Trilobites." A fossil of the trilobite OLENELLUS [17] shows what a fossil trilobite molt looks like, while the living trilobites looked like the examples of CALYMENE [18].

Other life that developed in the Cambrian seas included the clam-like brachiopods and bivalves (Fig. 8), squids with shells called cephalopods (Fig. 9), corals (Fig. 10), snails, and ARCHAEOCYATHIDS [13], which were one of the first organisms capable of building continuous community structures like reefs. Reef-like structures are important habitats

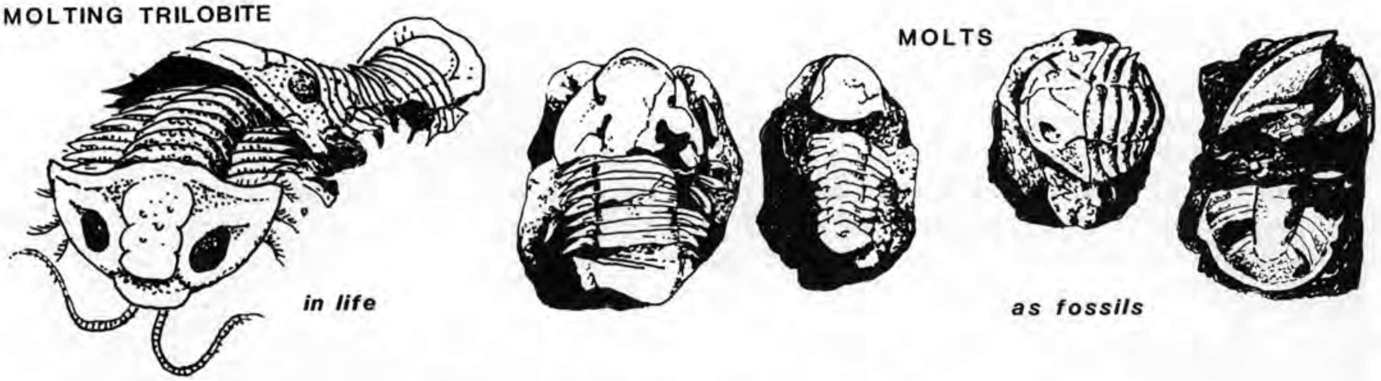

Figure 7. Trilobites in life and as fossils.

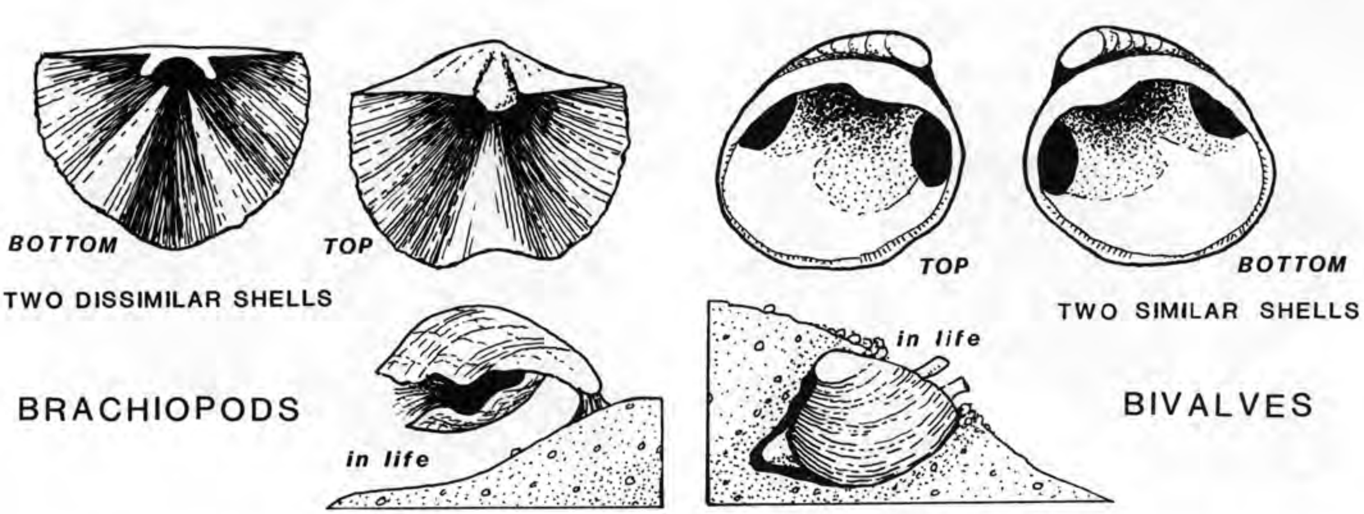

Figure 8. Comparison of brachiopods and bivalves. Bivalves are much more abundant today, but in the Paleozoic seas, brachiopods dominated.

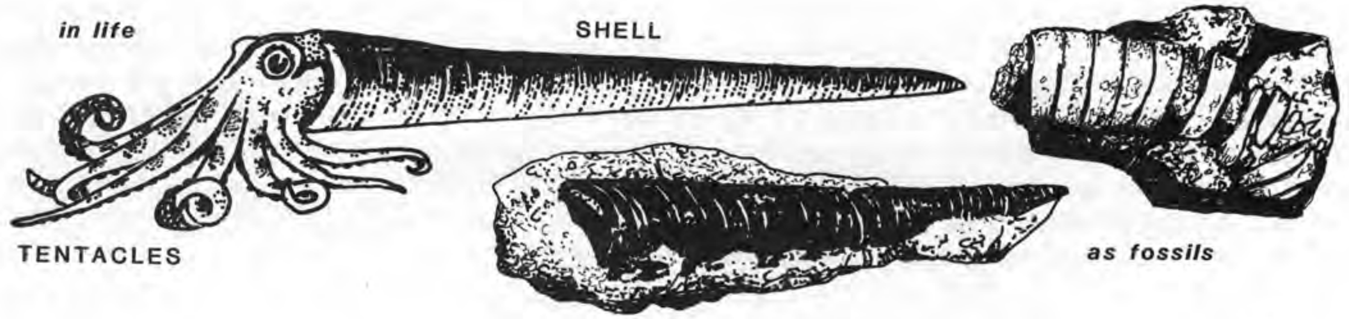

Figure 9. Cephalopods in life and as fossils.

because they offer protection and food for most marine life.

Ordovician Period [19–29]

During the Ordovician Period, seas still covered much of the world, and invertebrate aninmals became even more varied and widespread. If a person could have seen the Ordovician sea floor (which would have been impossible, since man didn't appear for millions of years), he might have seen sponges like BRACHIOSPONGIA [24] and the coral-like BRYOZOANS [19, 29] or "moss animals" (Fig. 11). Some bryozoans were just mounds on the sea floor, while others had delicate branches and twigs, like HALLOPORA [19] and CONSTELLARIA [29]. True corals, such as TETRADIUM [23], were also com-

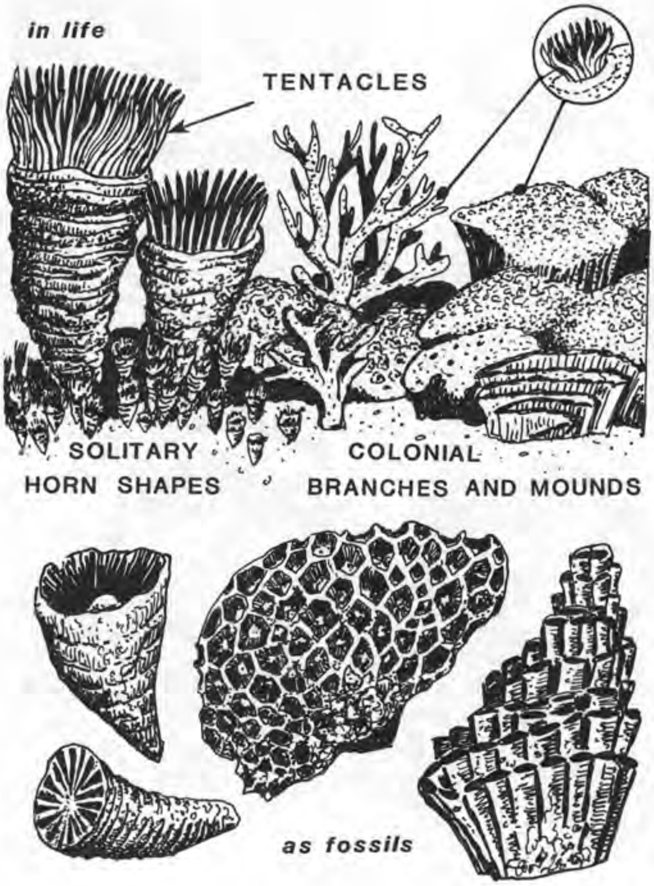

Figure 10. Corals in life and as fossils.

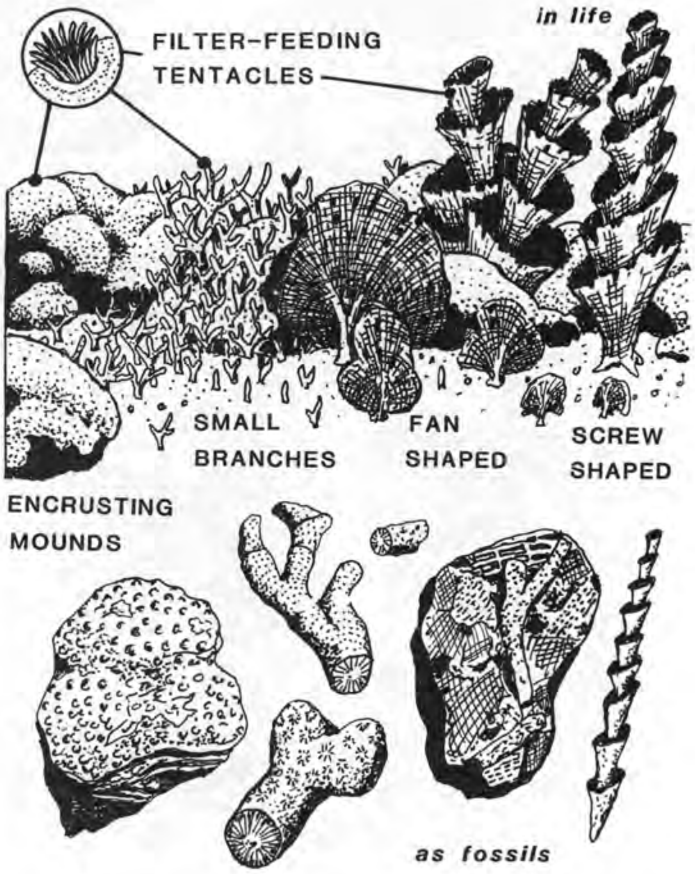

Figure 11. Bryozoans in life and as fossils.

mon. Bryozoans are filter–feeding animals that filter microscopic food out of the water through pores in their skeleton or grab particles with their tiny tentacles (Figs. 10–11).

Along with the bryozoans and corals were CRINOIDS [20], often called "sea lilies" because they looked like underwater flowers (Fig. 12). Actually, they were not plants, but invertebrate animals that used their feathery arms to gather tiny food particles from the water. Relatives of the crinoids, corals, and bryozoans still exist today.

The most common creatures of the Ordovician were the BRACHIOPODS [21, 22, 28] (Fig. 8). At first glance they appear very much like the clams and seashells of today, but the shapes of their shells and the animals that lived inside those shells were different from the clams. Clams belong to a group of animals called bivalves. Bivalves have a bottom and top shell that are often the same shape. Brachiopods had shells that often overlapped because one shell was bigger than the other. RAFINESQUINA [21] had a thin shell and laid flat on the sea floor; PLATYSTROPHIA [22] had a thick, strongly ribbed shell; and DINORTHIS [28] had a slightly ribbed shell and stood vertically on the sea floor.

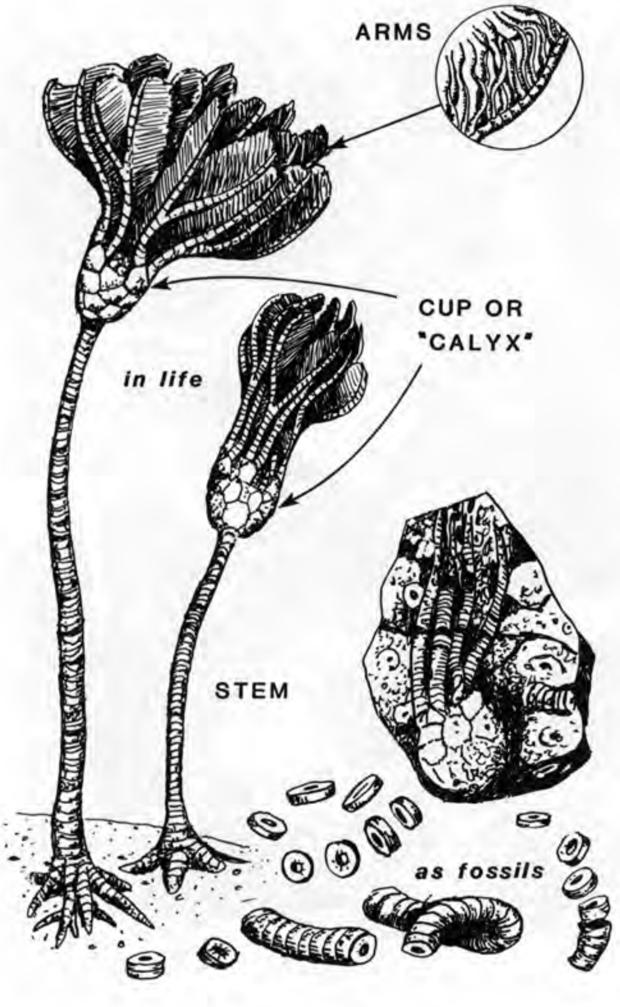

Figure 12. Crinoids in life and as fossils.

Bryozoans, corals, crinoids, clams, and brachiopods are mostly filter–feeding organisms. Other animals in the Ordovician seas were predators, directly feeding on other animals. Both filter feeders and predators are shown in Figures 13 and 14.

A major group of predators were the cephalopods. Cephalopods are the ancestors of the modern–day squid and octopus. In fact, they very much resembled a squid that lived in a hard shell (Fig. 9). The cephalopod ENDOCERAS [25] grew to lengths of more than 15 feet and was probably the dominant predator of its time. The poster shows a cephalopod grabbing a fleeing trilobite. The trilobites reached their peak during the Ordovician. Some, like ISOTELLUS [26], were large; others were quite small.

The Ordovician Period ended with an extinction that wiped out many species of marine invertebrates. One reason for the extinction was the movement of great pieces, or plates, of the earth's crust. One product of these plate movements was the uplifting of a great mountain range in the eastern United States. A second product was an ice age. Continents rest on plates of crust that are constantly in motion. When a continent is moved across the north or south pole, like Antarctica today, great ice sheets form. Water is drained from the oceans to form the ice. When enough water is drained, sea level drops, and the shallow seas dry up, causing extinctions.

Silurian Period [30–44]

As the Silurian began, the shallow seas returned, and large reefs became common (Figs. 15–16).

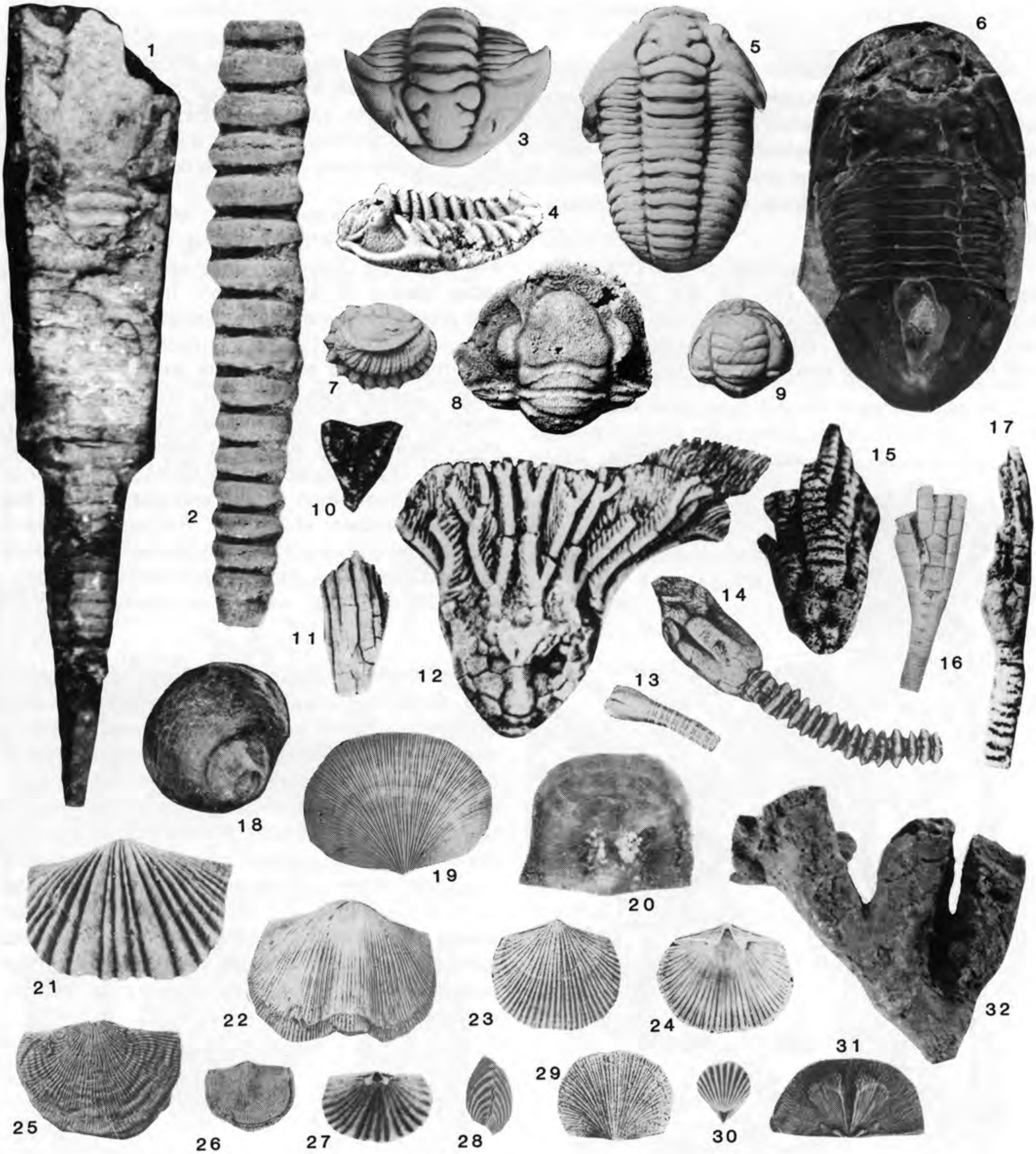

Figure 13. Ordovician marine fossils. Fossils pictured are: (1–2) cephalopods, (3–9) trilobites, (10–17) crinoids, (18) gastropod, (19–31) brachiopods, (32) bryozoan. See Appendix 1 for names and locations of fossils.

Figure 14. Reconstruction of an Ordovician sea. Note the brachiopods and bryozoans in the foreground, the cephalopod chasing the trilobite in the center, and the crinoids, bryozoans, and "horn" corals in the background.

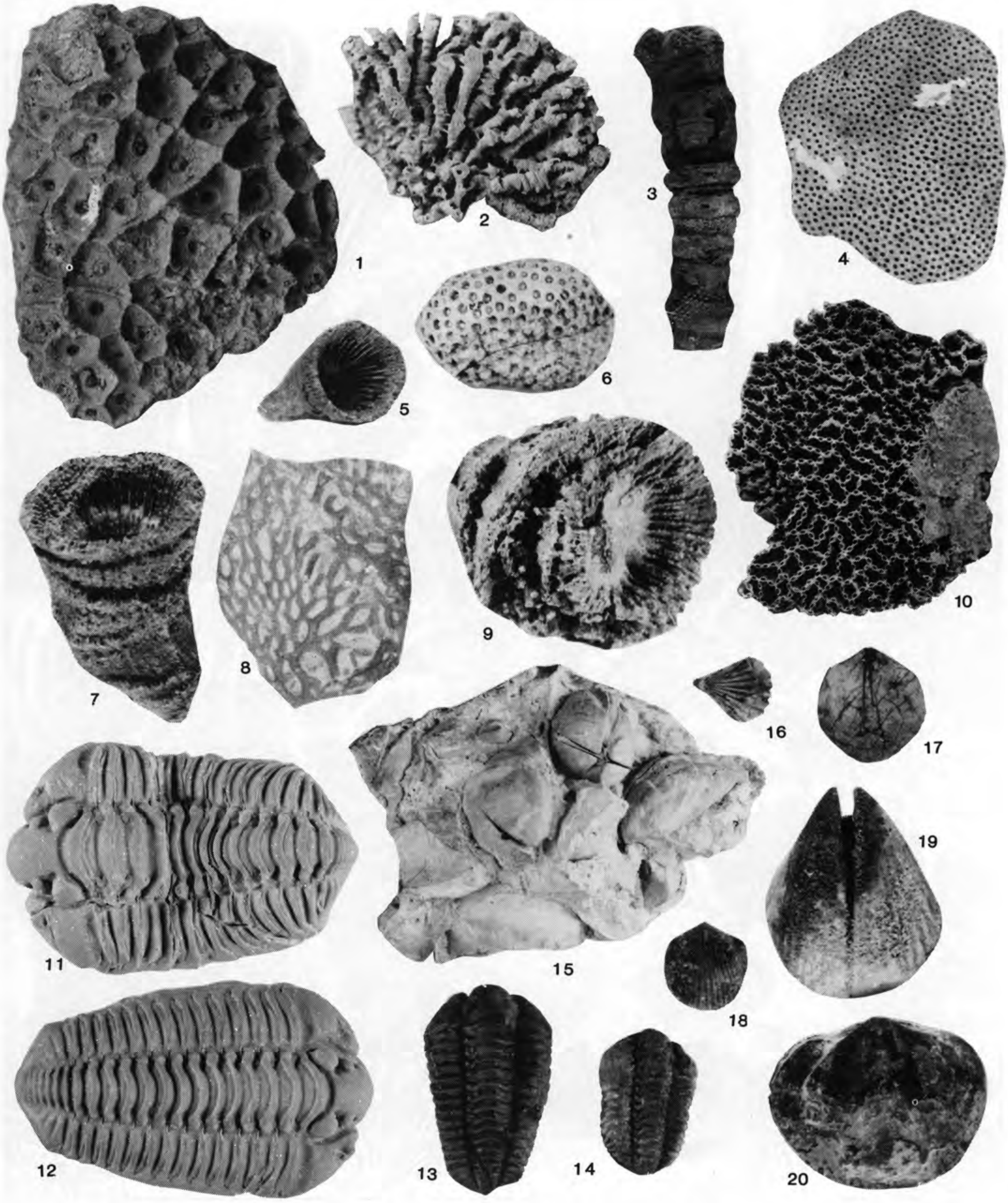

Figure 15. Silurian marine fossils. Fossils pictured are: (1–10) corals, (11–14) trilobites, (15–20) brachiopods. See Appendix 1 for names and locations of fossils.

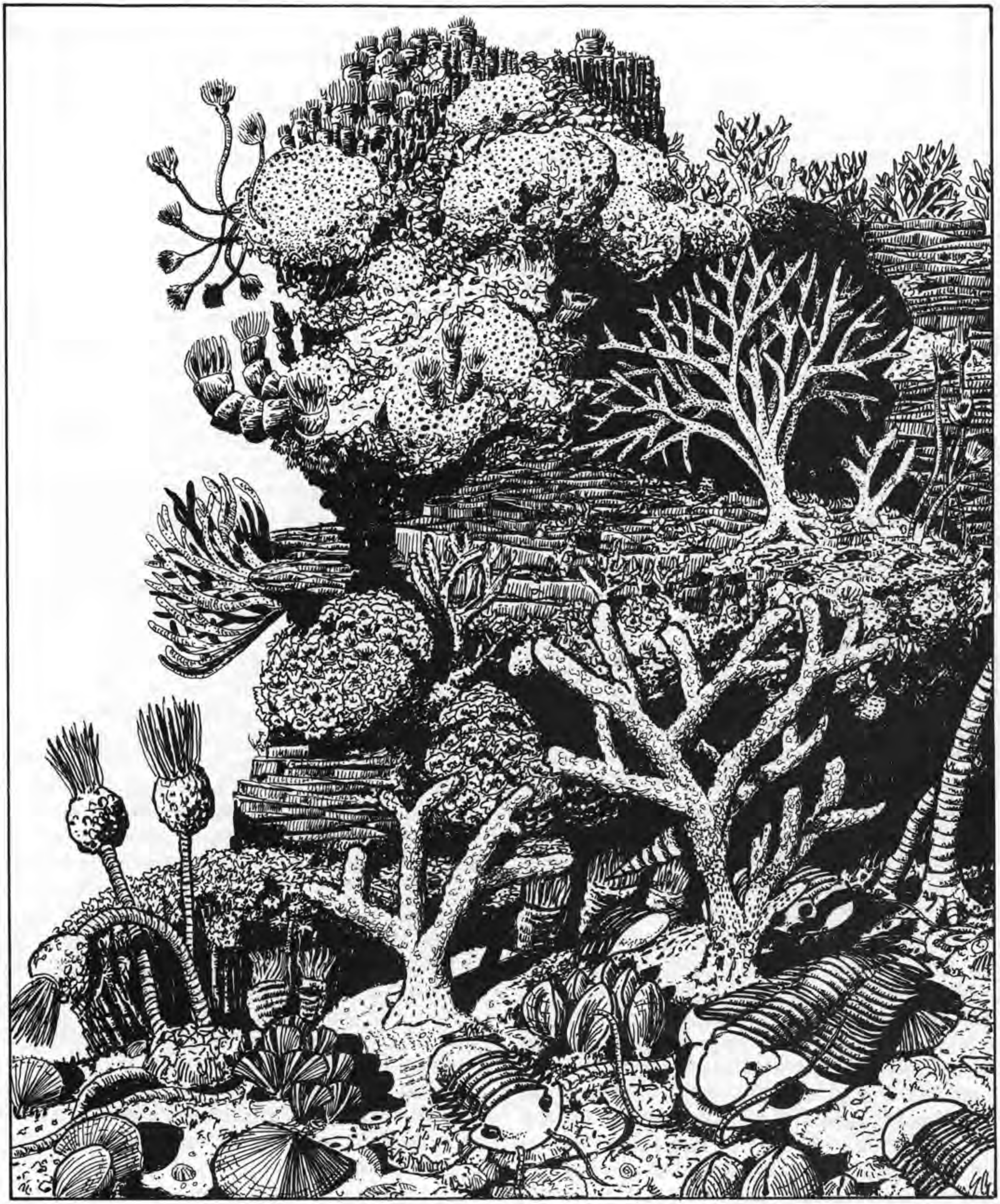

Figure 16. Reconstruction of a Silurian reef. Note the trilobites and brachiopods in the foreground. Corals dominate the background.

Some Silurian reefs were made up almost entirely of the coral-like bryozoans, such as the branching PACHYDICTYA [32] or the fan-shaped FENESTRATE BRYOZOANS [35], but most were constructed by true corals. One group of corals, called the tabulate corals, secreted a calcareous skeleton that glued the many little coral animals (called polyps) together until they had a honeycomb appearance. Examples of these colonial corals are the mound-shaped HELIOLITES [36], 'ARACHNOPHYLLUM [38], PLASMOPORA [39], and FAVOSITES [43]; the branching and mound-shaped CLADOPORA [41]; and the intertwining chain coral HALYSITES [42]. Solitary corals, which consisted of a single polyp like those of the CYSTIPHYLLUM [44], are called horn corals, and were also common in the reefs. These reefs provided shelter and food for many of the marine invertebrate animals, such as the brachiopods [40], ATRYPA [30] and PENTAMERUS [31], trilobites [18], and snails such as CYCLONEMA [37].

Because the reefs were home for so many small marine animals, they also were the favorite hunting grounds of the larger animals, such as the cephalopod ORTHOCERAS [34]. In fact, many scientists think that the decline of the trilobites in the Silurian and later may have been because they were hunted by cephalopods and their cousins, the nautiloids.

Devonian Period [45–52]

On land many interesting changes were taking place, and in the oceans vertebrates became more diversified (*see* pages 18–21). On the sea floor, coral reefs continued to flourish. Many of these reefs were fossilized, such as the reef at the Falls of the Ohio in Louisville, Kentucky, which has been protected as a world historical site (Figs. 17–18).

Colonial corals like FAVOSITES [43] continued to be common in the Devonian, but the types of horn coral increased greatly. The name "horn coral" is obtained from the shape of solitary, or rugose corals such as ZAPHRENTIS [45]. Some horn corals were very large, such as SIPHONOPHRENTIS [46]; some were small, such as HETEROPHRENTIS [47]; and some grew together into groups, such as the ERIDOPHYLLUM [48]. Cephalopods and their cousins the nautiloids continued to hunt along the edges of the reefs. Nautiloids such as HERCLOCERAS [49] were similar to cephalopods, and consisted of a squid-like organism in a straight or coiled shell. They may have hunted small, shelled invertebrates such as the BRACHIOPODS [50], bivalves such as PARACYCLAS [52], and trilobites. One Devonian trilobite the nautiloids might have had problems hunting was TERATASPIS [51]. This trilobite had long spines and grew to a length of 2 feet, making it considerably larger than most of the nautiloids of the time.

At the end of the Devonian another extinction devastated the shallow Paleozoic seas. Again the cause may have been the moving plates of the earth's crust, as the continents of North America and Europe collided. Once again the shallow seas were drained, and a great mountain range was uplifted in the eastern United States.

Mississippian Period [53–61]

In the beginning of the Mississippian Period shallow seas returned to cover a large part of the eastern United States as crustal disturbances stabilized. Although large coral reefs were less common after the Devonian, corals such as MENOPHYLLUM [53] and LITHOSTROTION [54] continued to flourish, as did the bryozoans. The most common Mississippian bryozoan was ARCHIMEDES [55], which consisted of spiraling filter-feeding fans around a support skeleton resembling a screw (Figs. 11, 19–20).

The dominant animals of the time were the echinoderms (Figs. 19–20). Echinoderms such as the blastoids and crinoids consist of a cup or crown called a calyx that is attached to a stem connected to the sea floor (Fig. 12). The organisms feed by filtering nutrients from the sea water from tentacles or arms that attach to the calyx. These calyxes are sometimes preserved as fossils, as in the example of PENTREMITES [56]. Some crinoid calyxes may also have their arms preserved, as in the example of FORBESIOCRINUS [58]. The arms and stems of the crinoids were both made of calcareous rings called COLUMNALS [59]. These columnals are very common fossils and are sometimes called "Indian beads" because of their bead-like shape. Both crinoids and blastoids occurred in widespread patches or gardens [57] throughout the Paleozoic. Note the many different kinds and shapes of crinoids and blastoids shown in the poster [56–60] and in Figures 19 and 20.

Along with crinoids and blastoids, other echinoderms such as starfish and BRITTLE STARS [61] thrived during the Mississippian Period. Some fossils of starfish eating crinoids have been found. They probably also ate shelled animals such as clams (bivalves), much as starfish do today.

OTHER PALEOZOIC AQUATIC LIFE

The previous section dealt mainly with bottom-dwelling sea creatures and some creatures that lived near the bottom. During the Paleozoic many free-swimming animals that were not restricted to the ocean floor developed.

One of these creatures was the CONODONT [62]. For many years scientists thought that conodonts might be fossil worm jaws, but recent fossil finds suggest that the conodont fossils are probably the remains of ancient soft-bodied organisms that lived in the ocean. They are first noted in the Precambrian, and became extinct during the Triassic Period of the Mesozoic Era. Because they evolved very rapidly and were widespread, conodont fossils are one of the major "index" or "guide" fossils. Index fossils are used to determine how old certain rocks are and to correlate rocks between different areas. Conodonts are also important because, like the lancelets [10], they may have been ancestors of the vertebrates (animals with backbones).

Index fossils are fossils that are widespread and confined to a certain interval of strata. In Figure 21, index fossils are used to correlate the strata between three different areas from oldest (1) to youngest (14). Note that not all of the fossils are index fossils. Also note that no one column has all the units. This is because the units were eroded or not deposited. For example, most of the Cretaceous-age rocks are missing from Kentucky.

Another floating and swimming creature used as an index fossil for Paleozoic rocks is the GRAPTOLITE [63]. Graptolites developed in the Cambrian Period, became widespread during the Ordovician, and were extinct by the Mississippian. When they died they sank to the bottom, were buried, and became fossils.

Another interesting sea creature was EURYPTERUS [64] or the "sea scorpion." Eurypterus was a type of arthropod that lived in Silurian lakes, not seas. Most were small, but some were as much as 9 feet in length. They had claws, much like modern crabs and scorpions, and they may have lived much as crabs do today. Some scientists believe that scorpion-like animals that descended from the eurypterids may have been the first animals to inhabit the land.

Vertebrates [66-70]

Vertebrates include all animals with a backbone. The first vertebrates probably originated during the Cambrian and were derived from primitive animals such as lancelets [10] or conodonts [62] that apparently had vertebral-like cords down their backs. These predecessors are thought to have developed into fish, the first commonly recognized vertebrate animals. Some of the first fish were small and lacked jaws. The Silurian fish PTERASPIS [65] and CEPHALASPIS [66] are examples of these primitive jawless fish. Jawless fish were superceded by fish with jaws. Some of the first jawed fish were called placoderms. PTERICHTHYODES [66] is an example of a placoderm. Like many of the jawless fish before them, placoderms were covered with thick, bony plates and scales to protect them from larger predators.

In the Devonian seas the first sharks developed. Sharks such as CLADOSELACHE [68] are an important group of fish because they developed cartilage, rather than bone skeletons. Because sharks do not have bony skeltons, the only hard parts usually preserved are teeth and thin dorsal spines (Fig. 22). But Cladoselache fossils with soft-body preservation have been found in the Cleveland Shale of Ohio. Preservation in these fossils is so good that scientists can see what the sharks' last meals were!

As much as most fish would have feared the sharks, the sharks probably feared DUNKLEOSTEUS [69] (Fig. 18). These fish had incredible armored heads and a skull structure that allowed the mouth to open very wide. They grew to lengths of nearly 30 feet and were undoubtedly the largest predators of the Devonian seas.

Adaptive innovations in fish continued in the Silurian and Devonian with the development of the first bony skeletons. Fish with bony skeletons are the most abundant group of fish today, but prior to the Silurian and Devonian they did not exist. Bone skeletons were an important step in the progression of life since a bony-support mechanism was needed for vertebrates to make the move to land. OSTEOLEPIS' [70] bone structure is very similar to that of fish that developed the capability to crawl out of the water and led the progression of life onto the land.

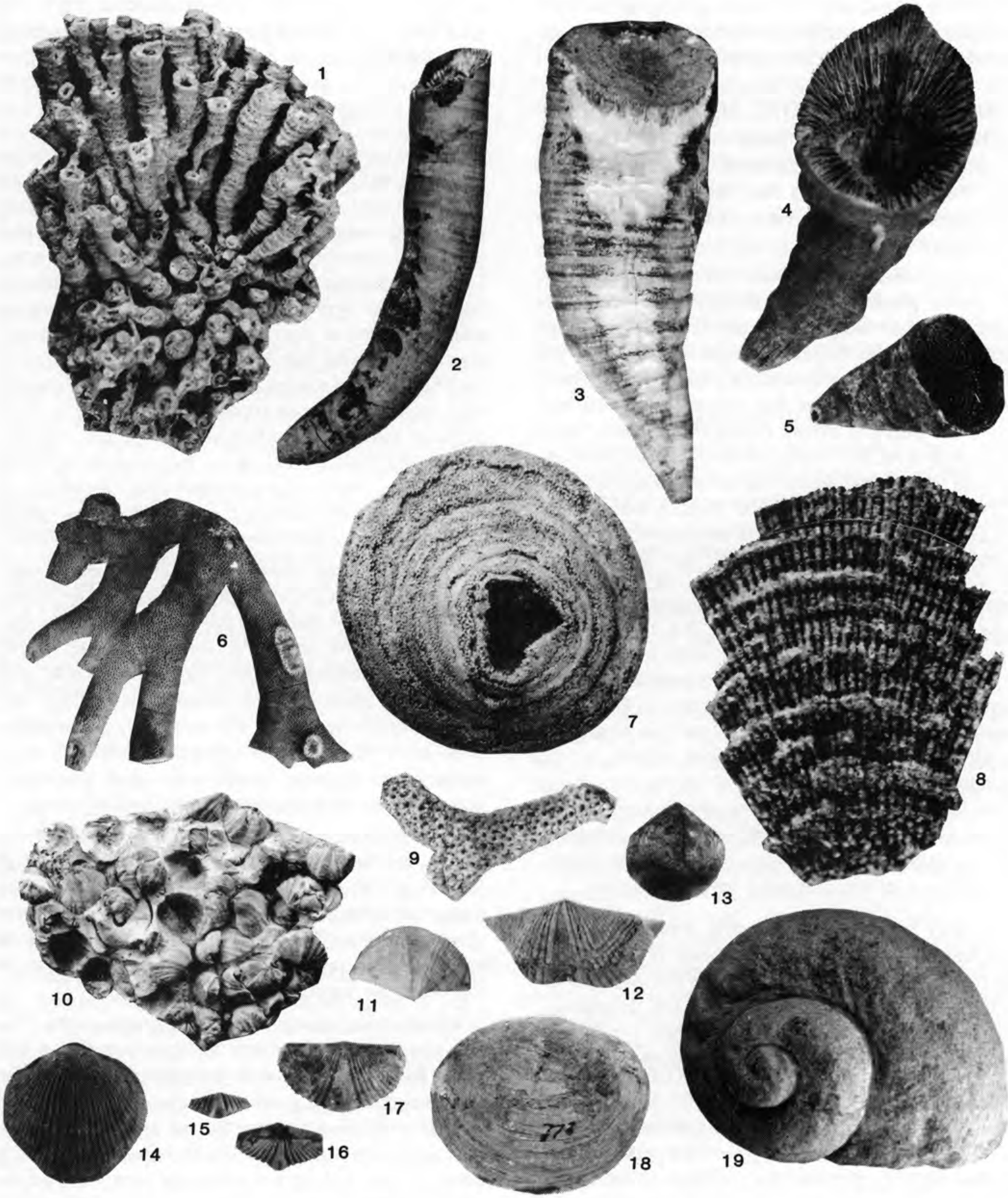

Figure 17. Devonian marine fossils. Fossils pictured are: (1–9) corals, (10–17) brachiopods, (18) bivalve, (19) gastropod. Most fossils are from the Falls of the Ohio near Louisville, Kentucky. See Appendix 1 for names and locations of fossils.

Figure 18. Reconstruction of a Devonian sea. A young Dunkleosteus *chases other primitive fish above a coral reef. The progression of fish is discussed in the section on vertebrates.*

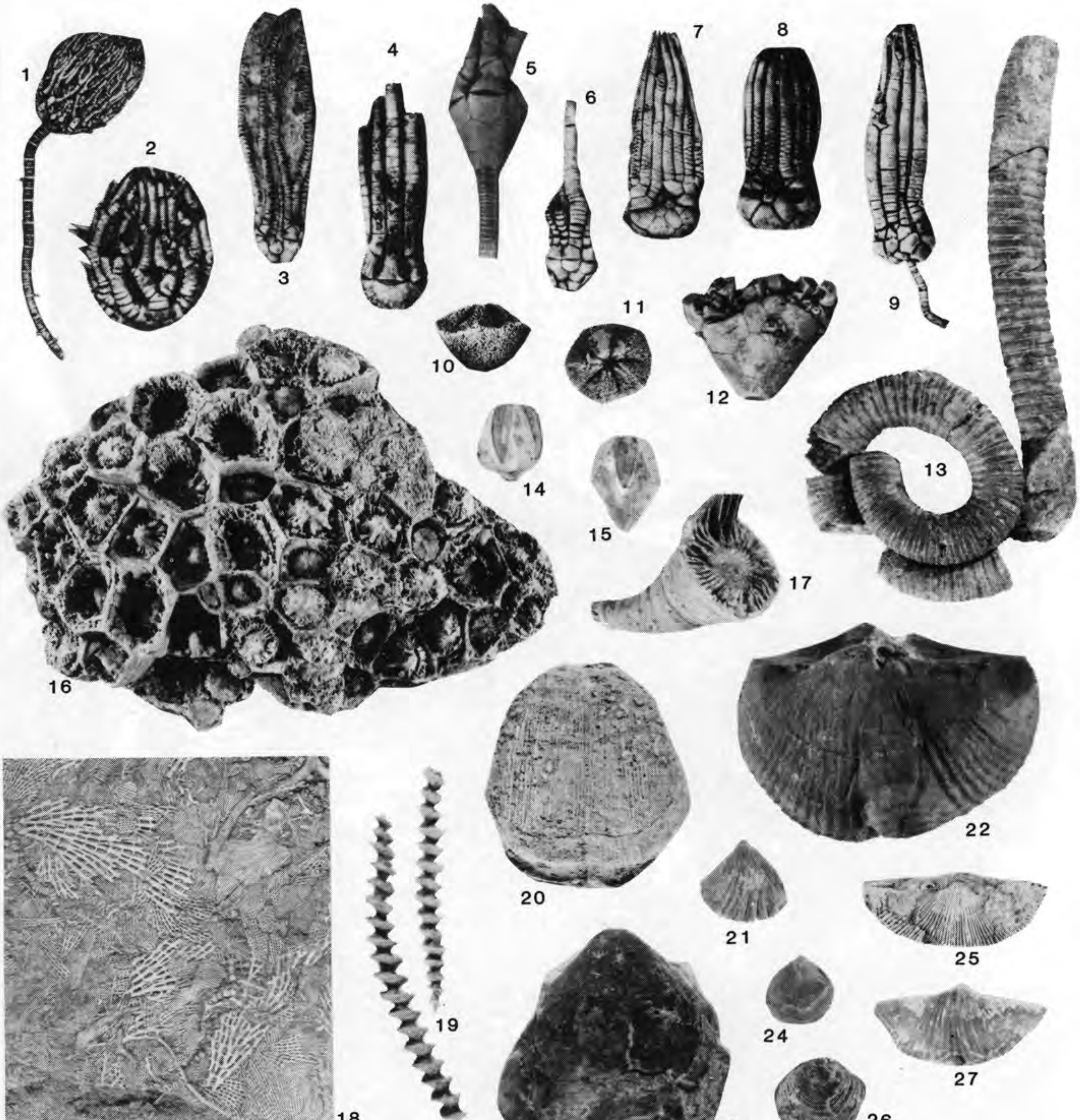

Figure 19. Mississippian marine fossils. Fossils shown are: (1–13) crinoids, (14–15) blastoids (both crinoids and blastoids are types of echinoderms), (16–17) corals, (18–19) bryozoans, (20–27) brachiopods. See Appendix 1 for names and locations of fossils.

Figure 20. Reconstruction of a Mississippian sea floor. Note the small blastoids and fan–shaped bryozoans at the bottom, the taller crinoids, and the spiralling bryozoans in the background. Also note the starfish eating the crinoid in the center of the figure.

PALEOZOIC TERRESTRIAL LIFE

Up to this point the discussion in this text has concentrated on the progression of life in the vast oceans that covered the earth during the Paleozoic. But during the Paleozoic the first life also came onto land. Some scientists believe that the first life forms to conquer the land were primitive plants; others

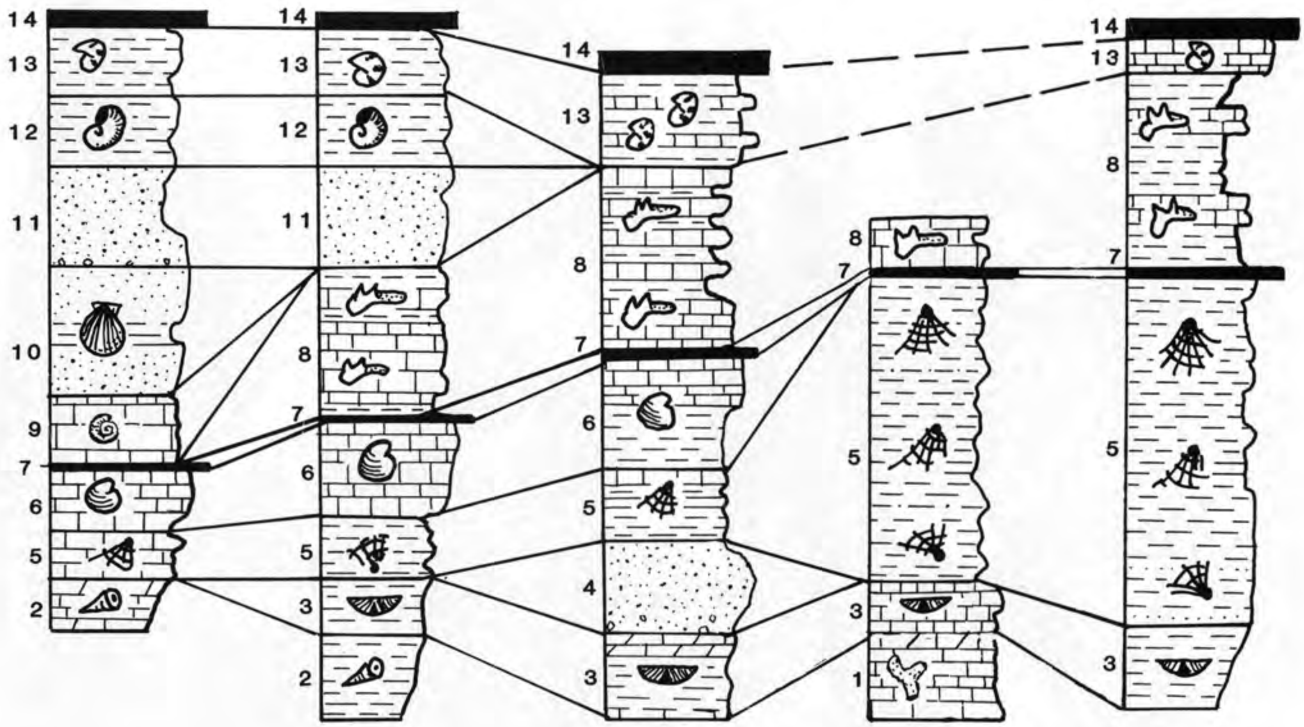

Figure 21. Correlating rocks. Units are correlated from oldest (1) to youngest (14). Some rocks (black) can be dated by the elements within them. More often, the relative age of rock units is determined by index fossils. Note: no one area has a complete record.

Figure 22. Shark fossils from the Paleozoic of Kentucky. (1–4) teeth, (5) dorsal spine. See Appendix 1 for names and locations.

think that worms or maybe arthropods, such as scorpions and crabs, were the first life on land.

Vertebrates [71–76]

The first true vertebrates were the fish. From the fish the entire progression or evolution of vertebrates can be traced (Fig. 23).

EUSTHENOPTERM [71] was a primitive lobe-finned fish (Fig. 24). In many ways it resembled *Osteolepis* [70], but *Eusthenopterm* developed strong bony fins and air pouches like lungs that allowed it to live on land for short periods of time. Lobe-finned fish still exist today. They spend most of their time in the water, but if the lake or pond they live in dries

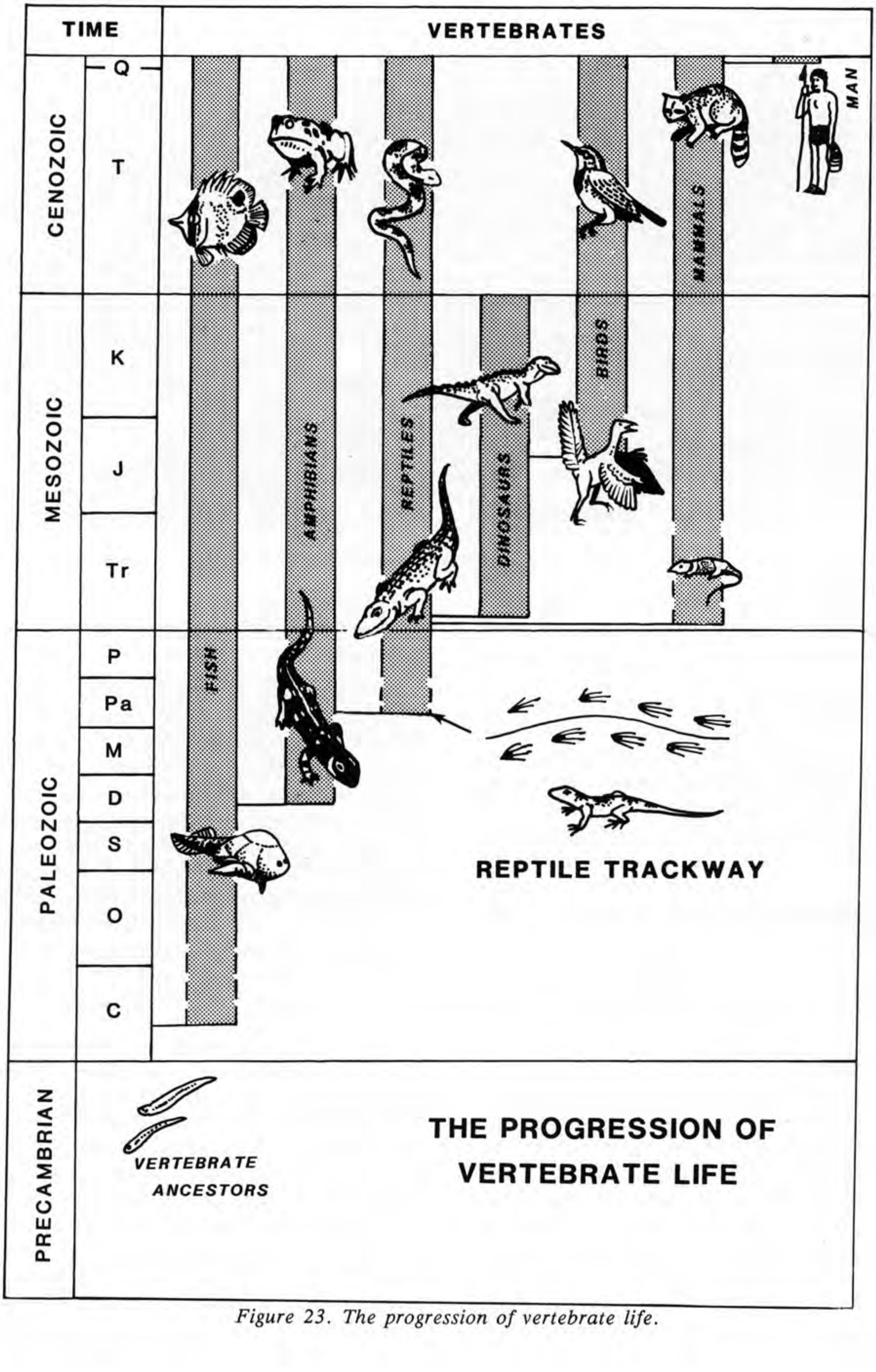

Figure 23. The progression of vertebrate life.

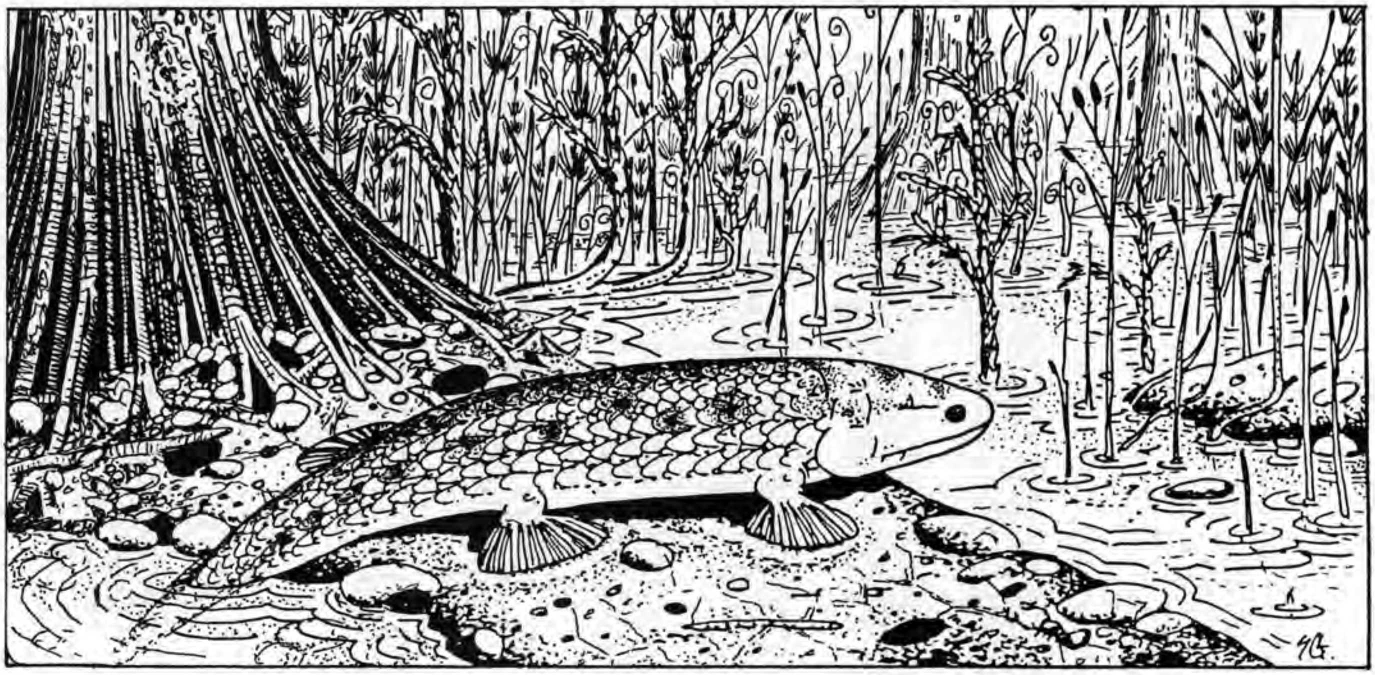

Figure 24. Reconstruction of a Devonian landscape. The lobe-finned fish, Eusthenopterm, *walks on land among early vascular plants.*

up, they can crawl several miles across land until they find a new pond.

A close relative of the lobe-finned fish was ICHTHYOSTEGA [72]. It progressed from its cousin by developing true legs and feet for better transportation on land. It is one of the first known amphibians. Modern amphibians include salamanders, frogs, and toads. Like fish, amphibians must lay their eggs in the water, but like reptiles, they can walk and breath on land. Scientists believe that amphibians prospered during the Devonian Period because at that time they had no other competition on land.

After a time, creatures that did not have to go back to the water developed from amphibians; these were the reptiles. HYLONONOMUS [73] is one of the first known reptiles. It was very lizard-like in appearance, and was distinguished from its amphibian ancestors by a skeleton developed completely for walking on land, a thick skin that would not dry out away from water, and the ability to lay shelled eggs on land instead of having to return to the water. Skeletons of these early reptiles have been found in Pennsylvanian rocks of Kansas and Nova Scotia, Canada. However, the earliest evidence of possible reptilian life was found right here in Kentucky. A set of possible reptile tracks and a tail groove were found in the Early Pennsylvanian rocks of McCreary County (Fig. 25).

What were the animals like that developed between the amphibians and reptiles? SEYMOURIA [74] is a good example of one of these evolutionary transitional animals. Fossils indicate that it had both reptilian and amphibian characteristics. It is important to understand that *Seymouria* represents just one example of a possible link between amphibians and reptiles. Other animals that show these characteristics also occurred earlier and later in geologic time. Since the first reptiles are known from the Pennsylvanian Period, the true ancestor to reptiles was not the Permian *Seymouria*, but an animal much like it that lived before the first reptile.

Once reptiles developed, they began to dominate the land. LIMNOSCELIS [75] was a medium-size reptile that lived during the Permian Period. A larger Permian reptile was DIMETRODON [76], which means "two sizes of teeth." *Dimetrodon* had very specialized, sharp teeth for tearing and chewing meat. *Dimetrodon* is part of a group of fin-backed reptiles called pelycosaurs that appear to have been the dominant carnivores (meat eaters) of the Permian. The most striking feature of *Dimetrodon* was the tall sail or fin on its back. There have been many theories about these fins, but scientists now believe

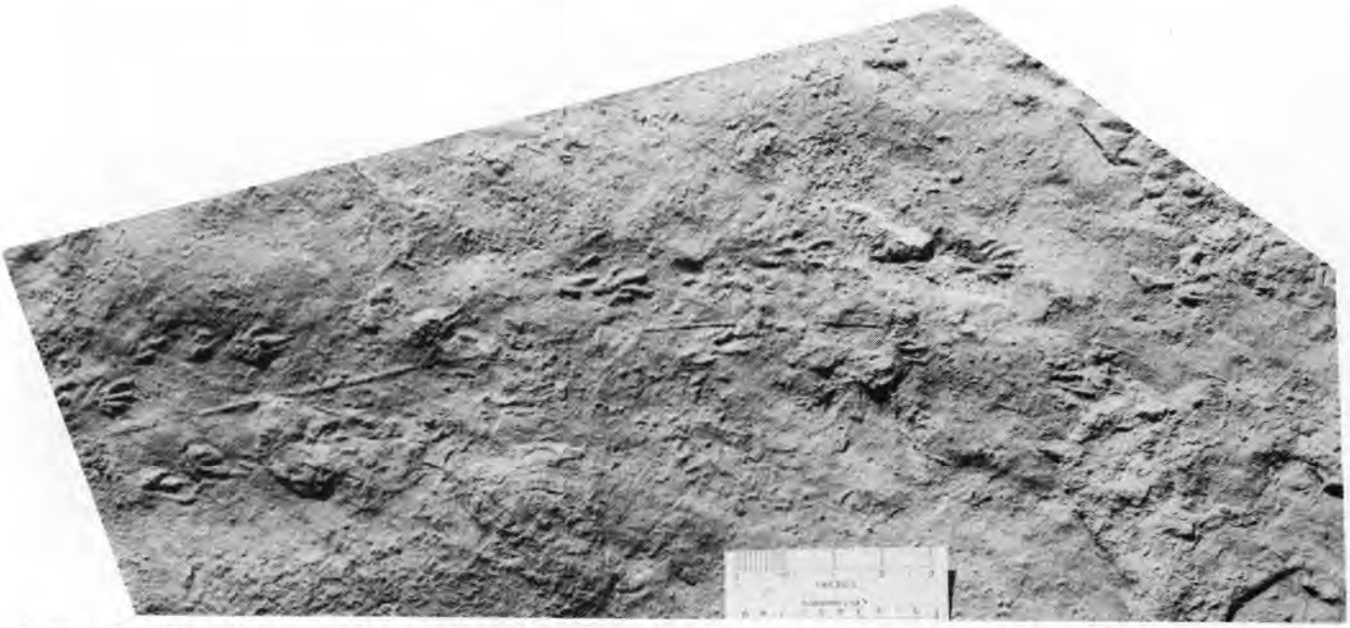

Figure 25. The oldest evidence of reptiles, found in Pennsylvanian-age Rockcastle Sandstone, McCreary County, Kentucky. On display at the Department of Geological Sciences Museum, University of Kentucky, Lexington.

that they acted like radiators or solar panels to warm up these reptiles by absorbing sunlight. This ability is important because reptile and amphibian blood is the same temperature as the surrounding air. If it is cold they have no energy, but if they can heat up their bodies they can remain active. This is why reptiles sun themselves in the morning.

Early Plants [77–79]

The Silurian-age COOKSONIA AND STEGANOTHECA [77] are the first known vascular land plants. They were very moss-like, and had adapted special tissue that allowed them to live out of water. RHYNIA [78] and ASTEROXYLON [79] are two other ancestors of vascular plants that developed in Early Devonian swamps. Vascular plants have tissue for conducting water and nutrients. These first ancestors were very moss-like, but later they would develop into large bushes and trees as the plants adapted to living farther and farther away from the water. Vascular plants are important because roots from these plants help create soil and hold the soil together. Before plants colonized the land 420 million years ago, there was little to hold the soil together, and land rapidly eroded away. Also, the colonization of land by plants created an abundant food source that may have helped tempt the first animals out of the water.

Devonian Period Forests [80–83]

Several localities of Devonian plant fossils show that as plants left the water and moved farther inland, great forests developed. Ground plants and ancient reeds such as HYENIA [80] flourished in the undergrowth, along with some of the first ferns, such as RHACOPHYTON [83]. EOSPERMATOPTERIS [81] is an example of a fern-like tree that grew to heights of nearly 40 feet. Some of the largest trees, such as ARCHAEOPTERIS [82], were nearly 60 feet tall.

Pennsylvanian Period Swamps [84–94]

Plants continued to diversify and evolve throughout the Mississippian Period, but in the Pennsylvanian the climate changed and vast swamps spread across much of the world (Figs. 26–27). The swamp plants were buried, and after burial, heat and pressure transformed the decaying plant material into the coal we see today in Kentucky and the eastern United States.

These swamp lands were also perfect for the diversification of animals. Fossil finds in the Mazon Creek area of Illinois are another example of rare, delicate parts of animals being preserved. From these fossils, scientists know that besides a great variety of plants, insects (including cockroaches and dragonflies), worms, centipedes, MILLIPEDES [84],

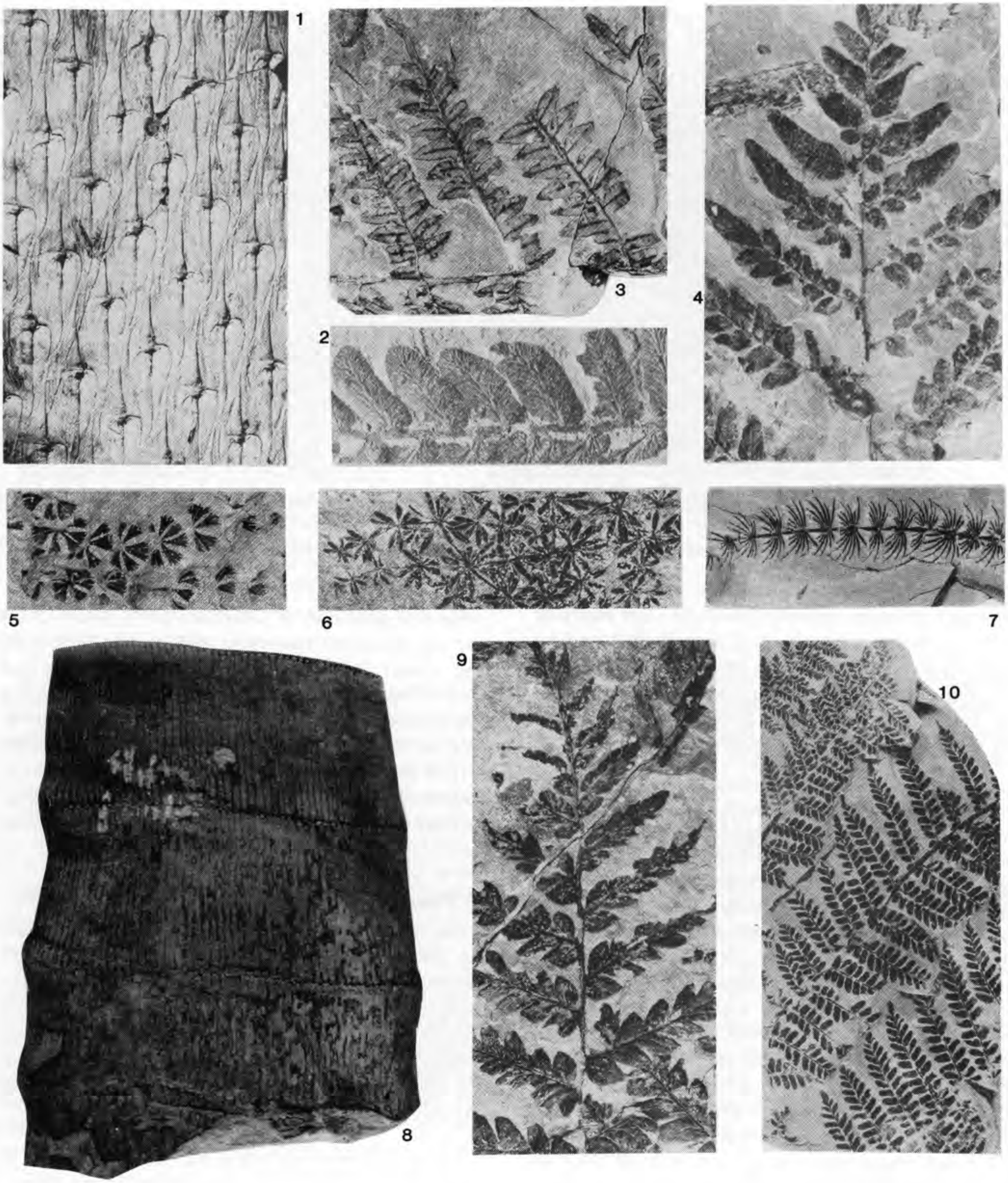

Figure 26. Pennsylvanian plant fossils from Kentucky. See Appendix 1 for names and locations.

Figure 27. Reconstruction of a Pennsylvanian swamp. An early reptile walks among trees, ferns, and reeds.

spiders, SCORPIONS [85], amphibians, jellyfish, snails, clams, fish, and many other creatures lived in the ancient coal swamps. Insects such as HOMALONEURA [87] are known from many areas, and fossil cockroaches up to 6 inches in length have been found in the rocks of 300-million-year-old swamps!

Many kinds of plants existed in the ancient coal swamps (Fig. 27). Reeds or rushes called CALAMITES [88] flourished along the wet banks of streams and swamps. Ferns such as NEUROPTERIS [89] spread throughout the lowlands, dominating the undergrowth of the swamps. Tree ferns such as MEDULLOSA [90] and PSARONIUS [91] thrived in the ancient wetlands, and tall trees such as LEPIDODENDRON [90] grew to be more than 160 feet tall. Immature LEPIDODENDRON trees [94] were probably very pole-like, and branching crowns were only developed during the later adult stages of their lives. During their younger stages, they may have looked like SIGILLARIA [91], another tree that grew in the swamps and had bundles of grass-like leaves instead of long branches.

MESOZOIC LIFE: "THE AGE OF THE DINOSAURS"

The end of the Paleozoic Era was marked by the greatest extinction of all time. Animals such as trilobites that had survived several smaller extinctions were wiped out during this event. This extinction may have been caused by a great collision of many of the smaller continents into one super continent that stretched from pole to pole, called "Pangea." When all the continents collided, the shallow seas were drained and uplifted into giant mountain ranges, killing off most marine life. The destruction of shallow seas and the creation of one huge land mass also changed the climate, causing the extinction of most plants and land animals. By the end of the Permian, more than 90 percent of all animal and plant life had been wiped out. With this great extinction, the Paleozoic Era ended. As the Mesozoic Era began, reptiles proved to be the group of animals best adapted to life on land, and radiated across the new world. One group of reptiles that is of special interest is the dinosaurs. Dinosaurs became so widespread and diverse during the Mesozoic Era that it is called "The Age of the Dinosaurs."

Triassic Period [95–97, 99–101]

During the Early Triassic, a group of transitional reptiles called thecodonts appeared (Fig. 28). Some were broad and low-lying like crocodiles, while others were thin and stood on two legs, such as HESPEROSUCHUS [95]. Most were no larger than a dog. But from these small thecodonts all dinosaurs developed. Dinosaurs split into two orders. The Saurischia or "lizard-hipped" dinosaurs include sauropods such as APATOSAURUS [102] and the meat-eating carnosaurs such as TYRANNOSAURUS [121] (Fig. 28). The Ornithischia or "bird-hipped" dinosaurs include most other dinosaurs, such as STEGOSAURUS [106], TRICERATOPS [112], and ANKYLOSAURUS [111] (Fig. 28).

Some of the earliest dinosaurs were small and looked much like their thecodont ancestors. COELOPHYSIS [96] means "hollow structure," and it was named for its light bone structure. With its light bones and long, clawed fingers, it was well adapted for chasing down and grasping slower prey.

Another meat-eating dinosaur of the Triassic was DILOPHOSAURUS [97]. Unlike *Coelophysis*, which

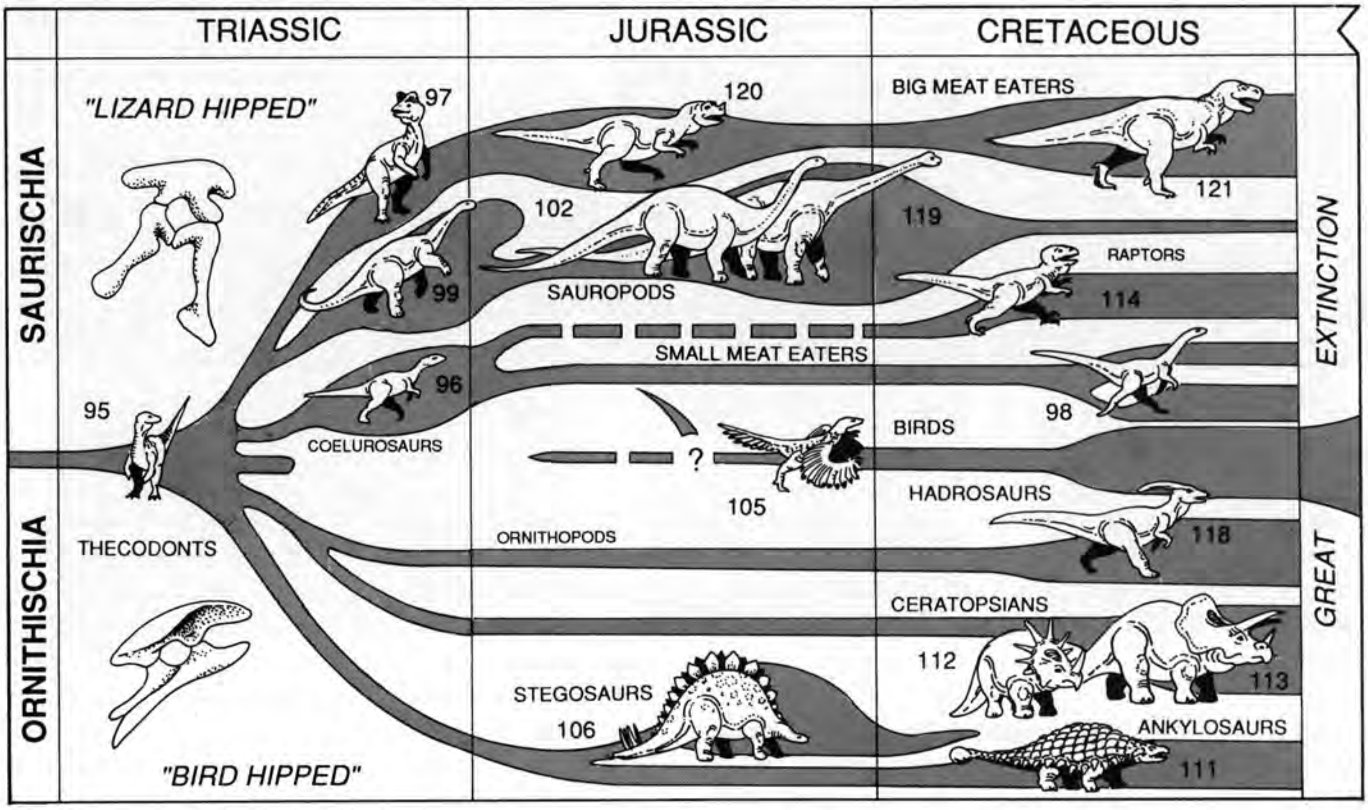

Figure 28. Evolution of the dinosaurs. Birds may be descendants of the dinosaurs.

was still only the size of a large dog, *Dilophosaurus* grew to 20 feet or more in length, making it the first of the large carnosaurs (meat-eating dinosaurs). *Dilophosaurus* means "two-crested reptile," and it was named for the two curious ridges of bone on its skull.

Although *Dilophosaurus* was the first large meat-eating dinosaur, the first large dinosaur was PLATEOSAURUS [99]. *Plateosaurus* was a plant eater that grew to lengths of 25 feet. It was the ancestor of the giant sauropod dinosaurs. With its long neck, *Plateosaurus* could feed on the leaves of palm-like cycad trees such as WILLIAMSONIA [100] and BJUVIA [101]. The first cycad plants developed in the Triassic Period and quickly became one of the dominant and most widespread plants of the Mesozoic Era.

Jurassic Period [102–106, 110–119, 120]

During the Jurassic Period the largest, and for many, the most familiar dinosaurs developed. APATOSAURUS [102], or *Brontosaurus*, as it was once called, is a well-known example of the sauropods or "thunder lizards." Sauropod dinosaurs are the largest land animals that have ever lived (Fig. 29). For example, a full-grown elephant weighs 7 or 8 tons, but the largest sauropod may have weighed over 130 tons! It was once believed that the sauropods must have lived in water to support their enormous weight, but recent evidence indicates that they probably lived far away from the sea and used their long necks to feed on the leaves of tall trees, like modern giraffes. In fact, if they lived in water, the lungs of large sauropods might have been crushed by the water pressure!

BRACHIOSAURUS [119] is an example of the largest types of sauropods. Three recent fossil discoveries from this group of dinosaurs have indicated how large some of these animals were. *Supersaurus* is the name of a brachiosaur that was 82 feet long and 54 feet tall (as high as a four-story building). Bones from *Ultrasaurus* indicate a dinosaur 100 feet long, weighing approximately 130 tons. Between 1980 and 1985 a partial brachiosaur skeleton consisting of a thigh bone, hind leg, and tail section was unearthed in New Mexico. The new brachiosaur, called *Seismosaurus*, or "earth-shaking reptile," is estimated to have weighed 100 tons and had a length of 120 feet! FOSSIL TRACKWAYS [104], or footprints, indicate that sauropods lived in large HERDS [103], as elephants do today. Modern elephants live in herds in which older adults protect the

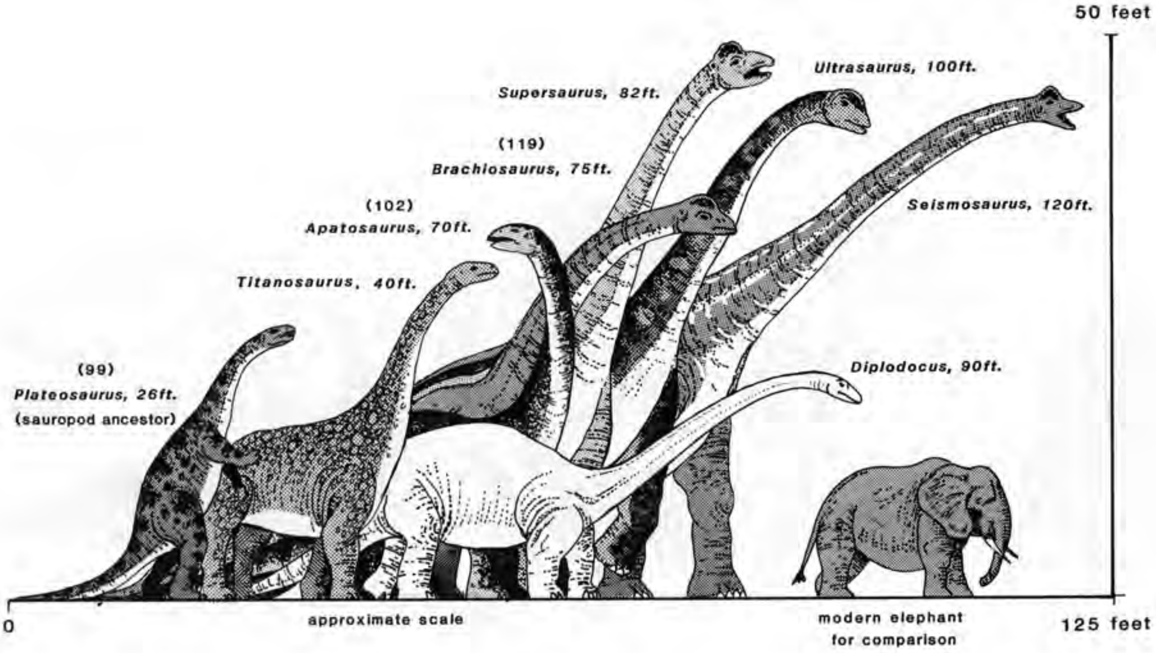

Figure 29. Just how big were sauropod dinosaurs?

young. Perhaps the sauropods also lived in herds to protect their young from the fearsome predators of the Jurassic.

One of the largest meat-eaters that probably would have hunted young sauropods was CERATOSAURUS [120]. *Ceratosaurus* had a large skull, a nose horn, and a sharp set of cutting and stabbing teeth. Except for the horn, it was similar to its larger cousin, *Allosaurus*. *Ceratosaurus* grew to be about 20 feet long. *Allosaurus* grew to over 40 feet in length. These meat eaters were the dominant predators of the Jurassic Period.

Some dinosaurs that did not travel in herds had to develop their own types of protection. STEGOSAURUS [106], or "roof reptile" grew to be 25 feet long, and got its name from the double row of bony plates or spikes along its back. These plates may have been used as defensive protection, or used to heat *Stegosaurus'* blood, in the same way that the large fin was used to transfer heat in *Dimetrodon* [76]. The fearsome set of 3- to 5-foot-long spikes on the end of *Stegosaurus'* tail was its major defensive weapon. It needed a weapon too, because *Stegosaurus* had a brain the size of a peanut and might not have known it was being attacked until it was too late!

Reptiles were truly progressing in the Jurassic (Fig. 30). They were large and small, fast and slow, plant eating and meat eating, some with weapons for attacking, and others with weapons for defending. But the most incredible progress was that reptiles were not only in the land but were spreading through the air and the seas as well.

The first reptile to conquer the air was ARCHAEOPTERYX [105]. It was a transitional animal that had the skeleton and teeth of a small dinosaur, but the skull and featers of a bird. In fact, *Archaeopteryx* is considered to be the first bird, and scientists believe that its feathers were simply the adaptation of long scales for flying. These first birds could only glide, but by the end of the Mesozoic many birds could truly fly.

While some reptiles were conquering the air to become birds, others were returning to the water. ICHTHYOSAURUS [110], or "fish lizard," was a reptile that looked very much like a modern-day dolphin and was well adapted for life in the water. Well-preserved fossils from Germany, like the one pictured in the poster, indicate that ichthyosaurs gave birth to their young live and ate fish and cephalopods (squids).

Cretaceous Period
[98, 107–109, 111–118, 121–122]

In the air, birds were becoming more numerous, and gliding reptiles called pteradactyls had developed. In the seas, large fearsome marine reptiles continued to prosper. TYLOSAURUS [107] was the largest of a group called the mososaurs. It grew to lengths in excess of 20 feet, and had massive jaws with large teeth. In fact, mososaur teeth marks on the fossilized shells of giant sea turtles indicate that they were not afraid to attack an animal over 10 feet in length. ELASMOSAURUS [108] is an example of another group of Cretaceous marine reptiles called the plesiosaurs. With the aid of its long neck, *Elasmosaurus* could have preyed quite effectively on fish

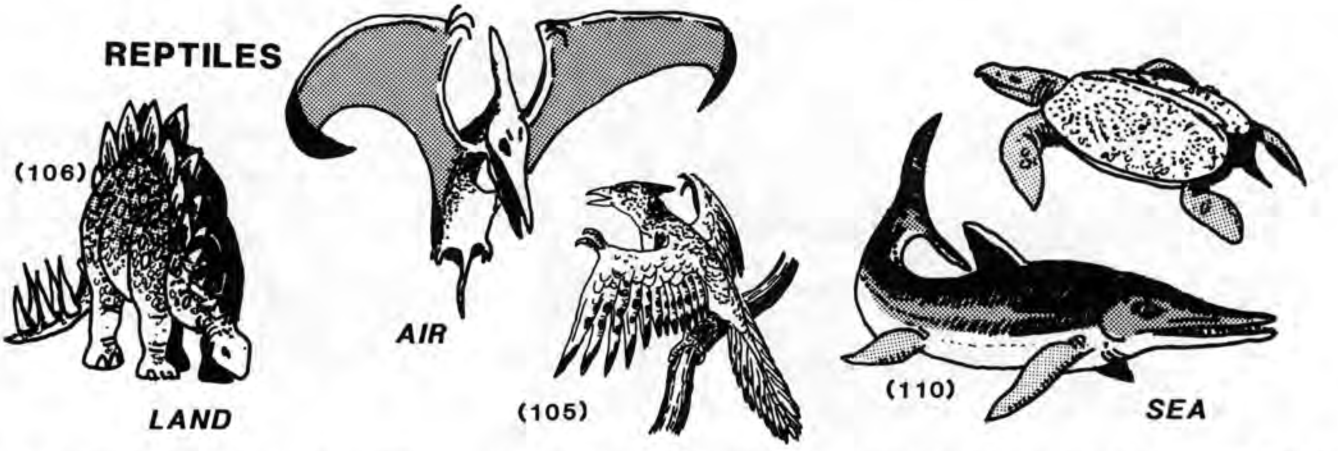

Figure 30. Reptiles radiated to many environments in the Mesozoic. Dinosaurs ruled the land; ancestors of birds and flying reptiles like Pteranodon *ruled the air; and giant reptiles swam through the seas.*

and squids. It is shown in the poster chasing a school of squids called BACCULITES [109]. Plesiosaurs are thought to have become extinct by the end of the Mesozoic, although the fabled Loch Ness Monster of Scotland is supposed to be a sea monster that, according to legend, looks like a plesiosaur.

On land, many of the large Jurassic dinosaurs such as the stegosaurs had become extinct by the Cretaceous, but new dinosaurs had developed to take their places. STRUTHIOMIMUS [98] belongs to a group of dinosaurs called ornithomimosaurs, or "bird-mimic dinosaurs," that were very common in the Cretaceous. These dinosaurs were small, fast-running animals that were toothless and may have had beaks like birds.

Another prosperous group of plant-eating dinosaurs was the hadrosaurs, or "duck-billed reptiles" (Fig. 31). Hadrosaurs were as much as 40 feet in length, and besides their duck-like mouths adapted for eating water plants, their most striking feature was their head crests. PARASAUROLOPHUS [118] had a tubular crest that stretched up to 6 feet behind its head. Theories about the purposes of the crests include their use as an air-storage tank, sensory organs, salt glands, and as visual signs for mating.

While many large, plant-eating dinosaurs like the hadrosaurs relied on fleeing into the water for safety, others developed protective armor (Fig. 32). ANKLYOSAURUS [111], or "fused-together reptile," got its name from the many armor plates joined together on its back and head. Like the stegosaurs [106], ankylosaurs had a wide diversity of horns and platy armor, but unlike the stegosaurs, ankylosaurs were almost completely covered in armor. Some species even had bony eyelids! *Ankylosaurus* was 33 feet long and had a tail that ended in a large bony mass. This tail could probably be used as a club if any meat-eating dinosaur was foolish enough to attack.

TRICERATOPS [112], or "three-horned face," got its name from the three long horns on its head. *Triceratops* was 30 feet long and weighed nearly 6 tons! *Triceratops* is probably the most famous of the ceratopsid dinosaurs. This group of dinosaurs is characterized by a head shield, horns, and a beak-like mouth. Some of the shields were quite elaborate. STYRAKOSAURUS [113], or "spiked reptile," had a head shield with six horn-like spines. These horns were undoubtedly a good defense against any meat eaters, but they also may have been used to show dominance in a herd, or to attract mates, like the horns of deers and antelopes today. Both *Triceratops* and *Styrakosaurus* had large nose horns that could have been used as a defensive weapon like the horns on a charging rhinoceros today. A charging ceratopsid dinosaur would have scared off even the most determined of the meat-eating dinosaurs.

Not only were the Cretaceous meat eaters determined, but they had developed into some of the most fearsome killing machines the planet has ever known (Fig. 33). DEINONYCHUS [114] is the running

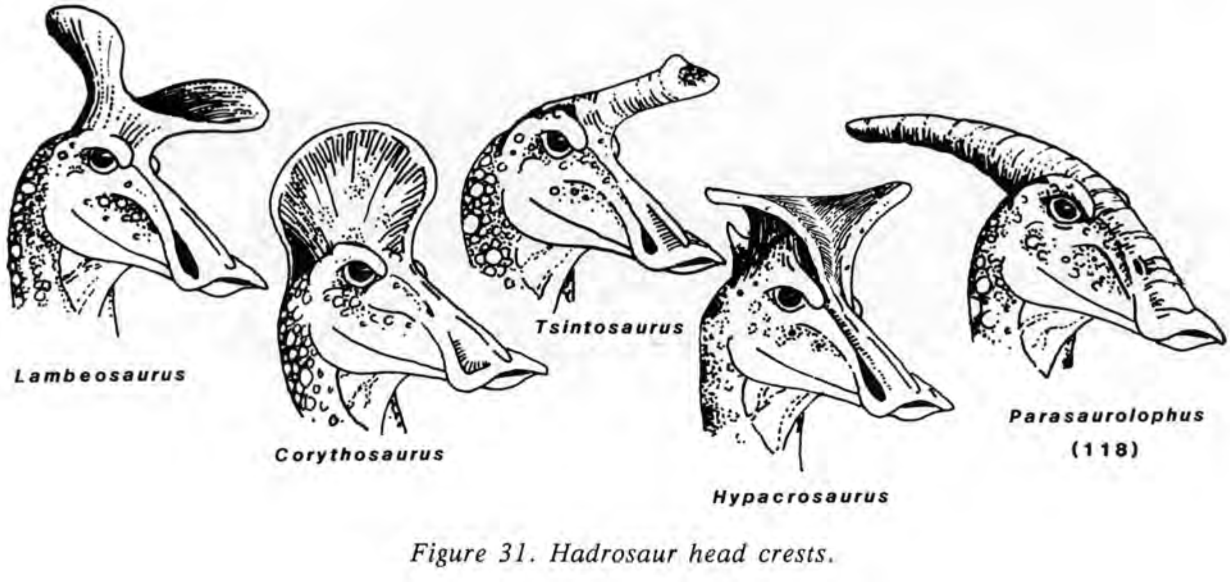

Figure 31. Hadrosaur head crests.

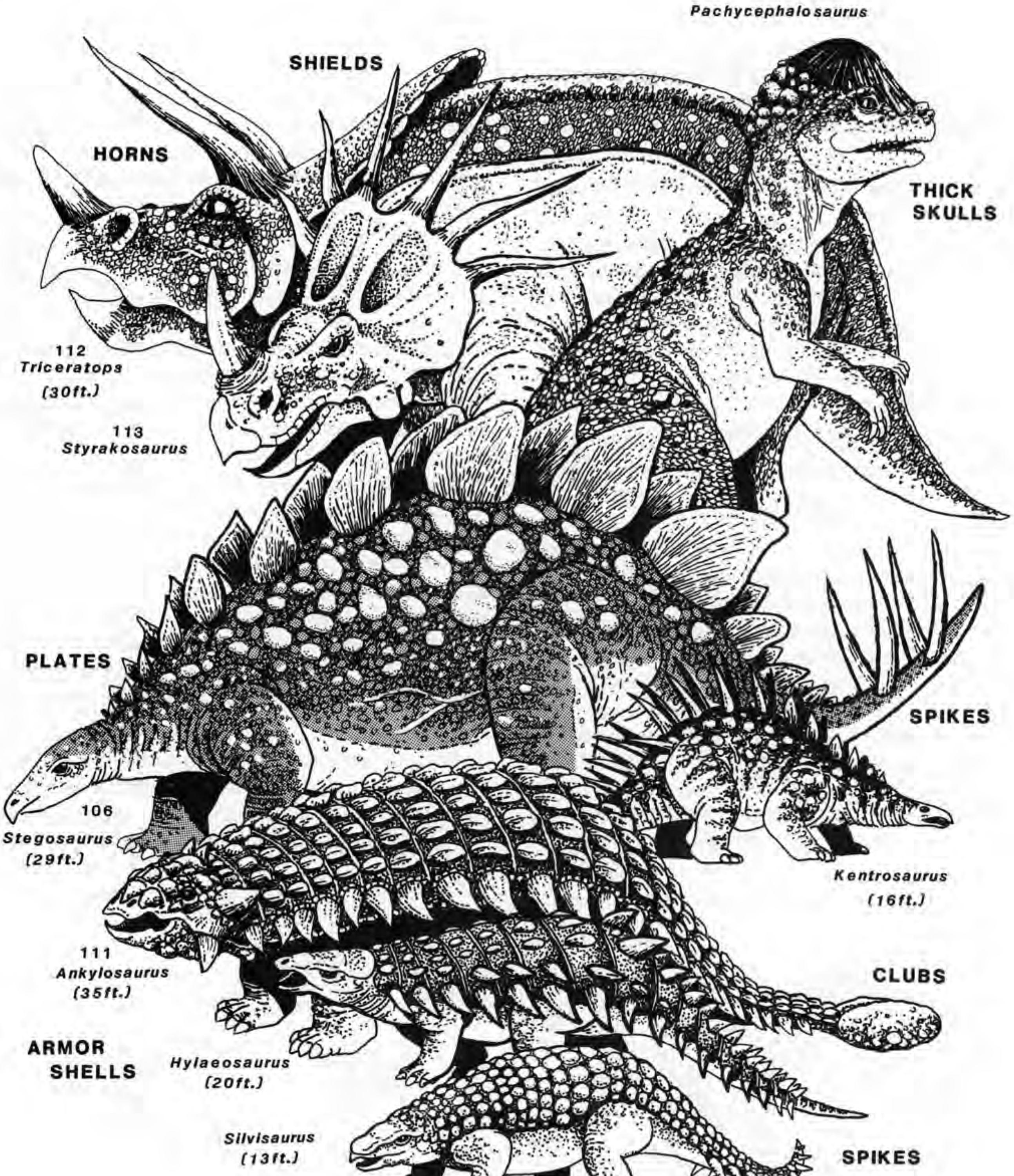

Figure 32. Defenses of the plant eaters.

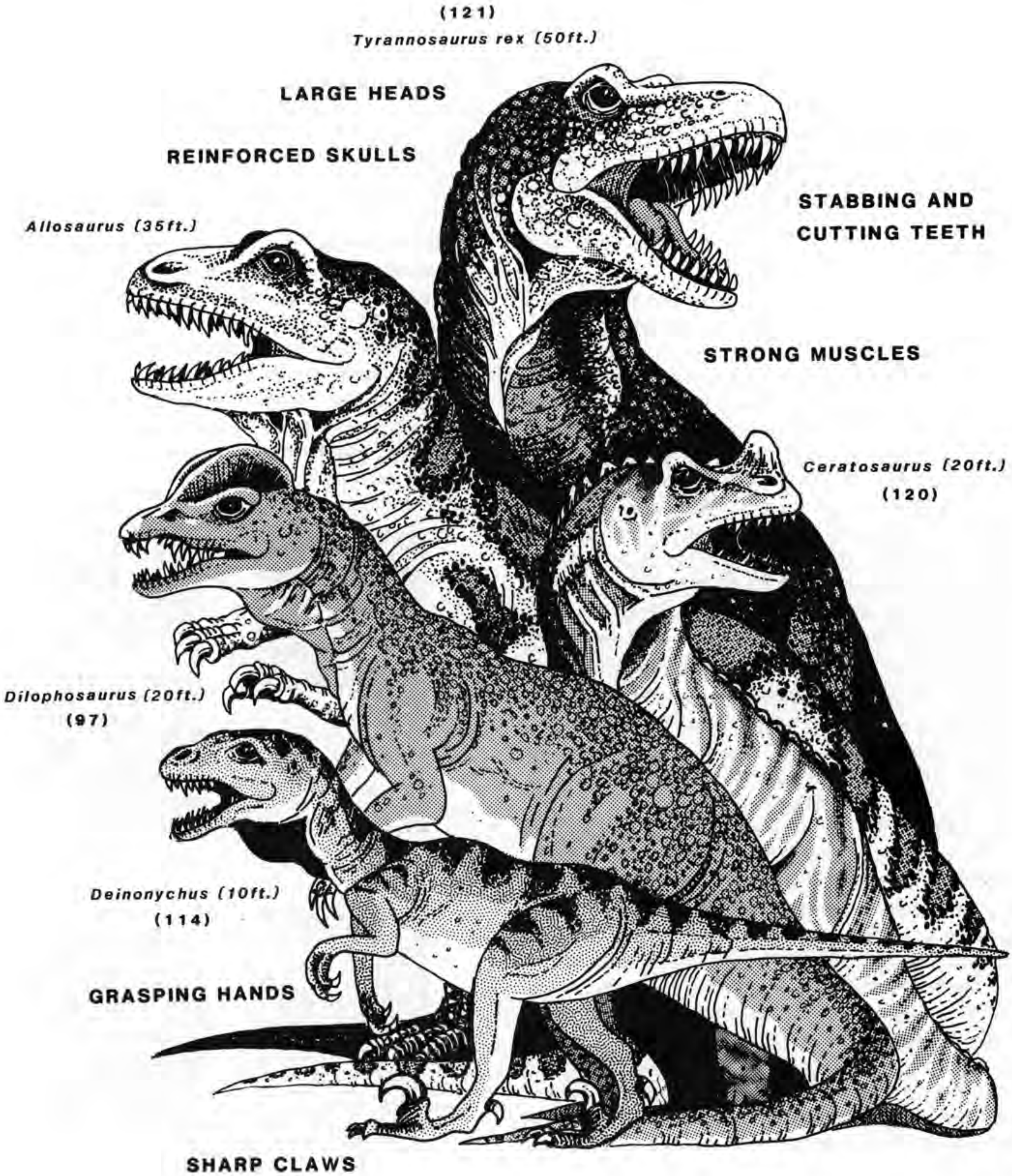

Figure 33. Weapons of the meat eaters.

dinosaur pictured alongside *Apatosaurus* [102]. This "running reptile," or dromaeosaur, was named for the "terrible claw" on its second toe. This sickle-shaped claw could be retracted like a cat's claw so that it did not interfere with running, or could be slashed downward when attacking and used like a sharp knife. Besides using its sharp claws and long, powerful arms, *Deinonychus* appears to have hunted in packs, like modern wolves, so that despite its small size (only 10 feet) it could hunt the largest plant eaters of the Cretaceous.

But even the "terrible claw" was not as feared as TYRANNOSAURUS REX [121], the "tyrant king." *Tyrannosaurus* grew to 46 feet in length, weighed 7 tons, and was the largest of the meat-eating dinosaurs. It had a massive skull with 6-inch, dagger-like teeth and a heavily reinforced neck that could be used to attack prey with the force of a small truck! We know that it could not have used its tiny arms as weapons, but they were probably useful in helping the huge carnosaur prop itself up off the ground. Many scientists think that although *Tyrannosaurus* could have killed most of the animals it lived with, it was too big to chase down its food as *Deinonychus* did, and may have spent most of its time as a scavenger, like today's king of the jungle, the lion.

While old dinosaurs were dying off and new dinosaurs were evolving, the plant world was undergoing a drastic change. One of the most important advances in the Mesozoic was the development of flowering plants or angiosperms. Flowers were an important adaptation in the plant world because now plants could be pollinated by insects and did not have to rely on the wind to spread their seeds. Today, angiosperms are the most abundant land plant, but prior to the Cretaceous they did not exist. Early flowers such as MAGNOLIA [115] are typical of the angiosperms. ANGIOSPERM TREES [116] like palms and oaks that still exist today are pictured behind the magnolia flowers.

Another group of plants that prospered during the Cretaceous and is still widespread today is the conifers. Conifers are trees with cones, such as the pines, redwoods, cypresses, and giant SEQUOIA [117] trees. Today only a few sequoia forests remain, but some trees in California's Sequoia National Park are so huge that tunnels were cut through the base of the trees so that a car could drive through!

At the end of the Cretaceous a great extinction wiped out all of the dinosaurs. Many people believe that only the dinosaurs became extinct, but in reality many creatures, including those that lived in the oceans such as the AMMONITES [122], became extinct. Thus, any theory that tries to explain the extinction of large, land-dwelling dinosaurs must explain the extinction of small, ocean-dwelling animals as well.

There are many explanations for the great extinction. Some believe that it was a slow process and the dinosaurs' time had simply run out. A more popular theory is that a giant comet or meteor collided with the earth and caused drastic changes in the earth's climate, to which the dinosaurs could not adjust (Fig. 34). These collisions may be part of a cycle of collisions that have occurred periodically throughout the history of the earth.

A comet or meteor... hits the earth...

creating a giant ash cloud... that changed the earth's climate.

Figure 34. Extinction of the dinosaurs.

CENOZOIC LIFE: "THE AGE OF MAMMALS"

During the Cenozoic Era, the large supercontinent that had been created at the beginning of the Mesozoic Era continued to split apart, and is continuing to split apart to this day. Just as the extinction at the end of the Paleozoic Era was followed by the adaptive radiation of reptiles, the extinction of the dinosaurs at the end of the Mesozoic Era left a large ecological vacancy on the drifting continents, which was filled by the mammals. Before the Cenozoic Era mammals were mainly small, rodent-like forms with little diversity. The first true mammals had developed earlier in the Triassic Period. But following the great extinction, mammals became widespread and continue to be widespread today. Mammals have advantages over reptiles in that they are warm-blooded and can regulate their own body temperature, their young are born alive and nurtured by their parents, and their brains are more highly developed.

Tertiary Period

Paleocene and Eocene Epochs [123–129, 132, 133, 144, 146]

In the beginning of the Tertiary Period, many small mammals whose ancestors had developed in the Mesozoic Era and continued to progress through the great extinction, such as the shrew-like PALAEORYCTES [123], the hedgehog-like DIACODON [124], the squirrel-like PTILODUS [128], and the ancestral rodent PARAMYS [125], flourished. Rodents, which include the squirrels, rats, and mice, quickly became one of the largest groups of mammals. Not all reptiles died off at the end of the Mesozoic. Many small reptiles such as lizards, snakes, and turtles like TRIONYX [126] survived and continue to this day.

PLESIADAPIS [127] was another squirrel-like animal that lived in the early Tertiary Period, but it was actually an ancestor of the primates. One of the first true primates was the lemur-like NOTHARCTUS [146]. Primates would take a little longer to develop than many of the other mammalian groups, but would ultimately include apes and man.

HYRACOTHERIUM [129], often called *Eohippus* or "dawn horse," was the first horse, although if you had seen it, you probably would not have guessed that it was a horse. First, *Hyracotherium* was only a foot tall. Second, it had three toes instead of a single hoof. But scientists have such a complete fossil record of the horse's ancestry that they can trace changes in the horse's size and hooves back to this Eocene ancestor.

Other mammals that lived in the plains and forests of the early Tertiary were PHENACODUS [132] and CORYPHODON [133]. *Coryphodon* is an ancestor of the modern-day hippopotamus and is believed to have spent much of its time in the water, as the hippos of Africa do.

These small- and medium-size plant-eaters probably did not fear other predatory mammals as much as they did the 6-foot, flightless predatory bird, DIATRYMA [144]. With its sharp beak and sharp talons, it was more than a match for most of the mammals of its time.

Oligocene and Miocene Epochs [131, 134, 136, 137, 140, 142, 145]

The most important event of the middle Tertiary was that GRASS [136] covered the land. Fossil grass seeds are known from as early as the Cretaceous Period, but grass did not become widespread until the Miocene. Grass is important because it binds the topsoil together to inhibit erosion, and because grasses such as oats, barley, wheat, and rice are the dominant food source for land-living mammals such as man. The variety of grazing mammals in the middle Tertiary is thought to have been a direct result of the availability of grass. An example of a grazing mammal is the deer-like SYNTHETOCERAS [140]. This primitive antelope had a large Y-shaped horn or antler on its nose, just as many of its modern cousins have a wide variety of horns and antlers.

Some grazers were quite large. BRONTOTHERIUM [134], often called *Brontops*, belongs to a group of grazing, horned mammals called the titanotheres (Fig. 35). Titanotheres were very common in the Oligocene and Miocene Epochs. They were large, four-legged, plant-eating mammals that possessed a varied assortment of horns on their heads. These horns may have been used for determining male dominance or as a defensive weapon, like the rhinoceros' horn.

Not all middle Tertiary mammals were grazers. DINOHYUS [137] was a large ancestor of the pigs or wild boars that probably ate roots and grubs, as pigs do today. Another root-eating animal was MOROPUS

Figure 35. Titanothere skulls.

[142]. These mammals were rather horse-like in appearance, but instead of hooves they had long claws. Since *Moropus* was a plant-eater, it probably used its claws to dig for roots, as a bear does.

While *Dinohyus* and *Moropus* were digging in the ground for roots, a distant cousin of the camels, AEPYCAMELUS [145], was using its long, giraffe-like neck to get to the leaves of tall trees that could not be reached by the shorter necked animals.

In the water, far away from the grassy plains, the progression of aquatic mammals was also continuing. Far back in the Mesozoic when some reptiles returned to the sea, a group of mammals also returned to the water. These mammals were the ancestors of the whales. The BLUE WHALE [131] is a type of baleen whale and is the largest animal on the planet today. Baleen whales developed in the Miocene and continue to the present.

Pliocene Epoch [130, 147]

During the Pliocene the progression of grazing animals continued. The large horse skull behind HYRACOTHERIUM [129] belongs to PLIOHIPPUS [130], the first modern horse. The three toes of its ancient ancestor had been reduced to a single toe or hoof for swifter running. *Pliohippus* also inherited specialized grinding teeth from its Miocene ancestors, *Protohippus* and *Merychippus*. These teeth were perfectly suited for eating grass. With specialized teeth and hooves, longer legs, larger size, and a larger brain, the horse became the perfect grass-grazing mammal (Fig. 36).

Besides the grazing mammals, the hunters were also progressing. During the late Pliocene a group of primates called AUSTRALOPITHECUS [147] developed the ability to make tools. Bones of this pre-human ape have been found at the famous Olduvai Gorge in Africa. This ape was small but walked up on its knuckles. It is thought to be an ancestor of man.

Quaternary Period

The Quaternary Period began 1.6 million years ago and continues today. During this period great ice sheets covered much of North America, and many cold-weather animals developed. Also, in the warmer climates of Africa, far south of the ice fields, the first humans appeared.

Pleistocene Epoch [135, 136, 141, 143, 147–149]

The Pleistocene Epoch is called the "Ice Age" because during this epoch at least four sheets of ice, each more than a mile thick, advanced from northern Canada to as far south as the Ohio River. The mammals that lived near these great ice sheets had to develop thick coats of fur to survive the arctic temperatures (Fig. 37). The WOOLY MAMMOTH [143] is one of the most famous ice-age mammals. It was the largest of the ancient elephants, and was characterized by huge, backward-curving tusks. Another group of ancient elephants that lived farther south of the great ice sheets was the mastodons. Mastodons were slightly smaller than mammoths, and their tusks did not curve backwards (Fig. 37). One of the largest finds of Pleistocene mammal bones, including mammoths, mastodons, giant bison, and horses, was in Kentucky at Big Bone Lick State Park. Fossils from Big Bone Lick were studied by such noted Early American scientists as Benjamin Franklin and Thomas Jefferson. The mammals at Big Bone Lick appear to have been buried by floodwaters from the great ice sheets to the north.

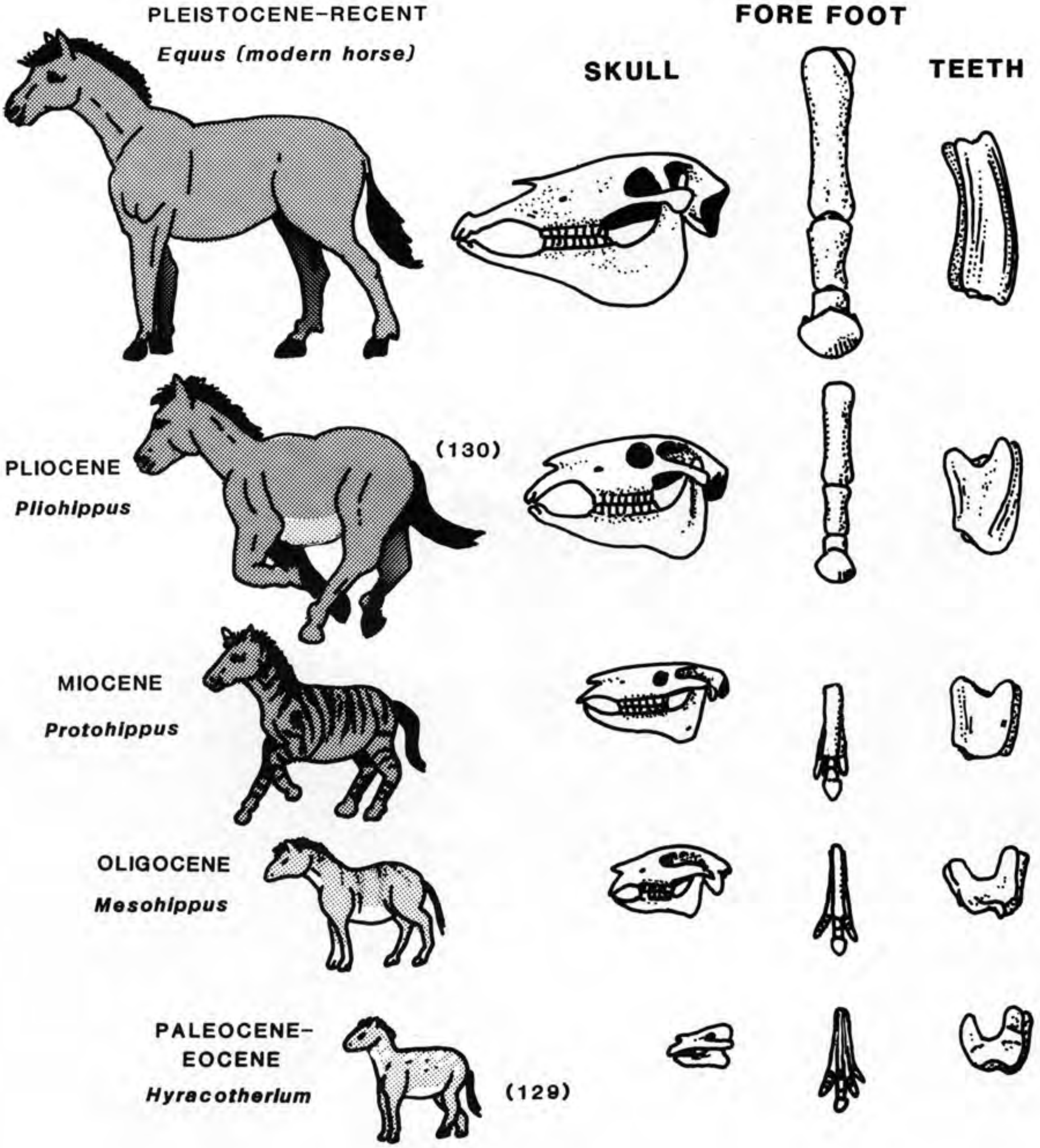

Figure 36. The ancestors of Kentucky horses.

Fossil mammal bones have also been found in other Pleistocene deposits in Kentucky. A herd of small pig-like animals called peccaries were found buried in thick glacial deposits called "loess" (Fig. 38). Loess is dust-sized sediment created by the great volume of rock pulverized and eroded by the mile-thick glaciers.

Another famous locality for Pleistocene mammal bones is the La Brea Tar Pits of Southern California.

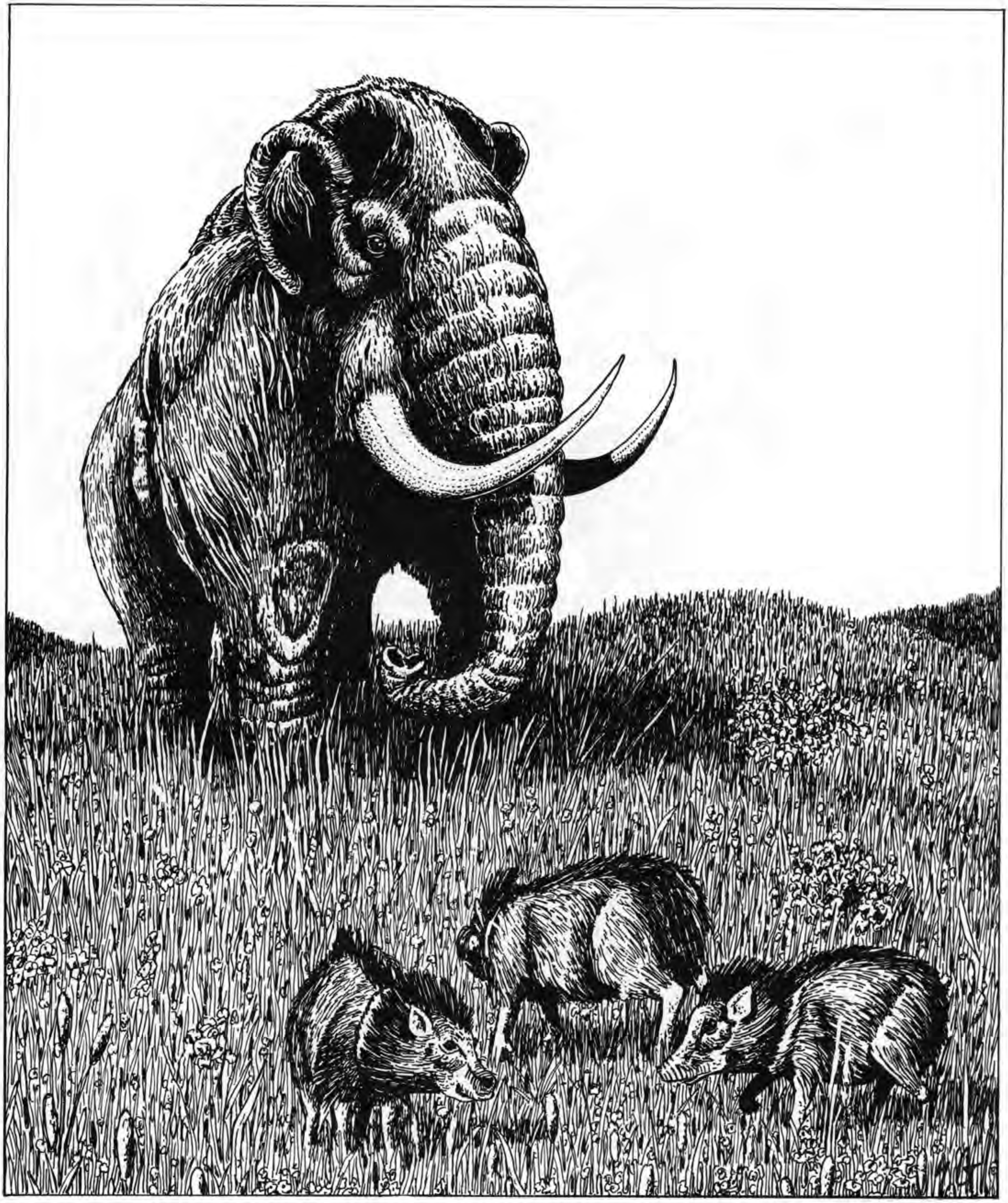

Figure 37. Reconstruction of a Pleistocene landscape. A large mastodon and small pig–like peccaries graze in tall grass.

After a rain the sticky tar would be hidden by a thin film of water. Animals such as the mastodons would come down to the water to drink and get stuck in the tar. Wolves, lions, and saber-toothed tigers came to the tar pits to feed on the animals stuck in the tar, and sometimes became stuck themselves. SMILODON [136] is an example of a saber-toothed tiger.

In South America some fairly common mammals grew to be giants. MEGATHERIUM (141) was a ground sloth nearly 18 feet in length. *Megatherium* had huge claws like *Moropus*' that could be used for digging roots. GLYPTODON (135) was a 6-foot-long armadillo. It had a solid, bony shield that covered its back and head and that could be pulled in as a turtle does if it was attacked.

Primates continued their radical evolution toward higher intelligence. During the Pleistocene the pre-human *Australopithecus* gave way to HOMO ERECTUS (148), the first true man. This early human developed 500,000 years ago in Africa, and is thought to have traveled as far as Asia. He had a larger brain than his ancestors and he used it to harness fire and fashion sophisticated stone-age tools such as axes and scrapers. Bones and artifacts of these early humans show that they walked upright and were skilled hunters. They appear to be the direct ancestors of modern man. The first modern man, *Homo sapiens neanderthalensis*, or Neanderthal man, was the famous cave man of Europe and Asia. These men hunted the giant animals of the ice ages, including the horse, giant cave bear, and wooly mammoth. Neanderthal man coexisted with and was replaced by CRO-MAGNON MAN (149), *Homo sapiens sapiens*. Cro-Magnon man is pre-agricultural modern man. He was very human looking, made the first blade tools, and was a skilled craftsman and artist. He was also a traveler. Nearly 34,000 years ago, during a period when the great ice sheets still covered much of the northern hemisphere, a land bridge existed between Asia and the United States, across the Bering Strait of Alaska. Cro-Magnon hunters followed game across this land bridge and populated the Americas.

Figure 38. Pleistocene peccary skeleton from western Kentucky. After *Finch and others (1972).*

Holocene Epoch (150)

The Holocene encompasses only the last 10,000 years of earth history. During this time agricultural MODERN MAN (150) developed and spread across the globe. In an incredibly short period of geologic time his large brain allowed him to learn how to work metal, domesticate other animals, grow his own food, build monuments, develop elaborate communications systems, travel to the moon, and discover the atom and the basic ingredient of life, DNA. As you read this last paragraph, you are a modern man (or woman) in the Holocene Epoch. All of the many creatures that live on the planet around us are living in the Holocene Epoch. Some of the life forms have been around for millions, even billions, of years with little change. Others have progressed and evolved from simple beginnings into the shapes we see now. All have been a part of the great progression of life.

PRONUNCIATION GUIDE[1]

Archaecyathid (ar–KAY–sye–ATH–id)
Allosaurus (al–lo–SAWR–us)
Anatosaurus (an–AT–o–SAWR–us)
Ankylosaurus (an–KILE–o–SAWR–us)
Apatosaurus (a–PAT–oh–SAWR–us)
Archaeopteryx (ark–ee–OP–ter–ix)
Archelon (AR–lee–lon)
Bjuvia (ZHEW–vi–a)
Brachiopod (BRAK–ee–o–POD)
Brachiosaurus (BRAK–ee–o–SAWR–os)
Brontotherium (BRON–toe–THEER–ee–um)
Bryozoan (BRY–uh–ZOH–in)
Cephalapis (SEFF–ah–LASS–pis)
Cephalopod (SEF–uh–la–POD)
Calamites (ka–la–MY–tees)
Ceratosaurus (SER–a–toe–SAWR–us)
Cladoselache (klad–o–SEE–lack–ah)
Coelophysis (SEE–lo–FY–sis)
Coryphodon (Ko–RIF–uh–don)
Corythosaurus (kor–ith–o–SAWR–us)
Crinoid (CRY–noyd)
Cyclonema (sye–CLO–neem–ah)
Deinonychus (DYE–no–NIKE–us)
Diacodon (dye–AK–o–don)
Diatryma (dye–uh–TRY–ma)
Dilophosaurus (die–LOAF–o–SAWR–us)
Dimetrodon (di–MEET–ro–don)
Dinohyus (dye–no–HYE–us)
Dinorthis (DYE–north–is)
Diplodocus (dip–LOD–o–kus)
Dunkleosteus (dunk–LEE–os–TEE–us)
Echinoderm (ee–KYE–no–derm)
Ediacara (ee–DEE–uh–CARE–uh)
Eucaryote (YOU–care–EE–oat)
Eurypterus (yur–IP–ter–us)
Eusthenopteron (use–then–OP–tair–on)
Favosites (FAVE–o–site–ees)
Forbesiocrinus (for–BISS–ee–o–CRY–ness)
Glyptodon (GLIP–to–don)
Hadrosaur (HAD–ro–SAWR)
Hylaeosaurus (HY–lee–o–SAWR–us)
Hylonomus (hi–lo–NO–mus)
Hyracotherium (HYE–rak–o–THEER–ee–um)
Ichthyosaurus (ik–thee–o–SAWR–us)
Kentrosaurus (KEN–tro–SAWR–us)
Lambeosaurus (LAM–bee–o–SAWR–us)
Lepidodendron (lep–i–do–DEN–dron)
Limnoscelis (lim–no–cell–iss)
Monoclonius (MON–o–KLONE–ee–us)
Moropus (MORE–oh–pus)
Nautiloid (NAW–till–oyd)
Neuropteris (noor–OP–ter–is)
Ollenellus (OH–lin–NEL–us)
ornithischian (orn–ith–ISS–kee–yan)
Osteolepis (os–tee–o–LEEP–is)
Paracyclas (pair–ah–SYKE–less)
Paramys (PAR–a mees)
Parasaurolophus (par–a–sawr–AH–lof–us)
Pelycodus (pe–LIEK–o–dus)
Plateosurus (PLATE–ee–o–sawr–us)
Platystrophia (plat–ee–STROFE–ee–ah)
Plesiadapis (pleez–ee–AD–ah–piss)
Pliohippus (ply–o–HIP–us)
Pteranodon (tair–AN–o–don)
Pteraspis (tair–ASP–iss)
Pterichthyodes (tair–IK–thee–o–dees)
Ptilodus (TILL–oh–dus)
Rafinesquina (raf–in–ESK–een–ah)
Rhinia (RYE–nee–ah)
Saurischian (sawr–ISS–kee–yan)
Saurolophus (SAWR–oh–LOAF–us)
Sauropod (SAWR–o–pod)
Seymouria (see–MORE–ee–ya)
Silvisaurus (SIL–vih–SAWR–us)
Smilodon (SMIL–o–don)
Stegosaurus (STEG–o–sawr–us)
Stromatalite (STROH–mat–uh–LITE)
Struthiomimus (STROOTH–ee–o–MIME–us)
Styrakosaurus (sty–rak–o–SAWR–us)
Synthetoceras (sin–the–TAH–sir–us)
Thecodont (THEEK–o–dont)
Titanosaurus (tie–TAN–o–SAWR–us)
Triceratops (tri–SAIR–a–tops)
Trilobite (TRY–lah–bite)
Trionyx (TRY–ah–nicks)
Tylosaurus (tile–o–SAWR–us)
Tyrannosaurus (tie–RAN–o–sawr–us)

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[1] From Ostrom and Delevoryas (1977); Schankler and others (1978); Watson (1983); Benton (1984).

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*Children's book.

APPENDIX 1

This appendix is an explanation of the fossils pictured in Figures 13, 15, 17, 19, 22, and 26. Each citation indicates the genus (first italicized word; capitalized first letter) and in many cases species (second italicized word; lower case first letter) of the fossil. When the species is unknown the genus name is followed by the abbreviation "sp." In a few cases the species of the fossil is similar but not exactly like a known species; then the abbreviation "cf." is used, followed by the name of the species the speciman most closely resembles. After the name, the size of the specimen is indicated. For example, "X 0.25" indicates that the photograph is only one-quarter of the size of the original specimen. In other words, the actual fossil is 4 times larger than the photograph. Likewise, "X 3" indicates that the specimen is only one-third as large as the photograph. After the size, the geologic unit and location where the specimen was originally found are indicated. The last notation is the specimen number and source. Most of the fossils are from scientific collections. Abbreviations used are USNM for U.S. National Museum collection, UKGS for the University of Kentucky Department of Geological Sciences collection, and KGS for Kentucky Geological Survey collection. Where photographs have been used from previously published material the author and date are indicated, and further information can be obtained from the reference list.

Figure 13: Ordovician Fossils

Cephalopods

1. *Endoceras* sp., X 0.4, Lexington Limestone?, Bluegrass area, Kentucky, UKGS N127.
2. *Actinoceras sp.*, X 0.8, Lexington Limestone, Woodford County, Kentucky, UKGS 5895.

Trilobites

3. *Flexicalymene meeki*, X 1, enrolled individual, McMillan Formation, Hamilton County, Ohio, USNM 154420 (from Ross, 1967, plate 5, no. 4).
4. *Prismaspis* sp., X 4, Clays Ferry Formation, Harrison County, Kentucky, USNM 206861 (from Ross, 1979, plate 5, no. 9).
5. *Flexicalymene* cf. *F. retorsa*, X 1.5, Arnheim Formation, Lewis County, Kentucky, USNM 154421 (from Ross, 1967, plate 5, no. 8).
6. *Isotelus* sp., X 0.8, Grant Lake Limestone, Nelson County, Kentucky, R. T. Hendricks collection.
7. *Triarthrus eatoni*, X 4, lateral view of enrolled individual, Campbell County, Kentucky, UCM 40633e (from Ross, 1979, plate 1, no. 12).
8. *Decoroproetus* sp., X 4, enrolled individual, Clays Ferry Formation, Harrison County, Kentucky, USNM 206837 (from Ross, 1979, plate 1, no. 1).
9. *Triarthus eatoni*, X 4, dorsal view of enrolled individual, Campbell County, Kentucky, UCM 40633e (from Ross, 1979, plate 2, no. 7).

Crinoids

10. *Heterocrinus* sp., X 2.2, Lexington Limestone, Madison County, Kentucky, no. N230 (from Smith, 1986, plate 2, no. 7).
11. *Ectenocrinus simplex*, X 2.2, Clays Ferry Formation, Fayette County, Kentucky, no. 462 (from Smith, 1986, plate 2, no. 12).
12. *Pycnocrinus ramulosus*, X 2.5, Curdsville Limestone, Garrard County, Kentucky, no. N206., (from Smith, 1986, plate 2, no. 11).
13. *Cincinnaticrinus varibrachialus*, X 2.2, Kope Limestone, Hamilton County, Kentucky (from Axon, 1987, Fig. 13b, p. 53).

Figure 13 (continued)

14. *Heterocrinus* sp., X 2.5, Lexington Limestone, Woodford County, Kentucky, USNM 245185 (from Parsley, 1981, plate 1, no. 5).
15. *Cupulocrinus kentuckiensis*, X 1.3, Lexington Limestone, Fayette County, Kentucky, no. N227 (from Smith, 1986, plate 3, no. 20).
16. *Ectenocrinus simplex*, X 2, Kope Limestone, Hamilton County, Ohio, (from Axon, 1987, Fig. 13a, p. 42).
17. *Columbicrinus crassus*, X 1.3, Lexington Limestone, Mercer County, Kentucky, no. N216 (from Smith, 1986, plate 2, no. 13).

Gastropod

18. *Cyclonema* sp., X 1.7 , Clays Ferry Formation, Madison County, Kentucky, KGS SG100.

Brachiopods

19. *Heterorthina macfarlani*, X 1.6, Lexington Limestone, Franklin County, Kentucky, USNM 258453 (from Walker and Pojeta, 1982, plate 3, no. 32).
20. *Rafinesquina* sp., X 0.8, Lexington Limestone, Fayette County, Kentucky, KGS SG101.
21. *Platystrophia ponderosa*, X 0.8, Ashlock Formation, Madison County, Kentucky, USNM 189450 (from Alberstadt, 1979, plate 1, no. 9).
22. *Herbertella occidentalis*, X 0.8, Ashlock Formation, Madison County, Kentucky, USNM 258496 (from Walker, 1982, plate 5, no. 34).
23. *Pionodema rectimarginata*, X 3.5, exterior view, Lexington Limestone, Madison County, Kentucky, USNM 155510 (from Neuman, 1967, plate 1, no. 8).
24. *Pionodema rectimarginata*, X 3.5, interior view, Lexington Limestone, Madison County, Kentucky, USNM 155510 (from Neuman, 1967, plate 1, no. 9).
25. *Leptaena kentuckiana*, X 0.8, Ashlock Formation, Madison County, Kentucky, USNM 245367 (from Pope, 1982, plate 8, no. 4a).
26. *Furcitella* cf. *F. scofielda*, X 0.8, Camp Nelson Limestone, Jessamine County, Kentucky, USNM 245239 (from Pope, 1982, plate 5, no. 3d).
27. *Platystrophia ponderosa*, X 0.8, brachial interior view, Ashlock Formation, Madison County, Kentucky, USNM 189490 (from Alberstadt, 1979, plate 4, no. 19).
28. *Orthorhynchula linneyi*, X 1.3, side view, Calloway Creek Limestone, Garrard County, Kentucky, USNM 208657 (Howe, 1979, plate 4, no. 12).
29. *Dalmanella sulcata*, X 1.5, Lexington Limestone, Franklin County, Kentucky, USNM 155528 (from Neuman, 1967, plate 1, no. 22).
30. *Rhynchotrema increbescens*, X 2.5, Lexington Limestone, Mercer County, Kentucky, USNM 208623 (from Howe, 1979, plate 3, no. 5).
31. *Sowerbyella grierensis*, X 2.5, Lexington Limestone, Woodford County, Kentucky, USNM 208589 (from Howe, 1979, plate 1, no. 1).

Bryozoan

32. *Eridotrypa briaren*, X 0.8, Lexington Limestone, Harrison County, Kentucky, UKGS 2772.

Figure 15: Silurian Fossils

Corals

1. *Arachnophyllum striatum*, X 0.2, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS N402.

Figure 15 (continued)

2. *Entelophyllum eruciforme,* X 0.4, Louisville Limestone, Falls of the Ohio, Clark County, In., R. T. Hendricks collection.
3. *Stombodies shumardi*, X 0.8, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 273.
4. *Heliolites* sp., X 0.8, Loisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 3584.
5. *Zaphrenthis obiqua*, X 0.6, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 1273.
6. *Plasmopora* sp., X 0.6, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 1273.
7. *Craterophyllum invaginatum*, X 0.8, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 404.
8. *Cladopora reticulata*, X 0.8, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 445b.
9. *Omphyma verrucosa*, X 0.8, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 159.
10. *Halysites*, X 0.8, Louisville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 3624.

Trilobites

11. *Gravicalymene celebra,* X 2, Laurel Dolomite, Nelson County, Kentucky, R. T. Hendricks collection.
12. *Gravicalymene celebra,* X 2, Laurel Dolomite, Nelson County, Kentucky, R. T. Hendricks collection.
13. *Gravicalymene celebra,* X 0.8, Laurel Dolomite, Nelson County, Kentucky, KGS collection.
14. *Gravicalymene celebra,* X 0.8, Laurel Dolomite, Preble County, Ohio, UKGS N388.

Brachiopods

15. *Pentamerus laevis* (P), X 0.4, Laurel Dolomite, Nelson County, Kentucky, R. T. Hendricks collection, no. S1-59.
16. *Rhynotreta euneata americana*, X 0.8, Waldron Shale, Hartsville, Indiana, UKGS 12474.
17. *Pentamerus* sp., X 0.8, Louisville Limestone, Jefferson County, Kentucky, UKGS 5884a.
18. *Atrypa reticularis*, X 0.8, Waldron Shale, Cheatam County, Tennessee, UKGS 4902.
19. *Conchidium laqueatum*, X 0.8, Niagran Series, Carroll County, Indiana, UKGS N378.
20. *Whitfieldella nitida*, X 0.8, Waldron Shale, Bartholomew County, Indiana, UKGS N374.

Figure 17: Devonian Fossils

Corals

1. *Eridophyllum coagulatum*, X 0.6, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 3610.
2. *Scenophyllum conigerum*, X 0.5, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, R. T. Hendricks collection.
3. *Siphonophrentis elongata*, X 0.5, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, R. T. Hendricks collection.

Figure 17 (continued)

4. *Heterophrentis simplex*, X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS no. 670.

Figure 17 (continued)

5. *Zaphrenthis phrygia*, X 0.8, Jeffersonville Limestone, Jefferson County, Kentucky, R. T. Hendricks collection.
6. *Alveolites* sp., X 0.5, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, R. T. Hendricks collection.
7. *Favosites turbinatus*, X 0.4, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, R. T. Hendricks collection.
8. *Syringopora* sp., X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 36012.
9. *Trachyopora* sp., X 0.8, Jeffersonville Limestone?, Clark County, Indiana, UKGS 122.

Brachiopods

10. *Brevispirifer gregarius*, X 0.5, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, UK 670.
11. *Spirifer fornacula*, X 0.8, Jefferson LimestoneFormation?, Clark County, Indiana, UKGS 669.
12. *Spinocyrtia (Platyrrachella) fornacula,* X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 6878.
13. *Athyris virrata,* X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 2905.
14. *Atrypa reticularis*, X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 6882.
15. *Spirifer hobbsi*, X 0.8, dorsal view, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 6879.
16. *Spirifer hobbsi*, X 0.8, pedical view, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 6879.
17. *Athyris fultonensis,* X 0.8, Jeffersonville Limestone, Falls of the Ohio, Jefferson County, Kentucky, UKGS 6883.

Bivalve

18. *Paracyclas elongata*, X 0.8, Sellersburg Limestone, Falls of the Ohio, Clark County, Indiana, UKGS 772.

Gastropod

19. *Turbonopsis shumardi*, X 0.8, Jeffersonville Limestone, Falls of the Ohio, Clark County, Indiana, R. T. Hendricks collection.

Figure 19: Mississippian Fossils

Crinoids

1. *Rhopocrinus spinosis*, X 0.3, Pennington Formation, Pulaski County, Kentucky, USNM 4409-A (from Chesnut, personal comm.).
2. *Rhopocrinus spinosis*, X 0.5, Pennington Formation, Pulaski County, Kentucky, USNM 4409-C (from Chesnut, personal comm.).
3. *Phacelocrinus longidactylus*, X 0.3, Pennington Formation, Pulaski County, Kentucky, USNM S-2770 (from Chesnut, personal comm.).
4. *Phanocrinus maniformis*, X 0.8, Pennington Formation, Pulaski County, Kentucky, UK 115786 (from Chesnut, 1980, plate 6, no. 1g).

Figure 19 (continued)

5. *Phacelocrinus longidactylus*, X 0.8, Pennington Formation, Laurel County, Kentucky, UK 115815 (from Chesnut, 1980, plate 3, no. 1d).
6. *Anartiocrinus lyoni*, X 0.6, Pennington Formation, Laurel County, Kentucky, UK 115843 (from Chesnut, 1980, plate 5, no. 1b).
7. *Eupachycrinus boydii*, X 0.5, Pennington Formation, Pulaski County, Kentucky, UK 115802 (from Chesnut, 1980, plate 7, no. 2a).
8. *Eupachycrinus boydii*, X 0.5, Pennington Formation, Laurel County, Kentucky, UK 115800 (from Chesnut, 1980, plate 7, no. 1a).
9. *Phanocrinus maniformis*, X 0.7, Pennington Formation, Pulaski County, Kentucky, UK 115753 (Chesnut, 1980, plate 6, no. 1a).
10. *Agassizocrinus* cf. *A. dactyliformis*, X 1, lateral view of cup, Pennington Formation, Pulaski County, Kentucky, UK 115568 (from Chesnut, 1980, plate 5, no. 2a).
11. *Agassizocrinus* cf. *A. dactyliformis*, X 1, posterior view of cup, Pennington Formation, Pulaski County, Kentucky, UK 115568 (from Chesnut, 1980, plate 5, no. 2b).
12. *Phacelocrinus longidactylus*, X 1.5, lateral view of cup, Pennington Formation, Pulaski County, Kentucky, UK 115808 (from Chesnut,1980, plate 3, no. 1d).
13. Coiled crinoid stem, X 0.8, Borden Formation, Rockcastle County, Kentucky, KGS 1235.

Blastoids

14. *Pentremites robustus*, X 0.8, Glen Dean Limestone, Christian County, Kentucky, KGS collection.
15. *Pentremites elegans*, X 0.8, Glen Dean Limestone, Christian County, Kentucky, KGS collection.

Corals

16. *Acrocyathus* sp., X 5, St. Louis Limestone, Pulaski County, Kentucky, KGS collection.
17. *Zaphrentoides* sp., X 0.8, Paragon Formation, Pulaski County, KGS 1185.

Bryozoans

18. Fenestrate, X 1, Glen Dean Limestone, Grayson County, Kentucky, KGS collection.
19. *Archimedes* sp., X 1, Paragon Formation, Pulaski County, Kentucky, KGS collection.

Brachiopods

20. *Setigerites setiger*, X 0.8, Warsaw and Salem Formations, Wayne County, Kentucky, KGS 1127.
21. *Camarotoechia mutata*, X 0.8, Salem and Warsaw Formations, Wayne County, Kentucky, KGS 1130.
22. *Syringothyrid* sp., X 0.8, Borden Formation, Rockcastle County, Kentucky, KGS 1258.
23. *Brachythyris* sp., X 0.8, Warsaw and Salem Formations, Wayne County, Kentucky, KGS 1122.
24. *Composita subquadrata*, X 0.8, Paragon Formation, Pulaski County, Kentucky, KGS collection.
25. *Spirifer lateralus*, X 0.8, Salem and Warsaw Formations, Wayne County, Kentucky, KGS 1132.

Figure 19 (continued)

26. *Cleiothyridina sublamellosa*, X 0.8, Paragon Formation, Pulaski County, Kentucky, KGS 1214.
27. *Anthracospirifer* sp., X 0.8, Paragon Formation, Pulaski County, Kentucky, KGS 1207.

Figure 22: Paleozoic Shark Fossils

1. *Deltodus* cf. *D. cingulatus*, X 1, tooth, Mississippian, Bangor Limestone, Pulaski County, Kentucky, KGS 1036.
2. *Petalodus linquifer*, X 1, tooth, Mississippian, Warsaw and Salem Formations, Russell County, Kentucky, KGS 1763.
3. *Cladodont*? sp., X 1, tooth, Mississsippian, Bangor Limestone, Pulaski County, Kentucky, KGS 1002.
4. *Edestus* sp., X 0.6, partial jaw and teeth, Pennsylvanian, Carbondale Formation, Henderson County, Kentucky, KGS, no number.
5. *Ctenacanthid*? sp., X 0.8, dorsal spine, Mississippian, Bangor Limestone, Rockcastle County, Kentucky, KGS 116088.

Figure 26: Pennsylvanian Fossils

1. *Lepidodendron* cf. *L. aculeatum*, X 0.8, stem surface, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 1, no. 5).
2. *Alethopteris* cf. *A. lonchitica*, X 0.8, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 6, no. 1).
3. *Neuropteris* cf. *N. tenuifolia*, X 0.8, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 5, no. 1).
4. *Linopteris* (*Reticulopteris*) cf. *L. muenster*, X 2, Breathitt Formation, Perry County, Kentucky (from Jennings, 1981, plate 24, no. 9).
5. *Sphenophyllum cuneifolium*, X 0.8, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 4, no. 3).
6. *Annularia galioides*, X 0.8, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 3, no. 7).
7. *Asterophylites equisetiformis*, X 0.8, Breathitt Formation, Perry County, Kentucky (from Jennings, 1981, plate 23, no. 5).
8. *Calamites* cf. *C. undulatus*, X 0.5, Breathitt Formation, Eastern Kentucky Coal Field, KGS collection.
9. *Mariopteris nervosa*, X 0.8, Breathitt Formation, Clay County, Kentucky (from Spurgeon and Jennings, 1985, plate 6, no. 6).
10. *Neuropteris ravinervis*, X 0.5, Breathitt Formation, Perry County, Kentucky (from Jennings, 1981, plate 24, no. 7).

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