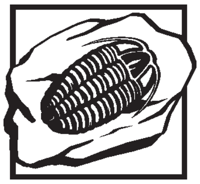


Chapter 3:
Fossils of the Southeastern US

Fossils (from the Latin word *fossilis*, meaning "dug up") are the remains or traces of organisms that lived in the geologic past (older than the last 10,000 years), now preserved in the Earth's **crust**. Most organisms never become fossils, but instead decompose after death, and any hard parts are broken into tiny fragments. In order to fossilize, an organism must be buried quickly before it is destroyed by **weathering**, decomposed, or eaten by other organisms. This is why fossils are found almost exclusively in sediment and **sedimentary rocks**. **Igneous rocks**, which form from cooling **magma** or **lava**, and **metamorphic rocks**, which have been altered by **heat** and pressure, are unlikely to contain fossils (but may, under special circumstances). Different fossils are found in different regions because of the presence of rocks deposited at different times and in a variety of environments. Since rapid burial in sediment is important for the formation of fossils, many fossils are from marine environments, where sediments are more likely to accumulate.

Fossils come in many types. Those that consist of an actual part of an organism, such as a bone, shell, or leaf, are known as **body fossils**; those that record the actions of organisms, such as footprints and burrows, are called **trace fossils**. Body fossils may be preserved in a number of ways. These include preservation of the original **mineral** skeleton of an organism, mineral **replacement** (chemical replacement of the material making up a shell by a more

Lagerstätten

The "soft" tissues of an organism, such as skin, muscles, and internal organs, are typically not preserved as fossils. Exceptions to this rule occur when conditions favor rapid burial and mineralization or very slow decay. The absence of oxygen and limited disruption of the sediment by burrowing are both important for limiting decay in those deposits where soft tissues are preserved. The Southeastern states contain numerous examples of such exceptional preservation, also called Lagerstätten, including the mid-Cambrian Conasauga Formation of northwestern Georgia and the Triassic-Jurassic insect fossil beds in Virginia's Culpepper Rift Basin.

crust • *the uppermost, rigid outer layer of the Earth.*

weathering • *the breakdown of rocks by physical or chemical means.*

sedimentary rock • *rock formed through the accumulation and consolidation of grains of broken rock, crystals, skeletal fragments, and organic matter.*

magma • *molten rock located below the surface of the Earth.*

lava • *molten rock located on the Earth's surface.*

heat • *a form of energy transferred from one body to another as a result of a difference in temperature or a change in phase.*

mineral • *a naturally occurring solid with a specific chemical composition and crystalline structure.*

CHAPTER AUTHOR

Warren D. Allmon

3

Fossils

Overview

silt • *fine granular sediment most commonly composed of quartz and feldspar crystals.*

filter feeder • *an animal that feeds by passing water through a filtering structure that traps food.*

intertidal • *areas that are above water during low tide and below water during high tide.*

crystal form • *a physical property of minerals, describing the shape of the mineral's crystal structure.*

Discovering Ancient Environments

The kinds of animals and plants living in a particular place depend on the local environment. The fossil record preserves not only fossil organisms, but also evidence of what their environments were like. By studying the geological and biological information recorded in a rock that contains a fossil, scientists can determine some aspects of the paleoenvironment.

Grain size and composition **of the rock can tell us what type of sediment surface the animal lived on, what the water flow was like, and whether the sediment was transported in a current. Grain size also tells us about the clarity of the water. Fine-grained rocks such as shales are made of tiny particles of** ***silt*** **or clay that easily remain suspended in water. Thus, a fossil found in shale might have lived in muddy or very quiet water.** ***Filter-feeding*** **organisms, such as clams or corals, are not usually found in muddy water because the suspended sediment can clog their filters.**

Sedimentary structures**, such as asymmetrical ripples and cross-beds, can indicate that the organism lived in moving water. Mud cracks or symmetrical ripples are characteristic of shoreline or** ***intertidal*** **environments.**

Broken shells **or** ***concentrated layers of shells*** **may indicate transportation and accumulation by waves or currents.**

Color of the rock **may indicate the amount of oxygen in the water. If there is not enough oxygen in the water, organic material (carbon) in sediments will not decompose, and the rock formed will be dark gray or black in color.**

stable mineral), **recrystallization** (replacement by a different **crystal form** of the same chemical compound), **permineralization** (filling of empty spaces in a bone or shell by minerals), and molds and casts, which show impressions of the exterior or interior of a shell. **Chemical fossils** are chemicals produced by an organism that leave behind an identifiable trace in the geologic record, and it is these fossils that provide some of the oldest evidence for life on Earth.

Fossils

3

Paleontologists use fossils as a record of the history of life. They tell us that an incredible multitude of organisms lived prior to the species that we see on Earth today; that most species that ever lived have become extinct; and that living things have changed through evolution over time, from one species into another, and adapted to changing environments. Fossilized organisms are also extremely useful in understanding the ancient environment that existed when they were alive. The study of the relationships of fossil organisms to one another and their environment is called **paleoecology**.

Fossils are the most important tool for dating the rocks in which they are preserved. Because species only exist for a certain amount of time before going **extinct**, their fossils only occur in rocks of a certain age. The relative age of such fossils is determined by their order in the stacks of layered rocks that make up the **stratigraphic** record (older rocks are on the bottom and younger rocks on the top—a principle called **superposition**). Such fossils are known as **index fossils.** The most useful index fossils are abundant, widely distributed, easy to recognize, and occur only during a narrow time span. This use of fossils to determine relative age in geology is called **biostratigraphy**. The **geologic time scale** is in part based on sequences of fossils correlated from around the world.

Some of the most useful index fossils are hard-shelled organisms that were once part of the marine plankton.

Ancient Biodiversity

Since life began on Earth more than 3.7 billion years ago, it has continuously grown more abundant and diverse. It wasn't until the beginning of the **Cambrian** period, around 541 million years ago, that *complex life*—living things with cells that are differentiated for different tasks—became predominant. This event at the beginning of the Cambrian, called the Cambrian Explosion, resulted in the emergence of most major animal phyla. The diversity of life has generally increased through time since then. Measurements of the number of different kinds of organisms—for example, estimating the number of species alive at a given time—attempt to describe Earth's **biodiversity**. With a few exceptions, the rate at which new species evolve is significantly greater than the rate of extinction.

Most species have a lifespan of several million years; rarely do species exist longer than 10 million years. The extinction of a species is a normal event in the history of life. There are, however, intervals of time during which extinction rates are unusually high, in some cases at a rate of 10 or 100 times the normal pace. These intervals are known as **mass extinctions**. There were five particularly devastating mass extinctions in geologic history (*Figure 3.1*), and these specific events have helped to shape life through time. Unfortunately, this is not just a phenomenon of the past—it is estimated that the extinction rate on Earth right now may be as much as 1000 times higher than normal, due mostly to human activity, and that we are currently experiencing a sixth mass extinction event.

Overview

paleoecology • *the study of the relationships of fossil organisms to one another and their environment.*

extinction • *the end of species or other taxonomic groups, marked by death of the last living individual.*

stratigraphy • *the branch of geology specifically concerned with the arrangement and age of rock units.*

geologic time scale • *a standard timeline used to describe the age of rocks and fossils, and the events that formed them.*

Cambrian • *a geologic time period lasting from 541 to 485 million years ago.*

biodiversity • *the number of kinds of organisms at any given time and place.*

mass extinction • *the extinction of a large percentage of the Earth's species over a relatively short span of geologic time.*

3 Fossils

Overview

erosion • *the transport of weathered materials.*

trilobite • *an extinct marine invertebrate animal characterized by a three-part body and a chitinous exoskeleton divided longitudinally into three lobes.*

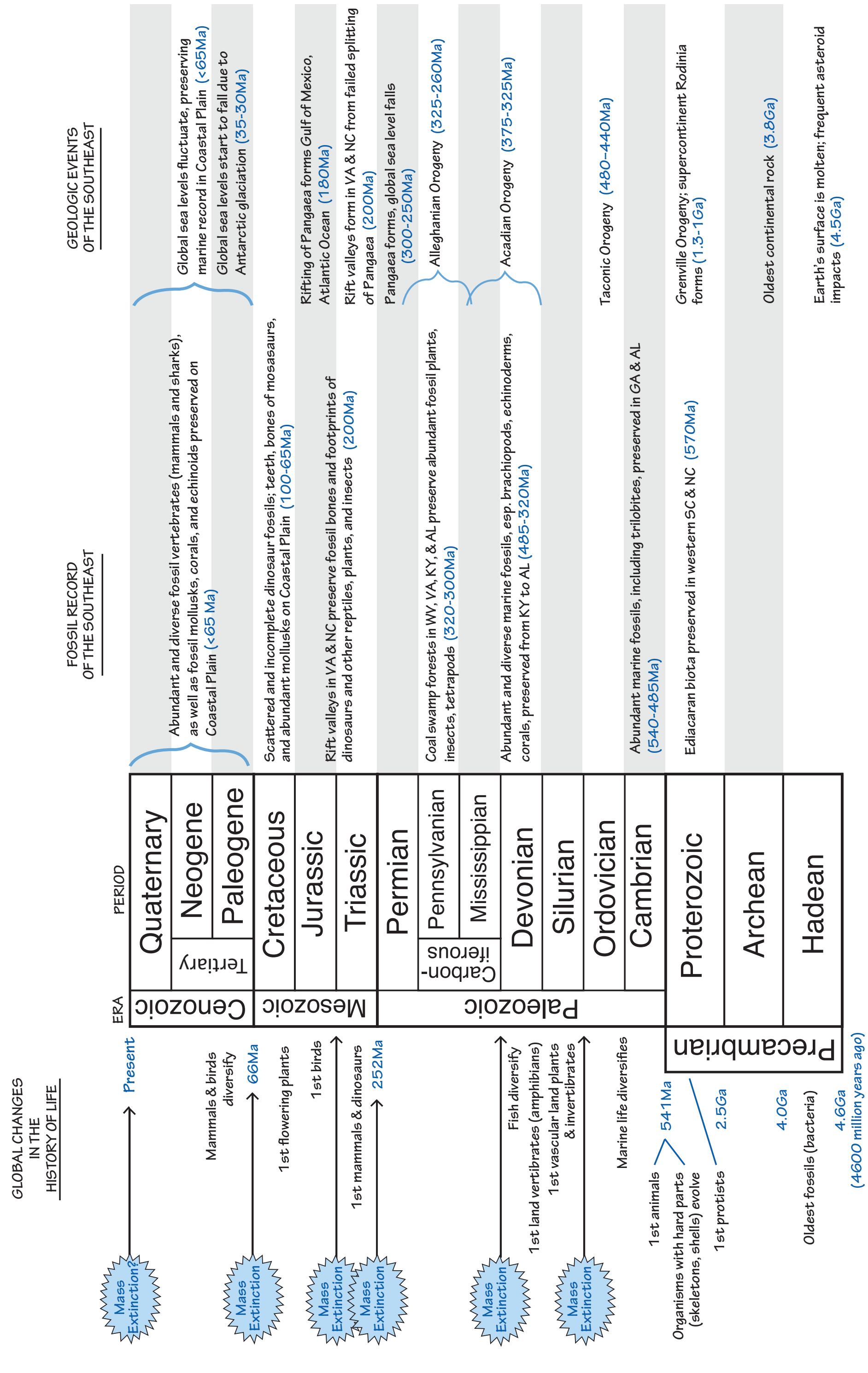


Figure 3.1: The history of life in relation to global and regional geological events and the fossil record of the Southeastern US (Time scale is not to scale).

Fossils 3

Fossils of the Southeastern US

The Southeast contains layers of sedimentary rock that preserve a tremendous variety of fossils and provide glimpses of what life was like over the last 560 million years. Fossils can be found in nearly every part of the Southeast, representing most major categories of organisms and most periods of geologic time. The history of life in the Southeast has been pieced together from the fossil record in many different areas, and from many different layers of rocks in these areas. Particular fossil organisms lived only in certain environments, and these changing environments did not exist continuously through time, nor were they all necessarily preserved in the rock record. Nowhere in the Southeast (or anywhere) is a complete record of rock from every period preserved. Not all sediment ends up as rock, and likewise, rock that formed long ago may have been **eroded** away. Not all organisms are preserved as fossils, and rocks that have contained fossils have not necessarily been preserved, or they may still be buried well below the current surface of the Earth, out of sight from paleontologists.

In the remainder of this chapter, we will highlight the major types of fossils present in most of the geologic periods represented by rocks in each state. The references at the end of the chapter should be consulted for details, especially for identifying particular fossils you might find.

Fossils of the Blue Ridge and Piedmont

Region 1

The rocks of the Blue Ridge and Piedmont are largely metamorphic and igneous, although many of them were initially sedimentary and may have contained fossils. Remarkably, a few fossils managed to escape the destructive heat and pressure of metamorphism. The oldest known fossils in the Southeast come from Stanly County in North Carolina, where in the early 1970s, a man found what looked like a **trilobite** in one of the rocks he was using to build a chimney. It turned out to be not a trilobite, but a fossil from the latest interval of the **Proterozoic**—part of what is called the Ediacara **biota** (*Figure 3.2*), a world-wide assemblage of fossils generally accepted as among the oldest known animals in the fossil record. A small number of additional Ediacaran-type fossils have been found in similar rocks in Stanly County. All of these rocks appear to date to between 542 and 556 Ma, putting them just before the Cambrian Explosion, making these fossils among the youngest representatives of the Ediacara biota in the world.

Cambrian rocks are not widespread in the Southeast (as they are, for example, in parts of the Western US), but some Cambrian sediments exposed in the southern Appalachians do contain well-preserved fossils. For example, **archaeocyathids** are found in metamorphosed early Cambrian **carbonate rocks** (**marbles**) in the Talladega Slate Belt of northeastern Alabama and northwest Georgia. Several species of middle Cambrian trilobites occur in rocks that are part of the Carolina Slate Belt. For example, trilobites from the Asbill Pond Formation near Batesburg (Lexington County), South Carolina (*Figure 3.3*) are similar to

Region 1

Proterozoic • *a geologic time interval that extends from 2.5 billion to 541 million years ago.*

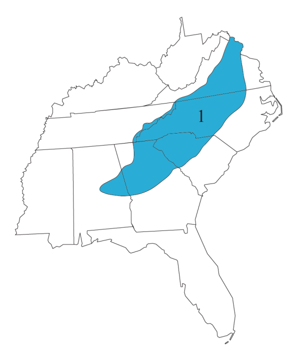
biota • *the organisms living in a given region, including plants, animals, fungi, protists, and bacteria.*

archaeocyathid • *a vase-shaped organism with a carbonate skeleton, generally believed to be a sponge.*

carbonate rocks • *rocks formed by accumulation of calcium carbonate, often made of the skeletons of aquatic organisms.*

marble • *a metamorphic rock composed of recrystallized carbonate minerals, most commonly calcite or dolomite.*

Baltica • *a late-Proterozoic, early-Paleozoic continent that included ancient Europe.*



3 Fossils

Region 1

terrane • *a piece of crustal material that has broken off from its parent continent and become attached to another plate.*

Paleozoic • *a geologic time interval that extends from 541 to 252 million years ago.*

Triassic • *a geologic time period that spans from 252 to 201 million years ago.*

Jurassic • *the geologic time period lasting from 201 to 145 million years ago.*

rift basin • *a topographic depression caused by subsidence within a rift.*

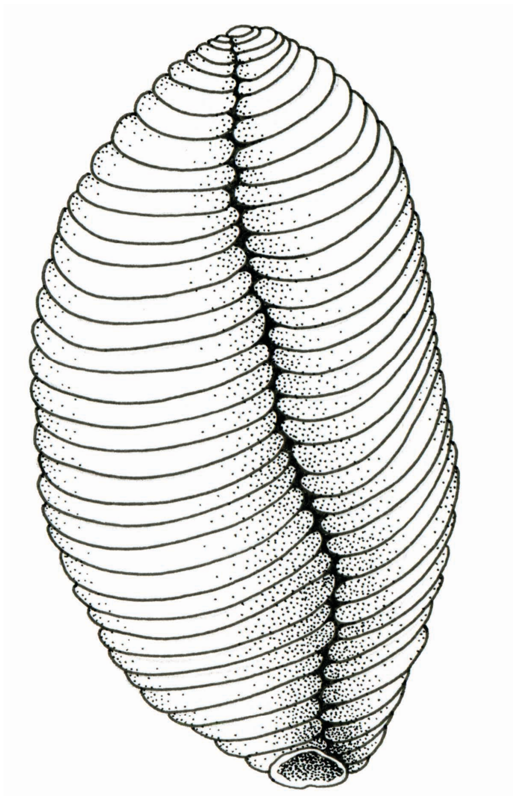


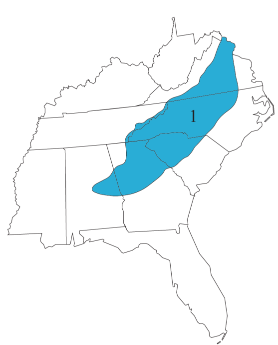
Figure 3.2: Fossil "frond" assigned to the Ediacaran organism Pteridinium, *late Precambrian, Stanly County, North Carolina. Approximately 9 centimeters (3.5 inches) long.*

trilobites from ancient paleocontinents that geologists call Armorica and **Baltica** (modern western and central Europe), but bear little similarity to the fossils of Laurentia (modern North America and western Europe). This peculiar fossil distribution is compatible with the Carolina Slate Belt's history as an exotic **terrane** that was added to North America during the early to middle **Paleozoic**. Almost all younger Paleozoic rocks in the Piedmont are metamorphic, and fossils are uncommon in them. In some places, such as Buckingham County, Virginia, fossils are found that were deformed by the tectonic forces of mountain-building long after they had been buried (*Figure 3.4*).

See Chapter 2: Rocks to learn more about the Carolina Slate Belt and other metamorphosed rocks in the Blue Ridge.

The **Triassic-Jurassic rift basin** rocks of the Piedmont formed after the Paleozoic **orogenies** had ended and the Atlantic Ocean began to widen. Lakes were common in these basins. Sediments deposited in and around the lakes—part of what geologists call the **Newark Supergroup**—contain fossils that record freshwater environments as well as terrestrial habitats along lake margins. The most common fossils are fishes, plant remains, and the footprints (trace fossils) of reptiles and amphibians.

See Chapter 1: Geologic History to learn about the formation of rift basins in the Mesozoic.



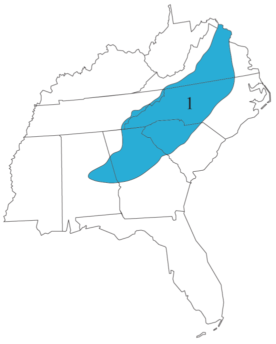
Ediacara: a Fossil Mystery

The Ediacaran biota is an assemblage of fossils, first described from southern Australia and subsequently worldwide, that dates to just before the beginning of the Cambrian (578–542 million years ago). Although the evolutionary affinities of the Ediacara organisms have been controversial, it is widely accepted that they include some of the earliest-known fossil animals. Ediacara fossils include a range of forms, including enigmatic centimeter-to-meter-long fronds, disks, and other shapes, as well as some that generally resemble modern animal groups. All appear to have been soft-bodied (i.e., lacking mineralized skeletons). None show evidence of appendages or sensory structures, and most show no sign of feeding, digestive, or locomotory structures. Scientists do not know whether they are all related to each other, or represent several branches of the evolutionary tree. Nevertheless, the Ediacaran biota is an extremely important piece of the story of how and when complex animal life evolved during the late Precambrian and Cambrian Explosion. It is therefore especially noteworthy that the Southeast has produced Ediacaran fossils.

A diorama depicting life in the Ediacaran sea.

orogeny • *a mountain-building event generally caused by colliding plates and compression of the edge of the continents.*

Newark Supergroup • *a sequence of nonmarine sedimentary rocks that accumulated along what is now eastern North America in the late Triassic to early Jurassic.*



3 Fossils

Region 1

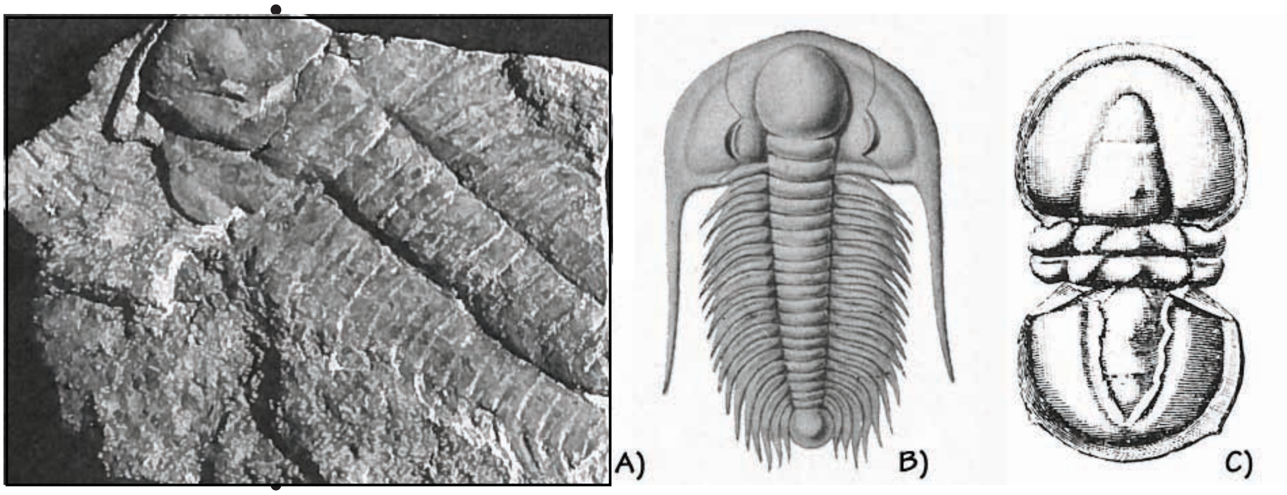
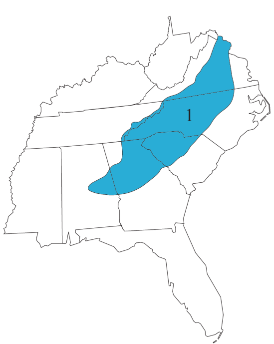


Figure 3.3: Carolina Slate Belt trilobites. A) Paradoxides (Acadoparadoxides) grandoculus, *from early Cambrian rocks in South Carolina; reconstructed length of the complete trilobite is approximately 7–8 centimeters (2.7–3.1 inches) long. B) For comparison, the very similar* Paradoxides harlani, *from early Cambrian rocks of eastern Massachusetts, approximately 30 centimeters (12 inches) long. C) A tiny, eyeless agnostid trilobite, similar to those found in the early Cambrian of South Carolina, approximately 0.8 centimeters (0.3 inches) long.*

Figure 3.4: A Cambrian trilobite deformed by mountain building.



Region 1

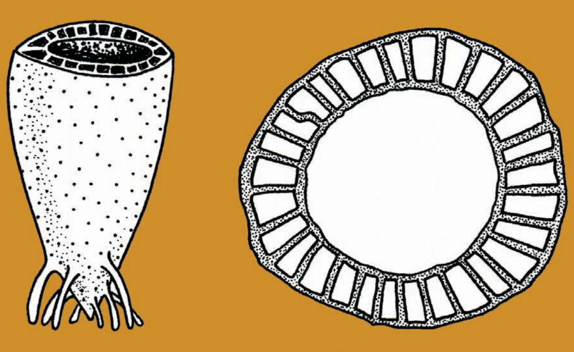
Trilobites

Trilobites are iconic Paleozoic fossils; they were more common in the Cambrian and Ordovician than in later periods, and became extinct at the end of the *Permian*. They were marine arthropods, and had well-defined head, tail, and thoracic (leg-bearing) segments. Most had large compound eyes, often with lenses that are visible to the naked eye. In life, they had antennae like many other arthropods, but since these were not mineralized, they only fossilize under exceptional circumstances. Many could roll up for protection, and several species also had large spines.

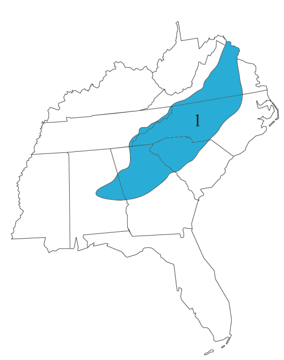
Permian • *the geologic time period lasting from 299 to 252 million years ago.*

Archaeocyathids

Archaeocyathids were the first important animal reef builders, originating in the early Cambrian. These vase-shaped organisms had carbonate skeletons and are generally believed to be sponges. They went extinct in the late Cambrian, but were very diverse. Archeocyathids are often easiest to recognize in limestones by their distinctive cross-sections.



Archaeocyathids are found in lower Cambrian rocks in the Talladega Slate Belt of northeastern Alabama and northwest Georgia. Their vase-shaped calcite skeletons commonly reached lengths of 5 to 20 centimeters (2 to 8 inches).



3

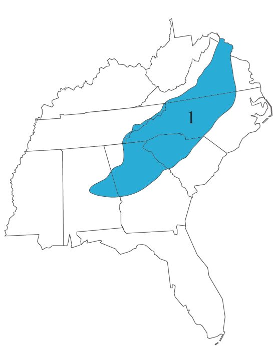
Fossils

Region 1

rift • *a break or crack in the crust that can be caused by tensional stress as a landmass breaks apart into separate plates.*

dinosaur • *a member of a group of terrestrial reptiles with a common ancestor and thus certain anatomical similarities, including long ankle bones and erect limbs.*

trackway • *a set of impressions in soft sediment, usually a set of footprints, left by an animal.*



Trace fossils are marks left by the behavior of organisms on sediment or other substrate. Traces include burrows, footprints, tooth marks, holes drilled in shells by predators, and the tunnels left by plant roots. Because paleontologists can almost never be sure of exactly which kind of organism made a particular trace, there is a completely separate system of naming trace fossils that does not refer to organisms represented by body fossils. Despite this difficulty, trace fossils are widely used to help reconstruct ancient environments. The Triassic-Jurassic **rift** basins of the East Coast have been renowned for their **dinosaur trackways** since the early nineteenth century, and the basins of North Carolina and Virginia do not disappoint in this respect (*Figure 3.5*). The tracks and skeletal fossils of other reptiles such as crocodilians are also well documented from other sites, including the famous Solite Quarry near the Virginia-North Carolina state line (*Figure 3.6*). The rift valley lakes also contained abundant fish, as we know from numerous fossils found in rocks that formed from lake-bottom sediments. Many of these fossils are from an extinct group armored with thick bony scales (*Figure 3.7*).

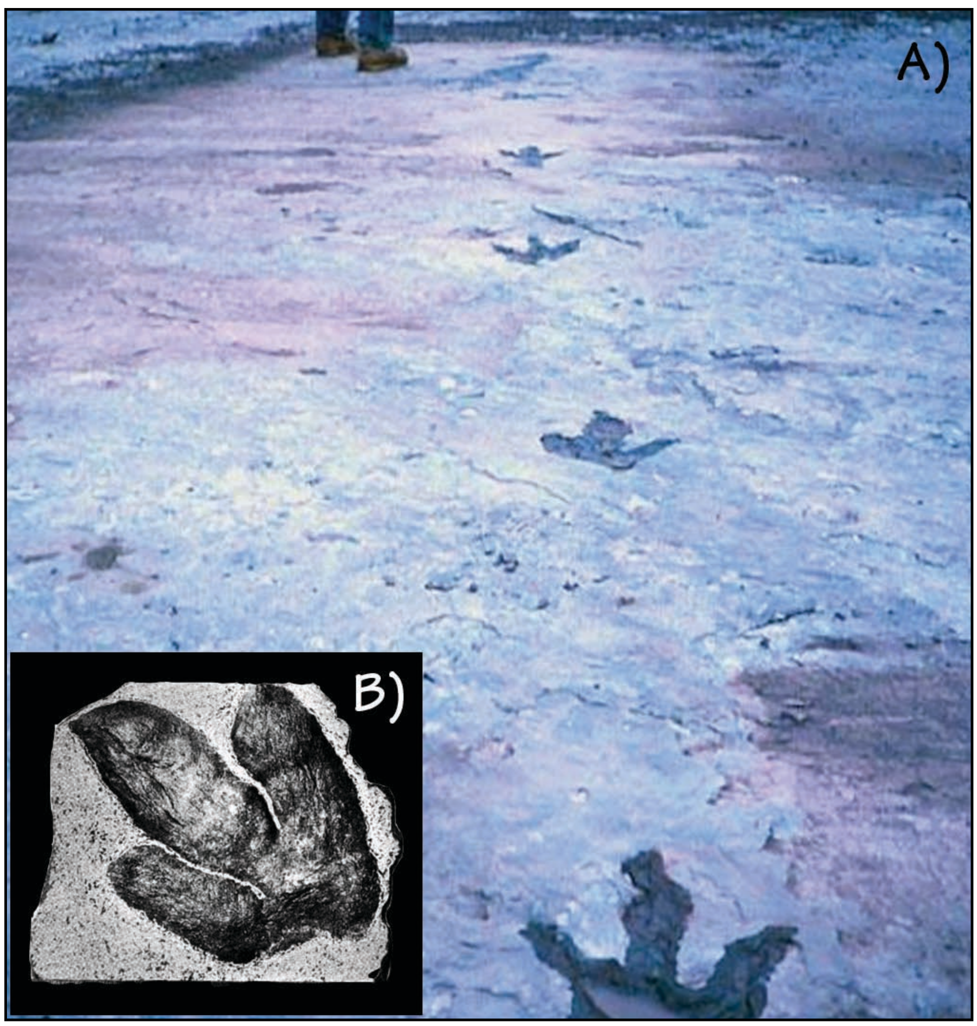


Figure 3.5: Late Triassic dinosaur footprints from the Culpepper Basin of Virginia. A) Trackway. B) Single track, from near Aldie, Loudon County, approximately 30 centimeters (1 foot) long.

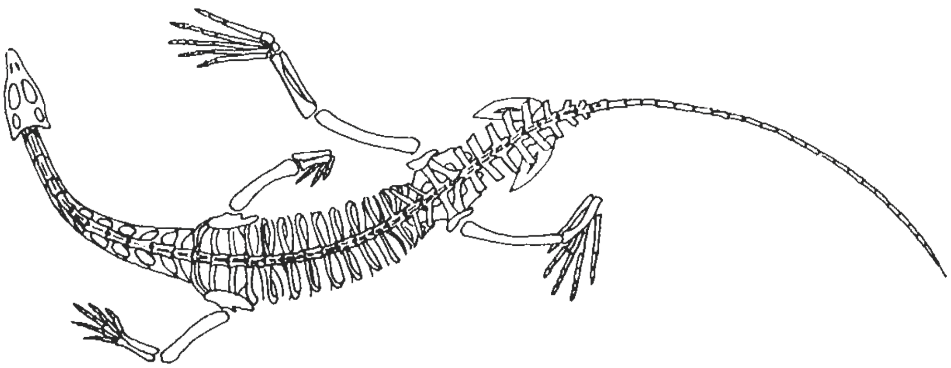


Figure 3.6: Skeleton of the small, late Triassic reptile Tanytrachelos. *Animal was approximately 13 centimeters (5 inches) long.*

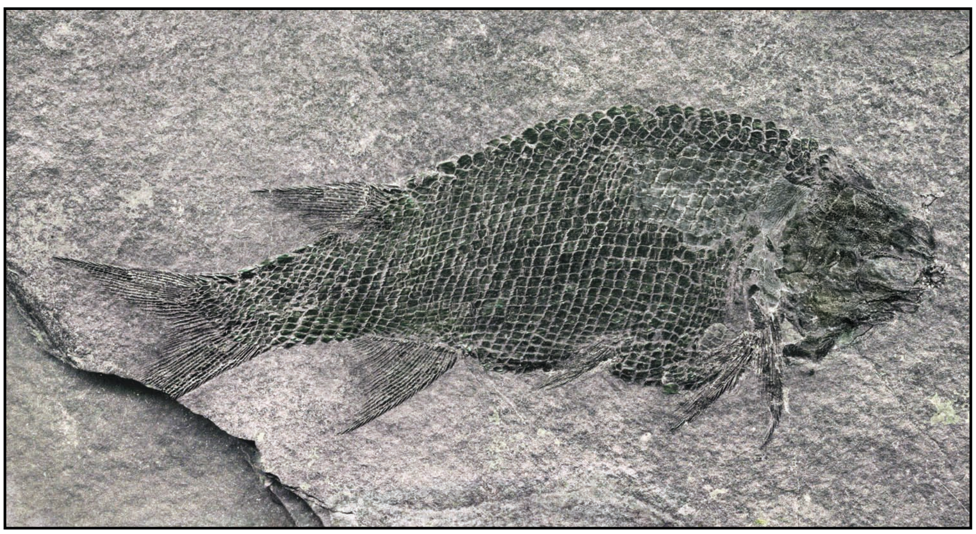


Figure 3.7: Triassic fossil fish, Redfieldius *sp., from the Culpepper Basin in Virginia, approximately 13 centimeters (5.1 inches) long.*

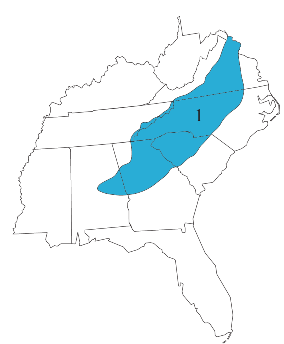
Fossil invertebrates in the Newark Supergroup rocks include clams, crustaceans, and abundant insects, many of which include soft tissue and delicate features (e.g., wings and antennae) (*Figure 3.8*). These fragile organisms may have been so well preserved thanks to poorly oxygenated lake bottom waters that slowed decomposition, or because of saline and alkaline water chemistry, which may have discouraged predators and **bioturbation** (burrowing) that otherwise would have contributed to deterioration of the body parts. Plant remains can also be particularly abundant in these rift valley sediments, and include a variety of foliage types such as **cycad** fronds, ferns, **ginkgos**, and **conifers** (*Figure 3.9*).

***bioturbation** • the displacement of sediment and soil by animals or plants.*

***cycad** • a palm-like, terrestrial seed plant (tree) characterized by a woody trunk, a crown of stiff evergreen leaves, seeds without protective coatings, and no flowers.*

***ginkgo** • a terrestrial tree belonging to the plant division Ginkgophyta, and characterized by broad fan-shaped leaves, large seeds without protective coatings, and no flowers.*

***conifer** • a woody plant bearing cones that contain its seeds.*



Region 1

inland sea • *a shallow sea covering the central area of a continent during periods of high sea level.*

brachiopod • *a marine invertebrate animal characterized by upper and lower calcareous shell valves joined by a hinge, and a crown of tentacles (lophophore) used for feeding and respiration.*

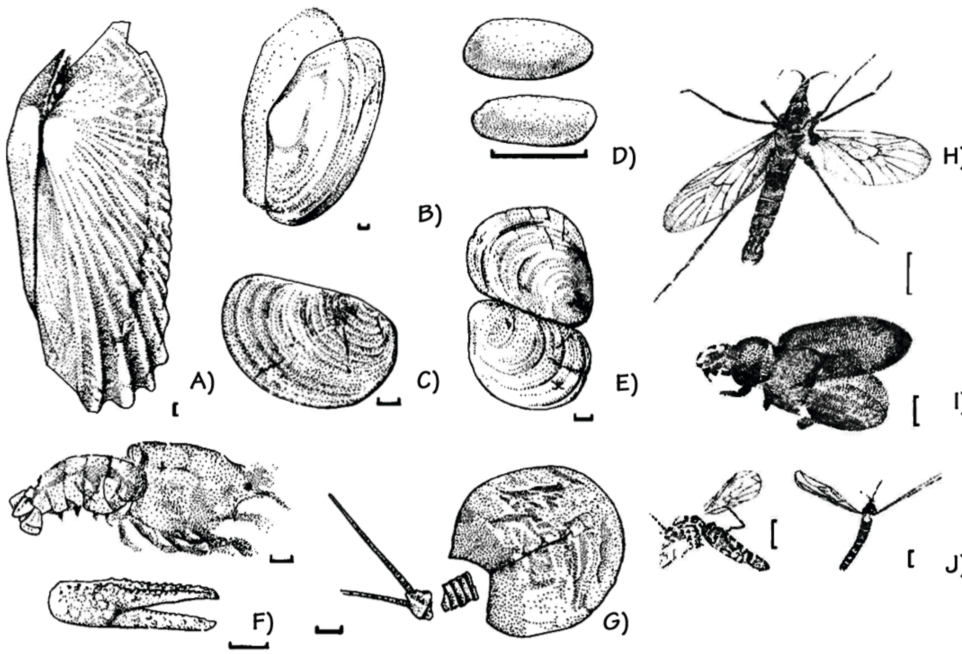


Figure 3.8. Fossil invertebrates from the lake sediments of the Newark Series in Virginia and North Carolina (scale bars = 1 millimeter [0.03 inches]). A) Diplodontid freshwater clam. B) Unionid freshwater clam. C) Cyzicus, *freshwater crustacean. D)* Darwinula, *ostracod. E) Corbiculid freshwater clam. F) Body and claw of the crustacean* Cytioclopsis. *G)* Triops, *notostracan crustacean. H) Dipterid insect. I) Beetle. J) Dipterid insects.*

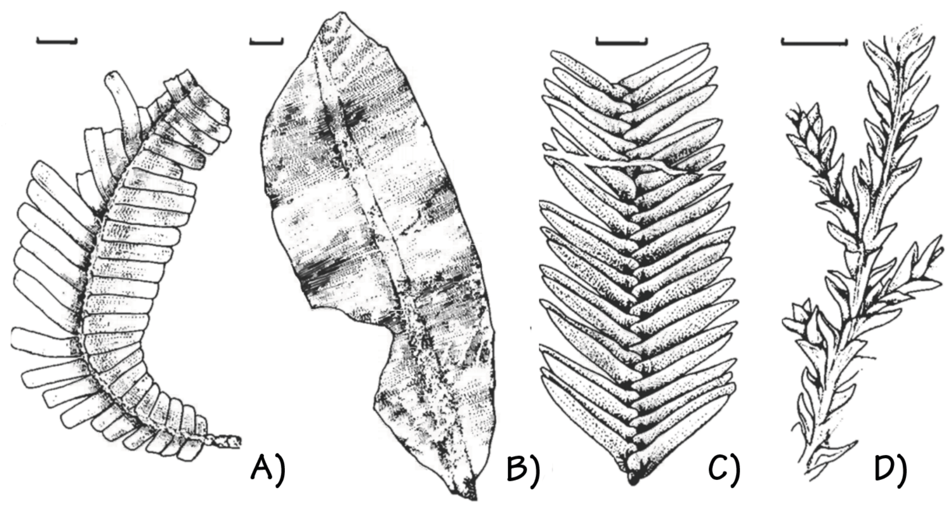
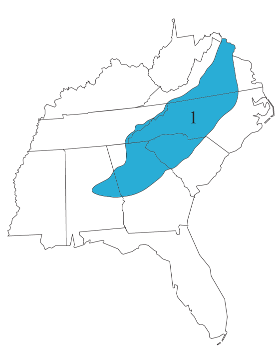


Figure 3.9: Fossil plants from the lake sediments of the Newark Series in Virginia and North Carolina (scale bars = 1 centimeter [0.4 inches]). A) Zamites powelli, *a cycadeoid. B)* Macrotaenipteris magnifolia, *a cycadeoid. C)* Otozamites *sp., a cycadeoid. D)* Pagiophyllum *sp., a conifer.*



Fossils 3

Region 2

Fossils of the Inland Basin
Region 2

The Inland Basin region primarily contains the story of Paleozoic mountain-building events, associated sediment deposited in the **inland sea**, and changes in relative sea level, superimposed on the evolution of Paleozoic marine and coastal plant life.

See Chapter 4: Topography to learn how changes in sea level influenced the Inland Basin's landscape.

Exposures of Cambrian rocks with fossils are uncommon in this region, but a few can still be found. The early Cambrian Antietam Sandstone of West Virginia and Virginia contains *Skolithos* trace fossils (*see Figure 3.19*), as well as occasional trilobites and **brachiopods**. Early Cambrian fossils, especially trilobites, are also found in western Virginia, eastern Tennessee, and northwestern Georgia (*Figure 3.10*). In eastern Tennessee (near Knoxville), trilobite trace fossils are common in Cambrian rocks that appear to have been deposited in intertidal environments (*Figure 3.11*).

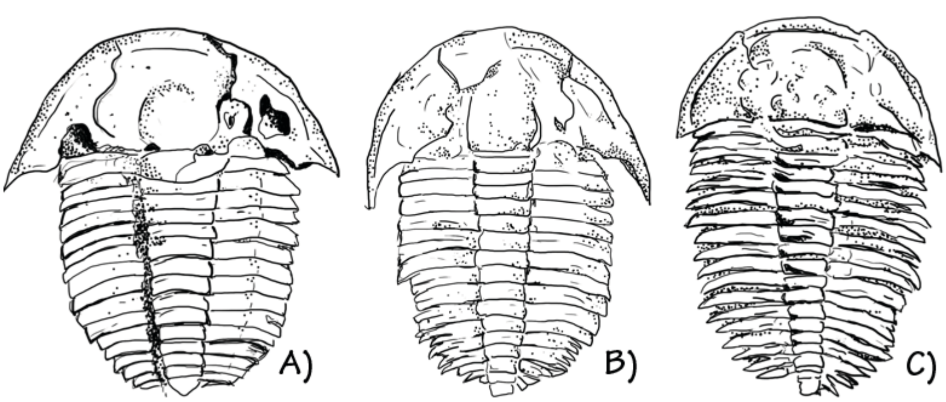


Figure 3.10: Cambrian trilobites from northwestern Georgia and northeastern Alabama. A) Elrathia antiquata*, approximately 2 centimeters (0.8 inches) long. B)* Aphelaspis brachyphasis*, approximately 2.5 centimeters (1 inch) long. C)* Modocia sp.*, approximately 2 centimeters (0.8 inches) long.*

Shales and **concretions** in the middle Cambrian Conasauga Formation of northeastern Alabama and northwestern Georgia contain body and trace fossils showing the preservation of diverse soft-bodied organisms, as well as many mineralized skeletons. These include algae, **sponges**, **arthropods**, brachiopods, **echinoderms**, mollusks, and trace fossils. Some of the most curious Conasauga fossils are "star cobbles," referred to the genus *Brooksella* (*Figure 3.12*). These enigmatic fossils have been variously thought of as medusae (jellyfish), algae, trace fossils, or inorganic structures. Recent research suggests, however, that they are most likely sponges with **siliceous** (SiO_2) skeletons.

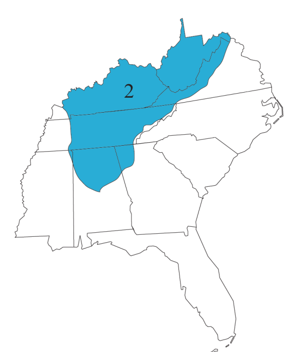
shale • *a dark, fine-grained, laminated sedimentary rock formed by the compression of successive layers of silt- and clay-rich sediment.*

concretion • *a hard, compact mass, usually of spherical or oval shape, found in sedimentary rock or soil.*

sponge • *a marine invertebrate belonging to the Phylum Porifera, and characterized by a soft shape with many pores and channels for water flow.*

arthropod • *an invertebrate animal, belonding to the Phylum Arthropoda, and posessing an external skeleton (exoskeleton), body segments, and jointed appendages.*

echinoderm • *a member of the Phylum Echinodermata, which includes starfish, sea urchins, and crinoids.*



Region 2

silica • *a chemical compound also known as silicon dioxide (SiO_2).*

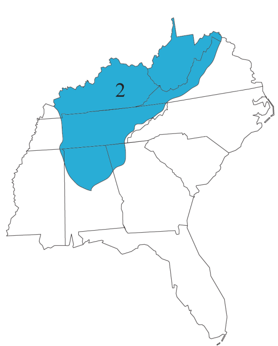
Ordovician • *a geologic time period spanning from 485 to 443 million years ago.*

Silurian • *a geologic time period spanning from 443 to 419 million years ago.*

Devonian • *a geologic time period spanning from 419 to 359 million years ago.*

graptolite • *an extinct colonial invertebrate animal characterized by individuals housed within a tubular or cup-like structure.*

crinoid • *a marine invertebrate animal characterized by a head (calyx) with a mouth surrounded by feeding arms.*



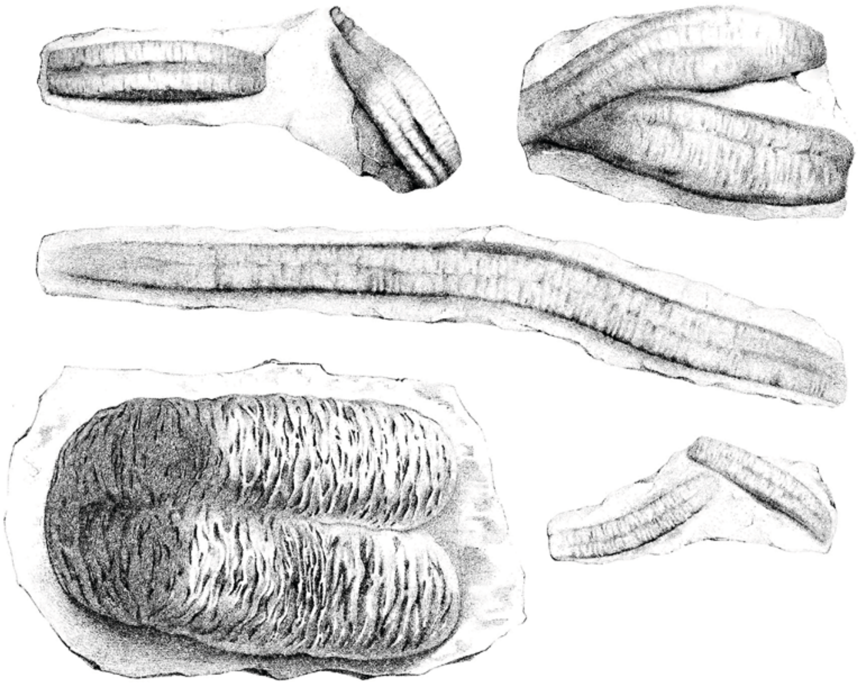


Figure 3.11: Trace fossils commonly associated with trilobites. Rusophycus *are resting traces, recording the outline of the organism while it remains still.* Cruziana *are elongate, bilaterally symmetrical paths with repeated striations, recording the animal's movement through the mud.*

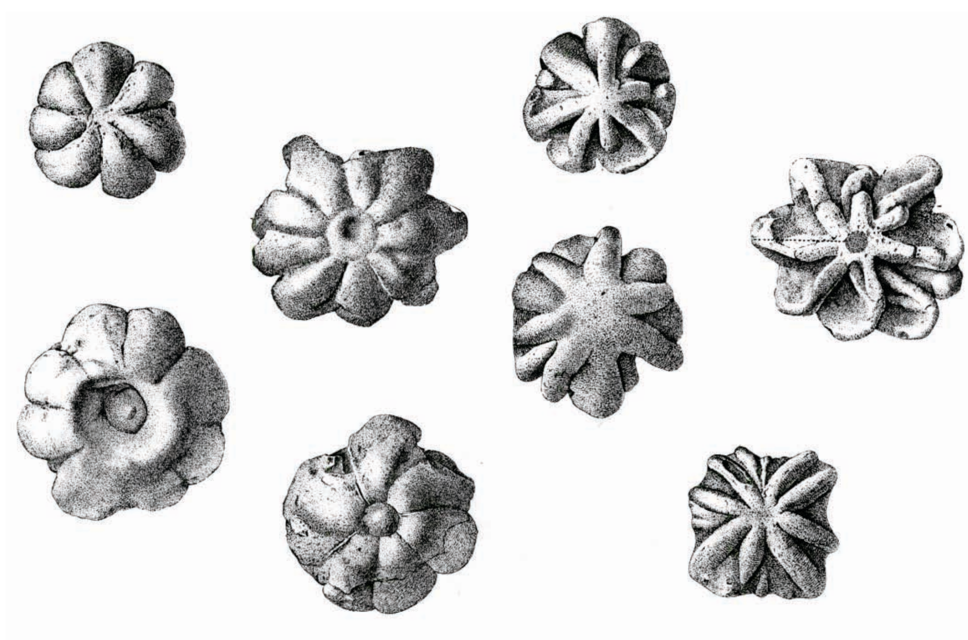


Figure 3.12: "Star cobbles" (Brooksella) *from the Cambrian Conasauga Formation. Fossils are 2.5–5 centimeters (1–2 inches) across.*

Fossils

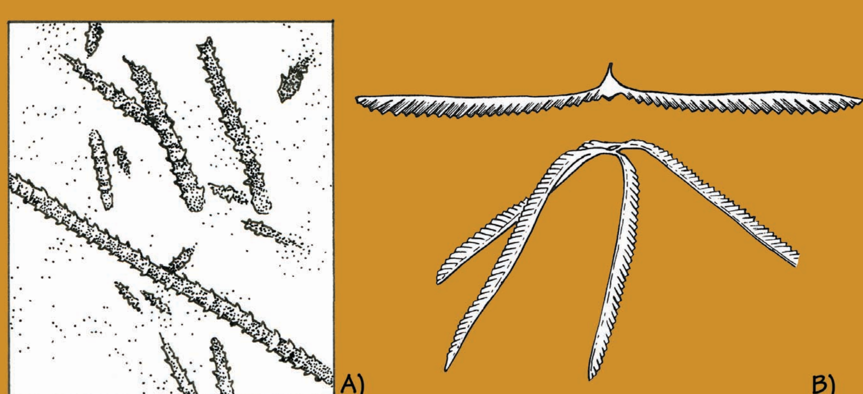
3

Region 2

Ordovician, **Silurian**, and **Devonian** marine fossils are widespread in the Inland Basin and are typically abundant, diverse, and beautifully preserved. These fossil assemblages are nearly always dominated by brachiopods, but also contain trilobites, **graptolites**, corals, clams, **crinoids**, *Skolithos*, and many others (*Figures 3.13–3.16*). Middle Ordovician **limestones** in Tennessee are well known for containing numerous crinoids and fossils of the large **gastropod** *Maclurites* (*Figure 3.17*). In Kentucky and Tennessee, trilobites, brachiopods, **bryozoans**, corals, and the distinctive sponge *Brachiospongia* are also found in Ordovician rocks (*Figure 3.18*). Late Ordovician fossils are abundant in central Tennessee (around Nashville), central Kentucky (southeast of Louisville), and northern Kentucky; Ordovician limestones in the area around Strasburg, Virginia contain abundant trilobites (*see Figure 3.16*). The fossils are preserved as silica (SiO_2), and can therefore be extracted from the surrounding carbonate rock by treating it with dilute acid. This allows for the examination of delicate fossils that would otherwise be impossible to study.

Graptolites

Graptolites (meaning "rock writing") are an extinct group of colonial, free-floating organisms. They lived from the Cambrian to the Carboniferous, and were relatives of modern hemi*chordates* such as acorn worms. Graptolites are frequently preserved as thin, black, sawblade-like streaks across black shale; tiny cups along these structures held individual animals. Graptolites are often useful as index fossils.



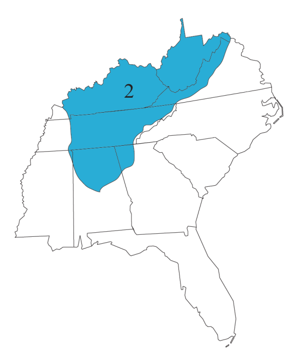
A) Specimen with many fragments of colonies of* Climacograptus*. Slab is 7.5 centimeters (3 inches) on each side. B) Restoration of what graptolite colonies may have looked like when they were alive and floating in the water.

limestone • *a sedimentary rock composed of calcium carbonate ($CaCO_3$).*

gastropod • *a marine, freshwater, or terrestrial invertebrate animal characterized by a single, coiled, calcareous shell, a muscular foot for gliding, and internal asymmetry caused by torsion.*

bryozoan • *a marine or freshwater colonial invertebrate animal characterized by an encrusting or branching calcareous skeleton from which multiple individuals (zooids) extend from small pores to filter-feed using crowns of tentacles (lophophores).*

chordate • *an animal that has a notochord, a hollow dorsal nerve cord, pharyngeal gill slits, an endostyle, and a post-anal tail during at least one stage of its development.*



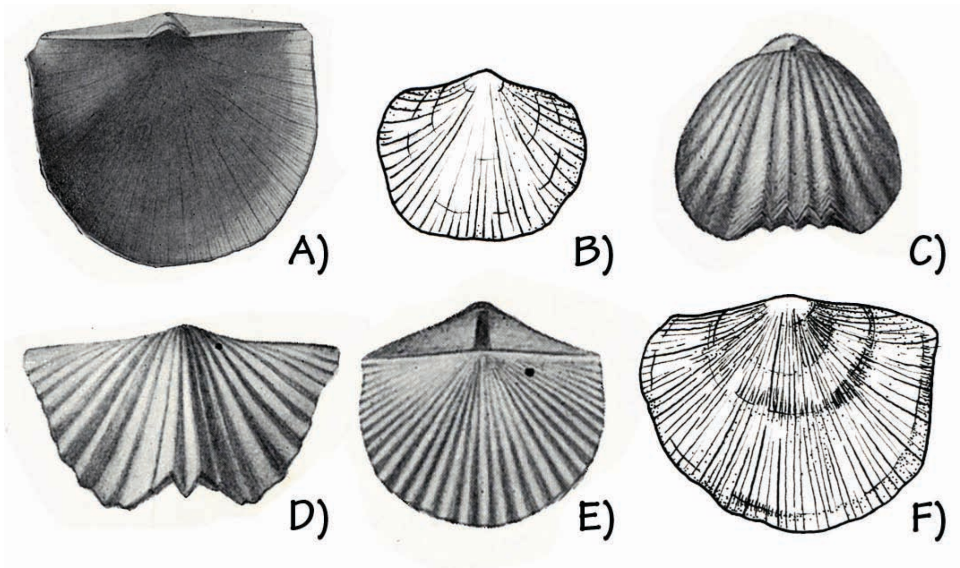


Figure 3.13: Common Ordovician brachiopods of the Interior Basin. A) Rafinesquina alternata*, approximately 4 centimeters (1.6 inches) wide. B)* Resserella *sp., approximately 1 centimeter (0.4 inches) wide. C)* Rhynchotrema capax*, approximately 1 centimeter (0.3 inches) wide. D)* Platystrophia laticosta*, approximately 2.5 centimeters (1 inch) wide. E)* Hesperorthis tricenaria*, approximately 1 centimeter (0.3 inches) wide. F)* Strophomena *sp., 1–2 centimeters (0.5–1 inch) wide.*

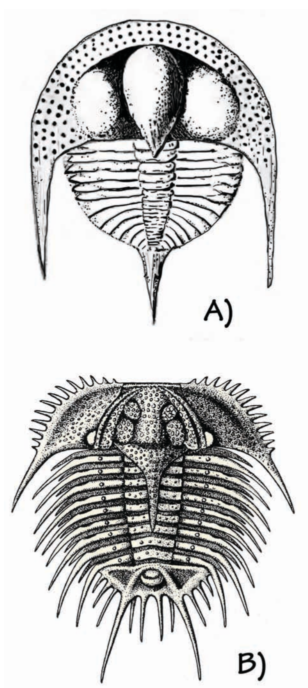


Figure 3.14: Ordovician trilobites of the Interior Basin. A) Trinucleus *sp., approximately 3 centimeters (1.5 inches) long. B)* Acidaspis rebecca*, 13 centimeters (5 inches) long.*

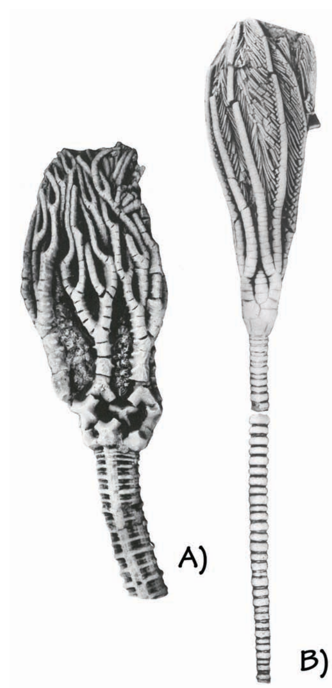
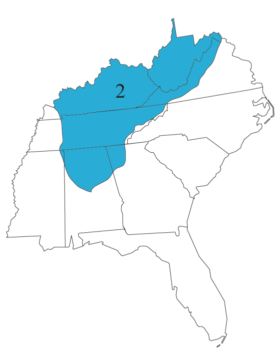
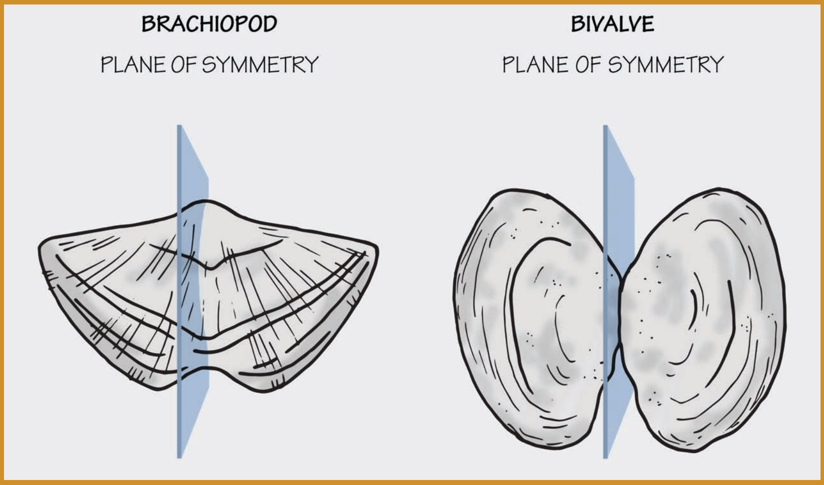


Figure 3.15: Crinoid calyces with arms and stem. A) Reteocrinus alveolatus*, approximately 6 centimeters (2.4 inches) long. B)* Cremacrinus *sp., approximately 16 centimeters (6.3 inches) long.*

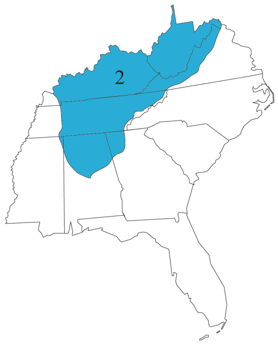


Brachiopods

Brachiopods are filter-feeding animals that have two shells and are superficially similar to bivalves (such as clams). Instead of being mirror images between shells (symmetrical like your hands), brachiopod shells are mirror images across each shell (symmetrical like your face). There are two major types of brachiopod shells, distinguished by how the two valves connect to each other: articulate brachiopods have tooth-and-socket hinges that tightly interlock, whereas inarticulate brachiopod shells lack hinge structures entirely. Internally, brachiopods are substantially different from bivalves, with a lophophore (filter-feeding organ made of thousands of tiny tentacles), and a small and simple gut and other organs. Bivalves, in contrast, have a fleshier body and collect their food with large gills.



The difference between the shells of a typical brachiopod (left) and a typical bivalve mollusk (right). Most brachiopods have a plane of symmetry across the valves (shells), whereas most bivalves have a plane of symmetry between the valves.



3 Fossils

Region 2

iron • *a metallic chemical element (Fe).*

hematite • *a mineral form of iron oxide (Fe_2O_3), with vivid red pigments that make it valuable as a commercial pigment.*

reef • *a feature lying beneath the surface of the water, which is a buildup of sediment or other material built by organisms, and which has positive relief from the sea floor.*

stomatoporoid • *a type of calcareous sponge that acted as an important reef-builder throughout the Paleozoic and the late Mesozoic.*

Mississippian • *a subperiod of the Carboniferous, spanning from 359 to 323 million years ago.*

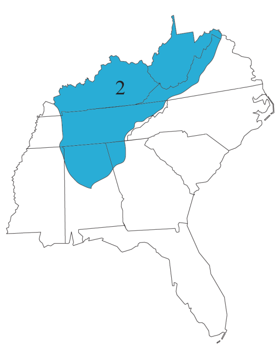


Figure 3.16: Slab of trilobites, Homotelus *sp., Ordovician of Virginia, approximately 38 centimeters (15 inches) across.*

Figure 3.17: Gastropod, Maclurites *sp. Fossils are approximately 2.5–5 centimeters (1–2 inches) across.*

In Alabama, the Silurian Red Mountain Formation, which is rich in the **iron** mineral **hematite**, contains significant **reefs** made largely of **stromatoporoid** sponges. *Skolithos* can be found throughout Silurian deposits in Tennessee (*Figure 3.19*), while Silurian deposits in Virginia contain abundant corals and brachiopods (*Figure 3.20*). Early to middle Devonian marine fossils are spectacularly exposed in the 390-million-year-old rocks at Falls of the Ohio in northern Kentucky. These beds of limestone are among the largest naturally exposed Devonian fossil deposits in the world, packed with the skeletal remains of countless corals, stromatoporoid sponges, echinoderms, brachiopods, mollusks, arthropods, and microscopic organisms. Well-preserved Devonian marine invertebrate fossils also occur in Tennessee, Virginia, and West Virginia (*Figure 3.21*).

See Chapter 5: Mineral Resources to learn about Alabama's iron and steel industry.

Mississippian limestones from West Virginia to Alabama contain numerous fossils, including corals, gastropods, **bivalves**, bryozoans, **blastoids** (*Figure 3.22*), and fossilized **shark** teeth. In fact, West Virginia's official state "**gemstone**" is *Lithostrotionella*, a Mississippian fossil coral from the Hillsdale Limestone found in portions of Greenbrier and Pocahontas counties. Crinoids are especially abundant (*Figure 3.23*); the Mississippian is sometimes referred to as the "age of crinoids," because they were so abundant that entire rocks are made up of bits of their **calcite** skeletons. **Carboniferous** trilobites have also been found in northwestern Georgia and northern West Virginia.

See Chapter 2: Rocks for a list of state rocks, minerals, and gems.

Sponges

Sponges (Phylum Porifera) are the simplest major group of animals; their earliest fossils appear in the late Precambrian. Most modern sponges live in the ocean and usually have basket-shaped bodies. They live by filtering food and oxygen out of water pumped in through openings in their body walls and out through a larger opening at the top. The familiar bath sponge has no mineralized skeleton, but many other kinds of sponges have skeletons composed of tiny structures called *spicules*, which are made of *calcium carbonate* ($CaCO_3$) or silica (SiO_2). It is these skeletonized sponges that have the greatest likelihood of becoming fossils. Over their long history, such sponges have frequently been important contributors to reefs and reef-like mounds.

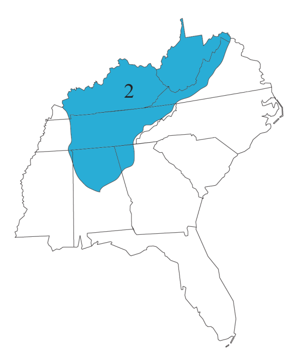
bivalve • *a marine or fresh-water invertebrate animal characterized by right and left calcareous shells (valves) joined by a hinge.*

blastoid • *an extinct form of stemmed echinoderm, similar to crinoids, possessing a nut-shaped body covered with interlocking plates.*

shark • *a large fish characterized by a cartilaginous skeleton and five to seven gill slits on the side of the head.*

gemstone • *a mineral that has aesthetic value and is often cut and polished for use as an ornament.*

calcite • *a carbonate mineral, consisting of calcium carbonate* ($CaCO_3$).

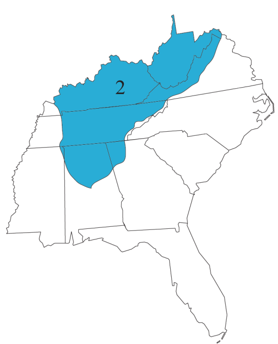


sessile • *unable to move, as in an organism that is permanently attached to its substrate.*

rugose coral • *an extinct group of corals that were prevalent from the Ordovician through the Permian.*

tabulate coral • *an extinct form of colonial coral that often formed honeycomb-shaped colonies of hexagonal cells.*

scleractinian coral • *a colonial or solitary marine invertebrate animal characterized by an encrusting calcareous skeleton enclosing polyps that capture prey with small tentacles equipped with stinging cells (nematocysts).*



Bryozoans

Bryozoans are colonial invertebrates, many of which build elaborate skeletons of calcium carbonate. Bryozoans are common in today's oceans, where they are frequently found encrusting rocks or shells. During the Paleozoic era, however, bryozoans commonly grew off of the sea floor as erect structures. After they died, their skeletons accumulated into thick beds of limestone. Although they do not appear to be, bryozoans are actually closely related to brachiopods—both groups have the same distinctive feeding and respiratory structure, the lophophore.

Corals

Corals are *sessile* relatives of jellyfish and sea anemones. They possess stinging tentacles, which they use to feed on small planktonic prey. Each group of coral possesses distinctly shaped "cups" that hold individual animals, or polyps. Colonial corals live in colonies of hundreds or even thousands of individuals that are attached to one another. Solitary coral lives independently, as a single isolated polyp.

***Rugose corals* were both colonial and solitary. (Solitary forms are often called "horn corals.") *Tabulate corals* were exclusively colonial and produced a variety of shapes, including sheetlike and chainlike forms. These corals receive their name from the table-like horizontal partitions within their chambers. Both rugose and tabulate corals went extinct at the end of the Permian. Modern corals—*scleractinians*—first appeared in the Triassic, and include both solitary and colonial species. Many scleractinian corals have photosynthetic symbiotic algae in their tissues, called zooxanthellae. This algae provides nutrition to the coral polyps, helping them to grow more rapidly.**

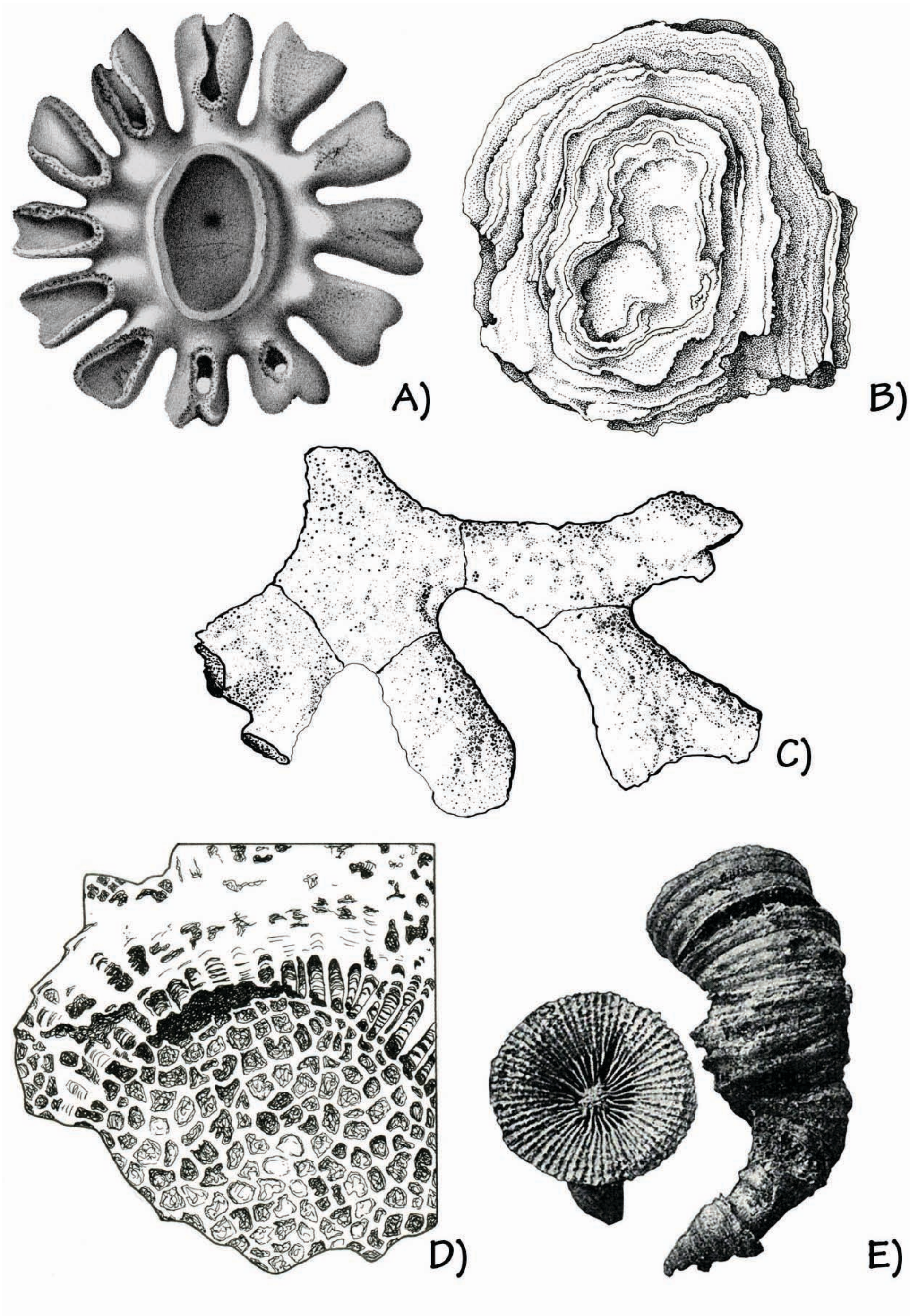


Figure 3.18: Common Ordovician reef-building organisms of the Interior Basin. A) Sponge, Brachiospongia digitata*, approximately 25 centimeters (10 inches) wide. B) Stromatoporoid sponge, approximately 30 centimeters (12 inches) across. C) Bryozoan,* Dekayia aspera*, approximately 1 inch (2.54 centimeters) across. D) Tabulate coral,* Favistella *sp., approximately 8 centimeters (3.2 inches) wide. E) Solitary rugose ("horn") coral,* Heliophyllum juvenae*, approximately 15 centimeters (6 inches) tall.*

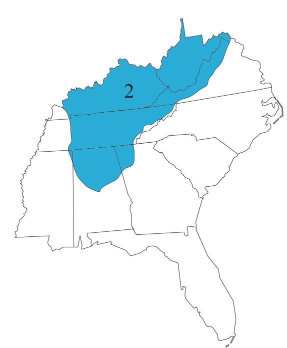


Figure 3.19: Skolithos *burrows from the lower Silurian Clinch Formation at Clinch Mountain, Tennessee. Rocks with abundant* Skolithos *are sometimes called "pipe rock." The organism that made these burrows is unknown, but their shape suggests a worm-like creature that lived in the vertical burrows. Rock containing burrows is approximately 15 x 30 centimeters (6 x 12 inches).*

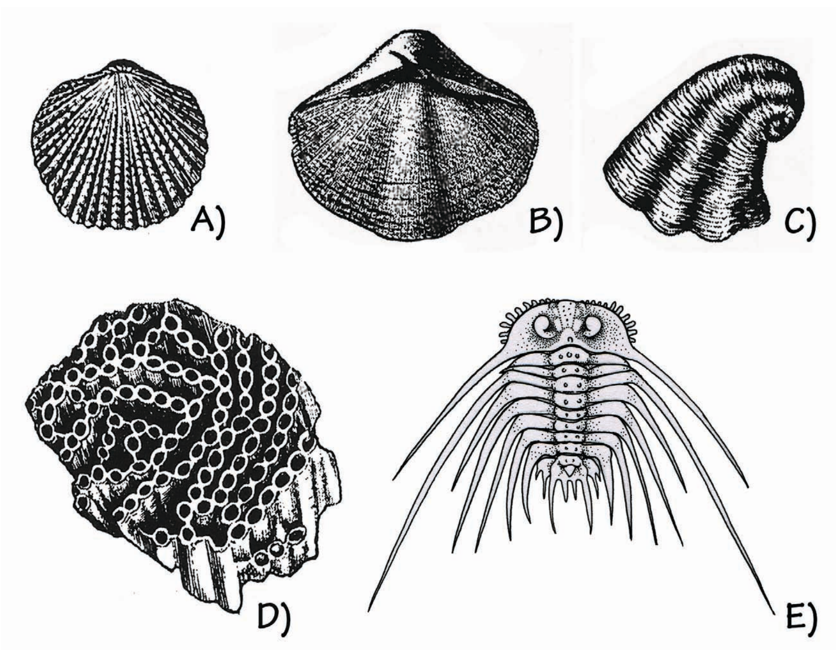
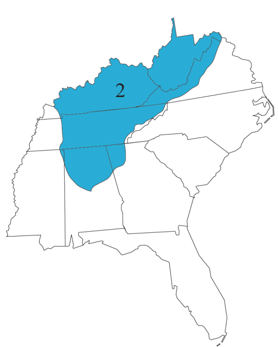


Figure 3.20: Common Silurian marine invertebrates of the Interior Basin region. A) Brachiopod, Atrypa nodostriata*, approximately 2.5 centimeters (1 inch) wide. B) Brachiopod,* Spirifer radiatus*, approximately 4 centimeters (1.6 inches) wide. C) Gastropod,* Platyceras angulatum*, 1–4 centimeters (0.5–1.5 inches) tall. D) Tabulate coral,* Halysites *sp., 15–20 centimeters (6–8 inches) wide. E) Trilobite,* Leonaspis williamsi*, approximately 3 centimeters (1.2 inches) long.*



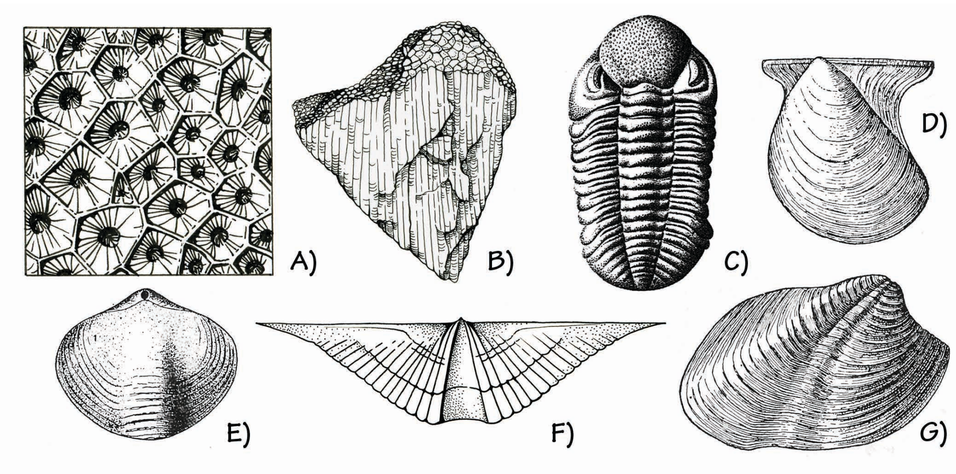


Figure 3.21: Common Devonian marine invertebrates of the Interior Basin region. A) Colonial rugose coral, Hexagonaria*, field of view approximately 2.5 centimeters (1 inch) wide. B) Tabulate coral,* Favosites*, 1–4 centimeters (0.4–1.5 inches) wide. C) Trilobite,* Eldredgeops rana*, approximately 2.5 centimeters (1 inch) long. D) Bivalve,* Leiopteria*, approximately 5 centimeters (2 inches) tall. E) Brachiopod,* Athyris spiriferoides*, approximately 2.5 centimeters (1 inch) tall. F) Brachiopod,* Mucrospirifer mucronatus*, 2–5 centimeters (1–2 inches) wide. G) Bivalve,* Grammysia*, approximately 4 centimeters (1.5 inches) wide.*

Sharks and bony fishes evolved rapidly during the Devonian and Carboniferous periods, and their fossils can sometimes be found in the rocks of the Inland Basin. Fossils of heavily armored bony fishes called **placoderms** are found in Kentucky and Tennessee, including the enormous *Dunkleosteus* (*Figure 3.24*). The teeth of sharks, which first appeared in the late Silurian period, are also preserved in these rocks (*Figure 3.25*). Among these are the bizarre and puzzling coiled tooth whorls of **edestid** sharks—these are sometimes found in shales overlying **coal** seams, indicating that the sharks inhabited shallow waters near shore.

The oldest known fossils of land plants are isolated spores dating to the Ordovician period. By the late Silurian, fossils of simple, leafless stems just a few centimeters tall are found in sediments that accumulated in low, wet, coastal environments. The first **trees** date to the early part of the Devonian period, and the first seeds to the middle Devonian; Devonian plant fossils are found in northeastern Alabama (Cherokee County). By the end of the Devonian, extensive forests containing many different kinds of trees and other plants had developed, and this continued into the Carboniferous period that followed. During the Mississippian and (especially) the **Pennsylvanian**, what is now the Interior Basin region of the Southeast was a broad, low coastal plain near the Equator and home to extensive swampy forests.

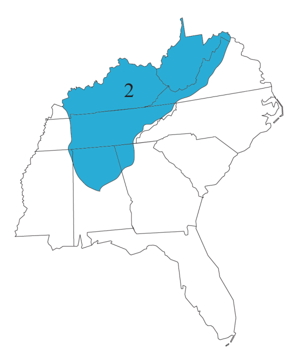
placoderms • *an extinct class of heavily armored fishes.*

edestid • *a member of a group of primitive sharks from the Carboniferous period known for their "tooth-whorls."*

coal • *a combustible, compact black or dark-brown carbonaceous rock formed by the compaction of layers of partially decomposed vegetation.*

tree • *any woody perennial plant with a central trunk.*

Pennsylvanian • *a subperiod of the Carboniferous, spanning from 323 to 299 million years ago.*



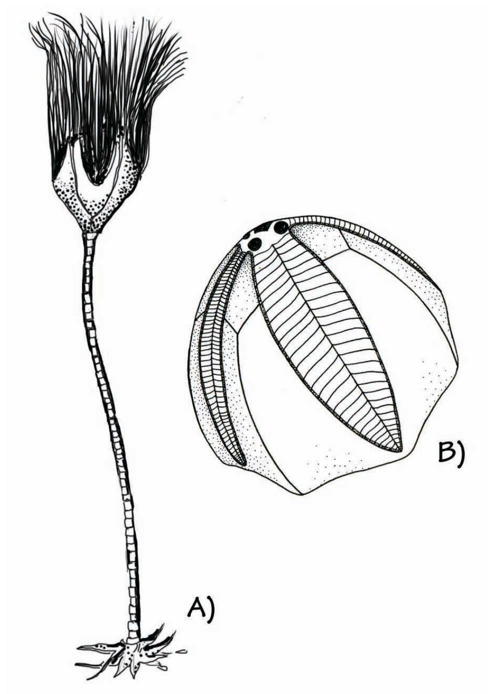
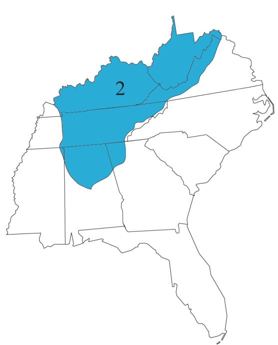


Figure 3.22: Blastoid, Pentremites *sp. Blastoids were a group of stalked echinoderms similar to crinoids. The calyx of a blastoid did not have long arms, but instead a series of holes called brachioles that held much shorter arms. A) Restoration, approximately 15 centimeters (6 inches) tall. B) Calyx.*

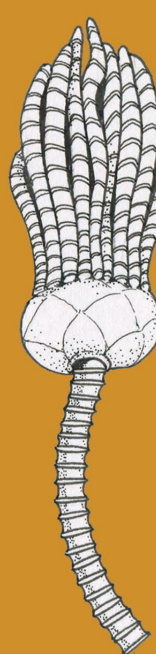
Figure 3.23: Gilbertsocrinus typus, *a crinoid from the Mississippian Borden Formation of north-central Kentucky, 8.5 centimeters (3.4 inches).*



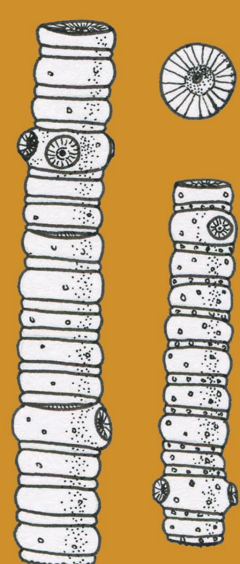
calyx • the head of a crinoid.

Crinoids

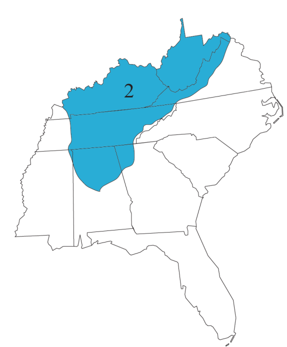
Crinoids are echinoderms, related to sea urchins and sea stars. These invertebrate animals feed by using their arms to filter food out of the water. Most are attached to the sediment by a stalk that ends in a root-like structure called the holdfast—some forms, however, are free floating. Crinoid fossils are most commonly found as "columnals," pieces of the stalk that hold the head (*calyx*) above the surface. The calyx and the holdfast are only occasionally preserved as fossils. Crinoids are still around today; those in shallow water are mostly stalkless, while those with stalks are restricted to deep water.



Crown and stem, about 15 centimeters (6 inches) long.



Stem fragments.



Fossils

Region 2

lycopod • *an extinct, terrestrial tree characterized by a tall, thick trunk covered with a pattern of diamond-shaped leaf scars, and a crown of branches with simple leaves.*

sphenopsid • *a terrestrial plant characterized by hollow, jointed stems with reduced, unbranched leaves at the nodes.*

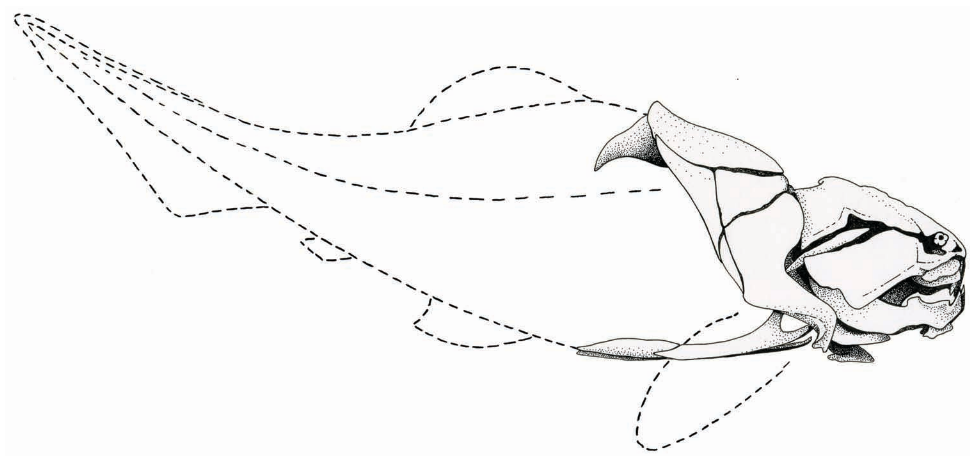


Figure 3.24: The giant Devonian placoderm fish Dunkleosteus. *The dotted lines show the inferred shape of the unpreserved part of the body. Total length was probably approximately 9 meters (30 feet).*

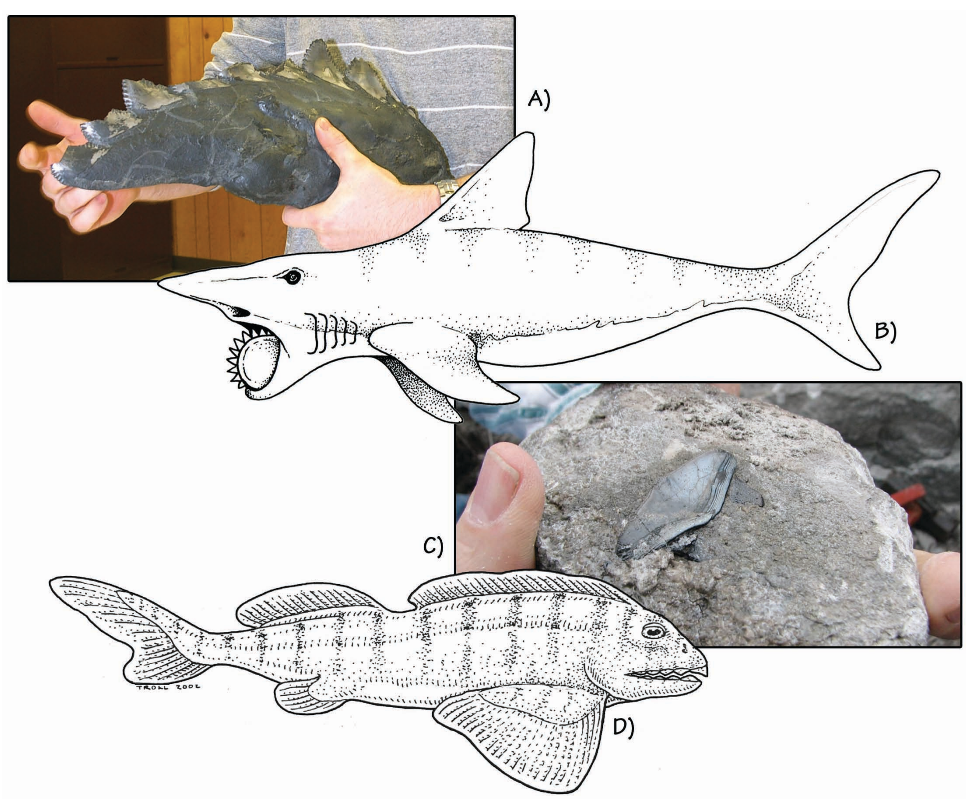
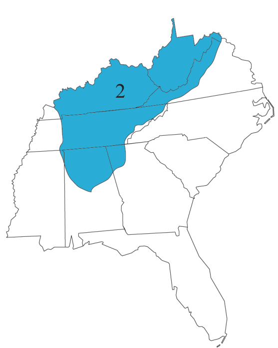


Figure 3.25: Carboniferous sharks. A) Jaw of the bizarre Pennsylvanian shark Edestus, *discovered in a coal mine in Webster County, Kentucky, 210 meters (700 feet) below the surface. B) Restoration of* Helicoprion, *an edestid shark, 3–4 meters (10–13 feet) long. C) Tooth of the Mississippian shark* Petalodus, *from Morgan County, Alabama. D) Restoration of* Petalodus, *approximately 1 meter (3 feet) long.*



The swamp forests that grew on Carboniferous coastal plains west of the Appalachian Mountains were dominated by four major groups of plants, each of which had independently evolved the style of growth known as the tree (a plant held erect by a single stem made of a stiff tissue called wood). The trees found in these forests, however, did not belong to the familiar groups that dominate modern forests, such as conifers and flowering broadleaf trees. Instead, these early forests were built by groups of plants that are either extinct or much less conspicuous today (*Figures 3.26 and 3.27*). These groups were the **lycopods** (club mosses), the **sphenopsids** (horsetails), the ferns, and the **cordaites**. Lycopods and horsetails survive today, but only as small, non-woody herbaceous plants. Tree ferns still grow today, but only in relatively restricted environments such as permanently moist subtropical forests. Cordaites are extinct.

The Carboniferous coal swamps were also home to a great diversity of animals, including insects, amphibians, and early reptiles (*Figures 3.28 and 3.29*). Although fossil bones have been found in Mississippian and Pennsylvanian rocks in West Virginia, Virginia, and Alabama, trace fossils are more common. One particular trackway site in Walker County, Alabama is one of the largest known Carboniferous tracksites in the world.

The Interior Basin contains no fossil-bearing outcrops of **Mesozoic** age. It does, however, have a rich fossil record from the Neogene, including numerous sites at which **Pleistocene** and older terrestrial vertebrates have been found. For instance, the Gray Fossil Site is located near the small town of Gray in

Fossils and Coal

Coal is technically a metamorphic rock formed of highly *compressed* and altered peat. As is the case in most metamorphic rocks, this alteration (sometimes called *coalification*) means that coal itself does not usually contain well-preserved plant fossils. Instead, we learn about the plants that make up coal from two kinds of fossils: impressions and compressed plant parts left in shales deposited above or below coal seams, and coal balls, which are masses of calcium carbonate that crystalize inside coals from minerals dissolved in groundwater, protecting the plants they contain from alteration. Coal balls are usually studied by slicing them with a saw, polishing the sliced surfaces, and then making peels of the surface using sheets of acetate. These coal-ball peels are then examined under a microscope. See Chapter 6: Energy for more information on coal in the Southeast.

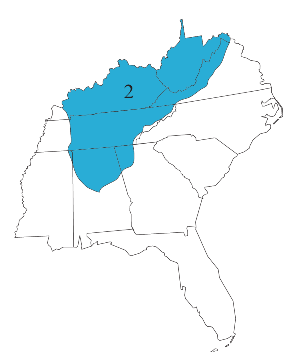
cordaite • *a member of the group Cordaitales, which were closely related to early members of the conifers.*

Mesozoic • *a geologic time period that spans from 252 to 66 million years ago.*

Pleistocene • *a subset of the Quaternary, lasting from 2.5 million to about 11,700 years ago.*

compression • *flattening or squeezing as a result of forces acting on an object from all or most directions.*

coalification • *the process by which coal is formed from plant materials through compression and heating over long periods of time.*



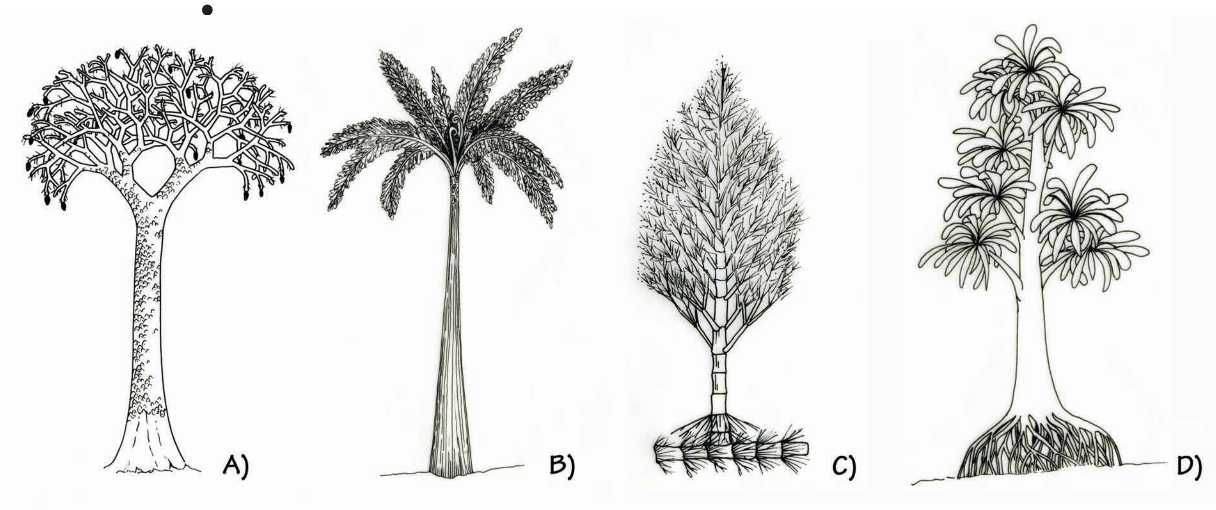


Figure 3.26: Restorations of Pennsylvanian coal swamp trees. A) Lepidodendron*, a lycopod (club moss), reached 30 meters (100 feet) tall. B)* Psaronius*, a tree fern, reached 3 meters (10 feet) tall. C)* Calamites*, a sphenopsid (horsetail), reached 20 meters (65 feet) tall. D)* Cordaites*, a conifer-like seed plant; reached 10 meters (35 feet) tall.*

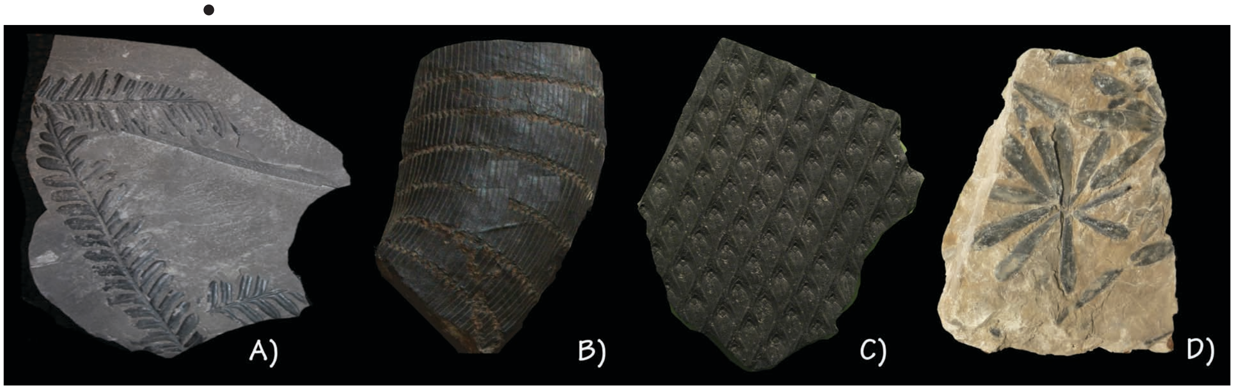
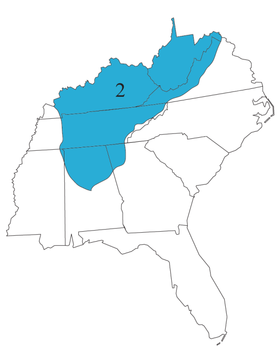


Figure 3.27: Coal swamp plant fossils. A) Seed fern frond, Alethopteris*, slab approximately 10 x 10 centimeters (4 x 4 inches). B)* Calamites *trunk, approximately 25 centimeters (10 inches) tall. C) Lycopod bark impression,* Lepidodendron *sp. Pennsylvanian lycopods reached huge sizes, up to 50 meters (150 feet) tall and 1 meter (3 feet) in diameter. D) Cordaite leaves,* Cordaites *sp., slab approximately 1.2 meters (4 feet) long.*



Washington County, northeastern Tennessee. It was discovered in 2000, when a road project unearthed fossil bones in a thick bed of **clay** that had apparently accumulated in a flooded sinkhole. Subsequent excavation revealed the bones of numerous species of mammals, reptiles, and amphibians. The particular species present constrain the age of the surficial fossil-bearing layer to the late **Miocene** (7–4.5 million years ago). The fossils recovered from the site so

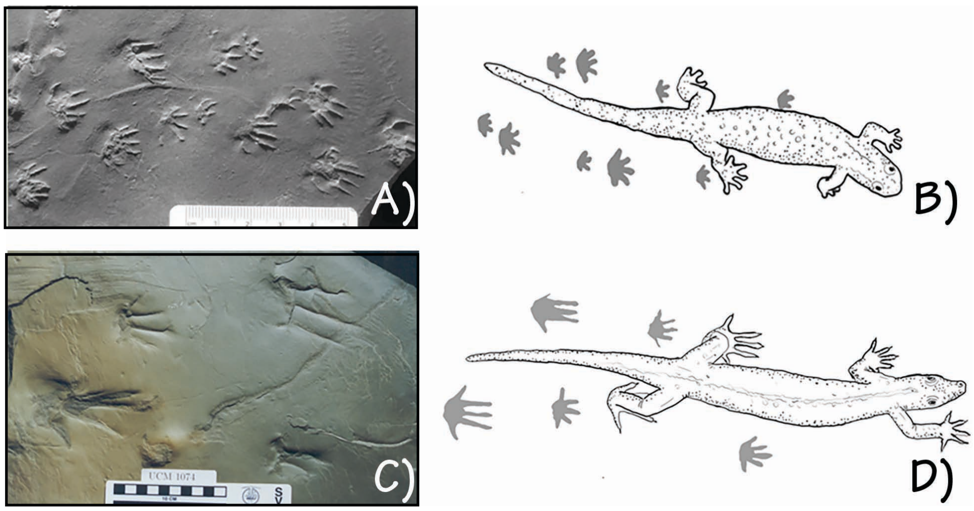


Figure 3.28: Some Pennsylvanian coal swamp animals, represented by fossils from the Union Chapel Mine site in northern Alabama. A) and B) Trackway and restoration of an amphibian, Nanopus reidiae*. Length of animal is approximately 15 centimeters (6 inches). C) and D) Trackway and restoration of an early reptile,* Attenosaurus subulensis*. Length of animal is approximately 1 meter (3 feet).*

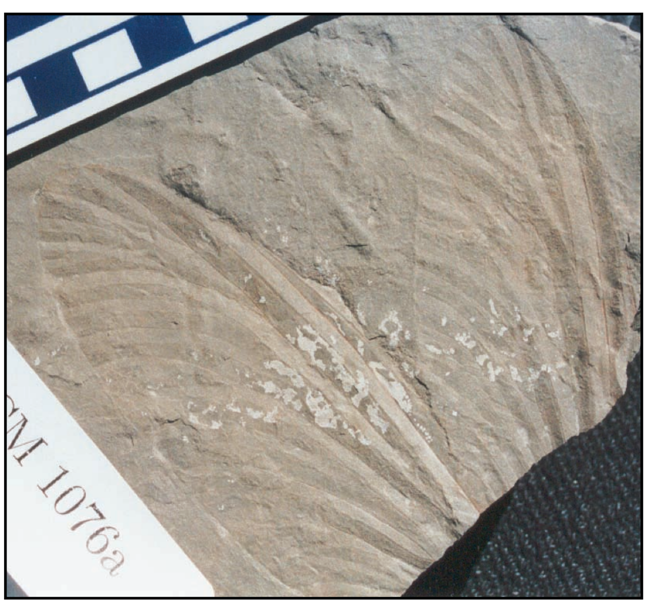
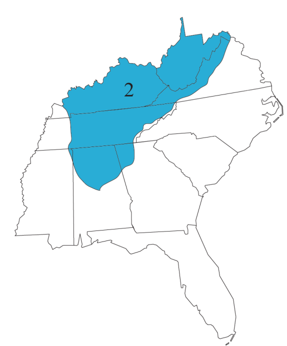


Figure 3.29: Wings of the insect Anniedarwinia alabamensis*. Scale above is in centimeters.*

clay • *the common name for a number of very fine-grained, earthy materials that become plastic (flow or change shape) when wet.*

Miocene • *a geological time unit extending from 23 to 5 million years ago.*

far are noteworthy for other reasons. The site is the world's largest fossil tapir find; it also contains the most complete skeleton of *Teleoceras* (an ancient rhinoceros) found in eastern North America, as well a new species of red panda that marks only the second (and most complete) record of this group in North America (*Figures 3.30 and 3.31*). Other fossil mammals present at the Gray Site include shrews, moles, rabbits, rodents, weasels, short-faced bears, sabertoothed cats, shovel-tusked elephants (gomphotheres), camels, peccaries, ground sloths (*Figure 3.32*), and three-toed horses.



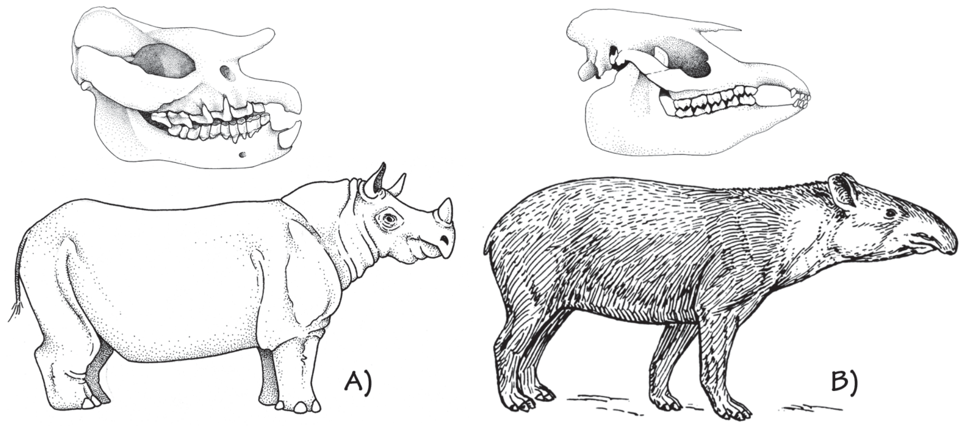


Figure 3.30: Common mammals found at the Gray fossil site in Washington County, Tennessee. A) Skull and life restoration of the rhinoceros Teleoceras, *body approximately 4 meters (13 feet) long. B) Skull and life restoration of a tapir, such as those found in Miocene sediments; skull is approximately 30 centimeters (12 inches) long.*

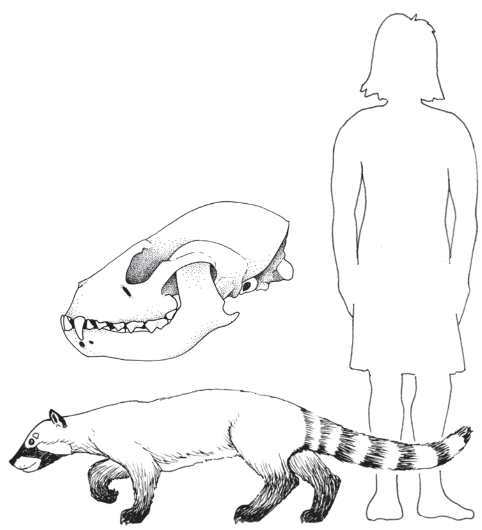


Figure 3.31: Skull and life restoration of an extinct species of red panda, Pristinailurus bristoli.

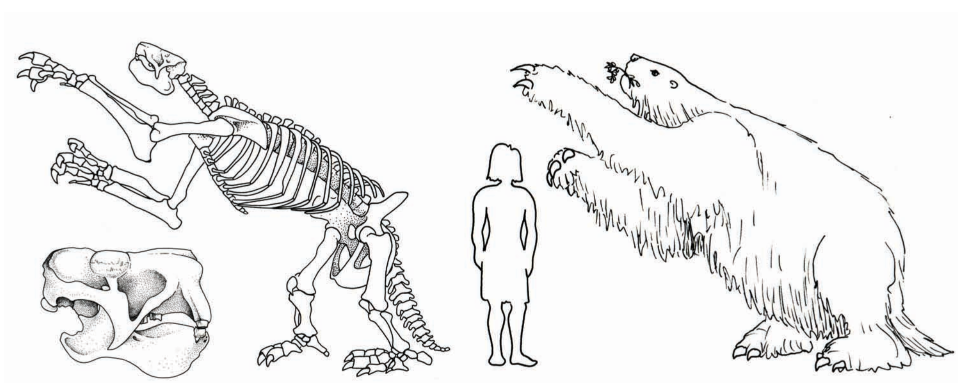
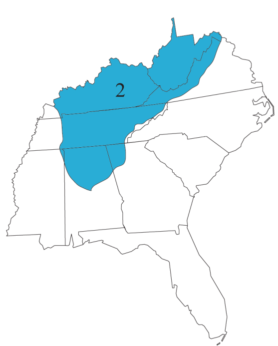


Figure 3.32: Skeleton, skull, and life restoration of the giant sloth Megatherium, *which lived throughout the Southeastern states during the Pleistocene. Skull is approximately 60 centimeters (24 inches) long.*



Bones of Pleistocene mammals are widespread and locally abundant throughout Kentucky, Tennessee, western Virginia and West Virginia, and northern Alabama. They occur mainly in caves, sinkholes, and boggy deposits, and include **mastodons**, **mammoths**, giant sloths, and peccaries. Fossils of bats from the late Pleistocene (38,000 years ago) have been found in guano deposits in Mammoth Cave, Kentucky. Perhaps the most famous Pleistocene mammal site in the region is Big Bone Lick, located less than 2 kilometers (1.2 miles) south of the Ohio River in Boone County, Kentucky (*Figure 3.33*). Big Bone Lick is sometimes called the "birthplace of American vertebrate paleontology" because the first published illustration of a mastodon fossil (in 1756) was based on a tooth collected there. US President Thomas Jefferson acquired fossils from the site in 1808 that eventually ended up at the Academy of Natural Sciences of Philadelphia, the Natural History Museum in Paris, and as part of Jefferson's personal collection at Monticello. Big Bone Lick gets its name from the large number of natural **salt** springs, or **salt licks**, in the area. During the late Pleistocene, these saline springs attracted numerous large mammals, many of which died and were buried there. The fauna includes an extinct horse (*Equus complicatus*), two giant ground sloths (*Megalonyx jeffersonii* and *Paramylodon harlani*), mammoths (*Mammuthus* sp.), mastodons (*Mammut americanum*), and caribou (*Rangifer tarandus*). **Radiocarbon dating** shows that the age of the bones at Big Bone Lick are between 11,000 and 12,300 years old.

See Chapter 4: Topography to learn more about Mammoth Cave and other karst formations in the Southeast.

Figure 3.33: Entryway sign at Big Bone Lick, Kentucky.

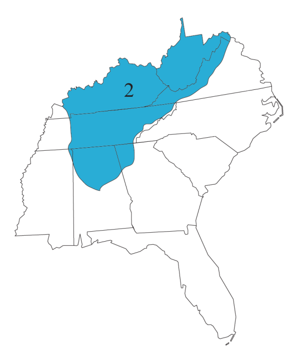
mastodon • *an extinct terrestrial mammal belonging to the Order Proboscidea, characterized by an elephant-like shape and size, and massive molar teeth with conical projections.*

mammoth • *an extinct terrestrial mammal belonging to the Order Proboscidea, from the same line that gave rise to African and Asian elephants.*

salt • *a mineral composed primarily of sodium chloride (NaCl).*

salt lick • *a naturally occurring salt deposit that animals regularly lick.*

radiocarbon dating • *a method of determining the age of a biological object by measuring the ratio of carbon isotopes ^{14}C and ^{12}C.*



Region 3

Cretaceous • *a geologic time period spanning from 144 to 66 million years ago.*

cephalopod • *a marine invertebrate animal characterized by a prominent head, arms and tentacles with suckers, and jet propulsion.*

mosasaur • *an extinct, carnivorous, marine vertebrate reptile characterized by a streamlined body for swimming, a powerful fluked tail, and reduced, paddle-like limbs.*

plesiosaur • *a member of a group of extinct long-necked Mesozoic marine reptiles.*

Fossils of the Coastal Plain
Region 3

The late **Cretaceous** marine sediments of the Coastal Plain are frequently rich in both invertebrate and vertebrate fossils. Mollusks are especially common, including snails (gastropods), clams (bivalves), and **cephalopods** (*Figures 3.34 and 3.35*). Crabs are also sometimes locally abundant. Vertebrates include sharks, as well as marine reptiles: **mosasaurs** and, more rarely, **plesiosaurs** (*Figures 3.36 and 3.37*).

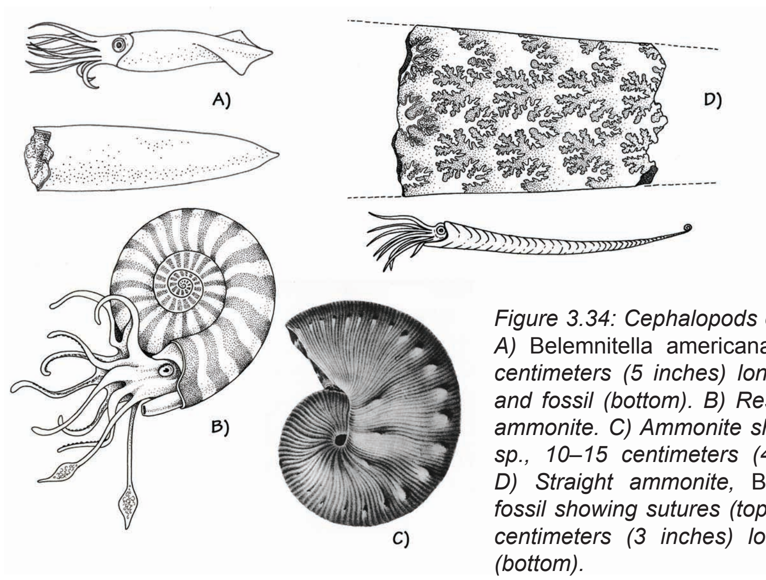


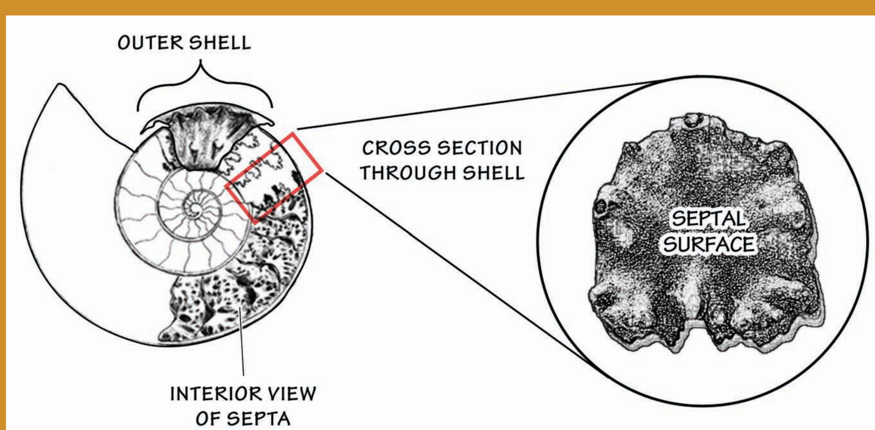
Figure 3.34: Cephalopods of the Coastal Plain. A) Belemnitella americana, *approximately 12 centimeters (5 inches) long. Restoration (top) and fossil (bottom). B) Restoration of a coiled ammonite. C) Ammonite shell fossil,* Scaphites sp., *10–15 centimeters (4–6 inches) across. D) Straight ammonite,* Baculites sp. *Partial fossil showing sutures (top), approximately 7.5 centimeters (3 inches) long, and restoration (bottom).*

Cephalopods

Cephalopods, such as squid, octopods, nautiloids, ammonoids, and belemnites, are mollusks with tentacles and beak-shaped mouths for catching prey. Some cephalopods such as belemnites and living cuttlefish have internal shells, while others have straight or coiled shells, such as those of ammonoids or nautiloids. Still other cephalopods, such as the octopus, have no shell. The mass extinction at the end of the Cretaceous (famous for eliminating the non-avian dinosaurs) also eliminated belemnites and ammonoids, which had been extremely diverse during the Mesozoic.

Ammonoids

Ammonoids are a major group of cephalopods that lived from the Devonian to the end of the Cretaceous. Both nautiloids (the group that today contains the chambered nautilus) and ammonoids have chambered shells subdivided by walls, or septa (plural of septum). These shells are frequently, but not always, coiled. The term "ammonoid" refers to the larger group of these extinct cephalopods, distinguished by complex, folded septa. Within ammonoids, "ammonites" is a smaller sub-group, distinguished by the extremely complex form of their septa. Ammonites were restricted to the Jurassic and Cretaceous periods. The form of the septa in nautiloids and ammonoids is not visible in a complete shell; it is most often seen in the trace of the intersection between the septum and the external shell. This trace is called a suture. Sutures are usually visible in fossils when sediment has filled the chambers of a shell, and the external shell has been broken or eroded away.



Ammonite shell break-away cross-section; surface plane of a septum and sediment-filled chamber.

ammonoid • *a member of a group of extinct cephalopods belonging to the Phylum Mollusca, and posessing a spiraling, tightly coiled shell characterized by ridges, or septa.*

Region 3

chalk • *a soft, fine-grained, easily pulverized, white-to-grayish variety of limestone, composed of the shells of minute planktonic single-celled algae.*

coccolithophore • *a marine phytoplankton with a skeleton made up of microscopic calcareous disks or rings, and forming much of the content of chalk rocks.*

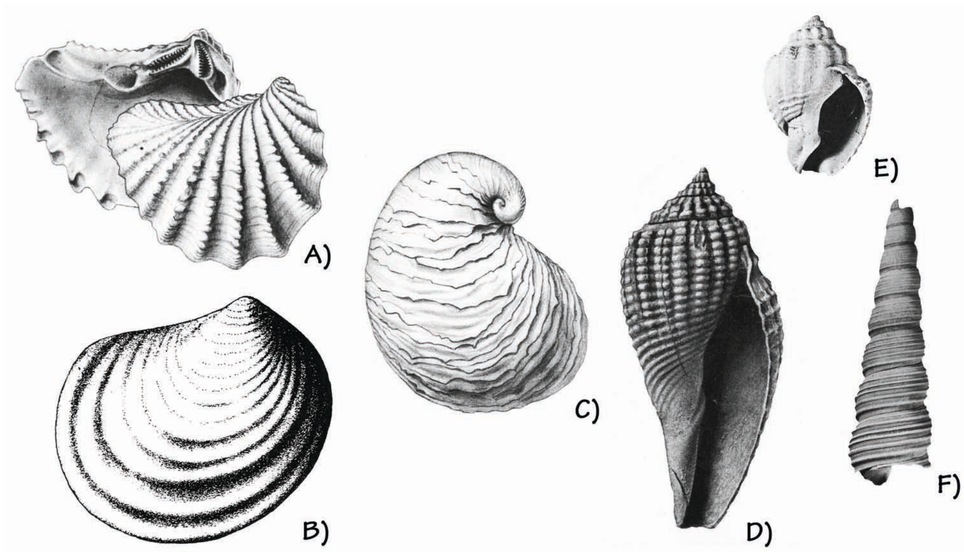


Figure 3.35: Common late Cretaceous marine mollusks from the Coastal Plain. A) Bivalve, Pterotrigonia thoracica*, 5 centimeters (2 inches) wide. B) Bivalve,* Inoceramus *sp., 15 centimeters (6 inches) wide. C) Bivalve,* Exogyra ponderosa*, 20 centimeters (8 inches) wide. D) Gastropod,* Volutomorpha mutabilis*, 8.5 centimeters (3.3 inches) tall. E) Gastropod,* Buccinopsis solida*, 4 centimeters (1.6 inches) tall. F) Gastropod,* Turritella vertebroides*, 7 centimeters (2.8 inches) tall.*

Figure 3.36: Cretaceous shark teeth, Greene County, Alabama.

During the Cretaceous, the Western Interior Seaway (*Figure 3.38*) stretched across the center of North America from the Gulf of Mexico to the Arctic Ocean, and from the foot of the still-forming Rocky Mountains to as far east as Iowa. In some areas of this seaway there was deposition of **chalk**—a kind of limestone made up primarily of the shells of microscopic marine algae, called **coccolithophores** (*Figure 3.39*). Today, such sediments accumulate mainly in the deep sea, but during the Cretaceous, when sea levels were much higher than

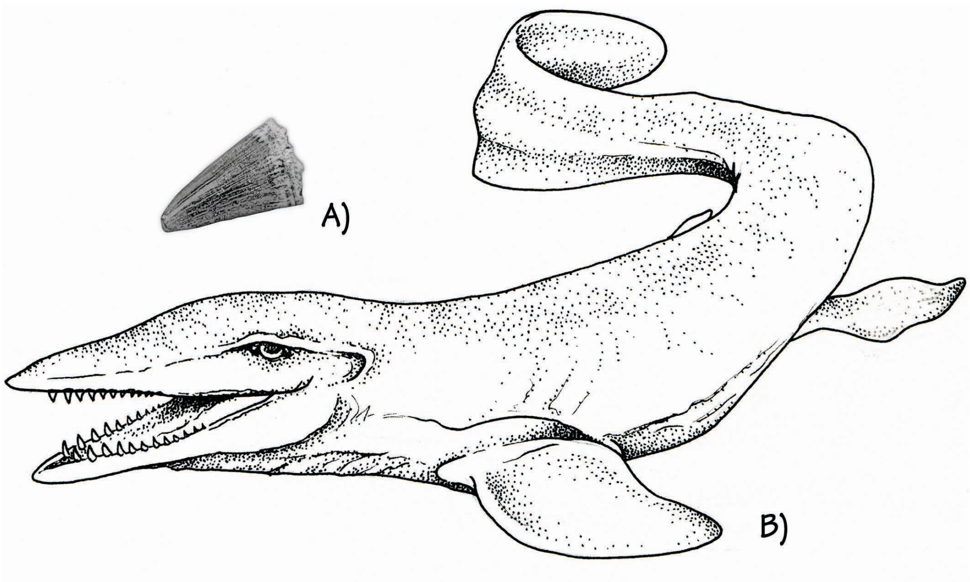


Figure 3.37: A) Mosasaur tooth, approximately 3 centimeters (1.2 inches) long. B) Restoration. Mosasaurs reached lengths of more than 10 meters (33 feet).

Figure 3.38: The Western Interior Seaway.

Region 3

pterosaurs • *extinct flying reptiles with wingspans of up to 15 meters.*

Cenozoic • *the geologic time period spanning from 66 million years ago to the present.*

those of today, chalk accumulated in extensive shallow seas. The Cretaceous period, in fact, is named for the abundance of chalk that accumulated during this time. (The Latin word for chalk is *creta.*) Cretaceous chalk is common across much of central Alabama.

Florida's Only Trilobite

There are no rocks at the surface in Florida older than Eocene in age (approximately 55 million years old), but older rocks and fossils have been found in cores drilled deep below the surface. The oldest of these rocks dates to the early Ordovician period, about 480 million years ago, as determined by index fossils such as graptolites and brachiopods. The only trilobite ever found in Florida is a single specimen from one such core, drilled in Madison County, at a depth of around 1570 meters (4630 feet).

The trilobite* Plaesiacomia exsul, *recovered from middle Ordovician rocks in a deep core from northern Florida. Field of view approximately 1.4 centimeters (0.7 inches) wide.

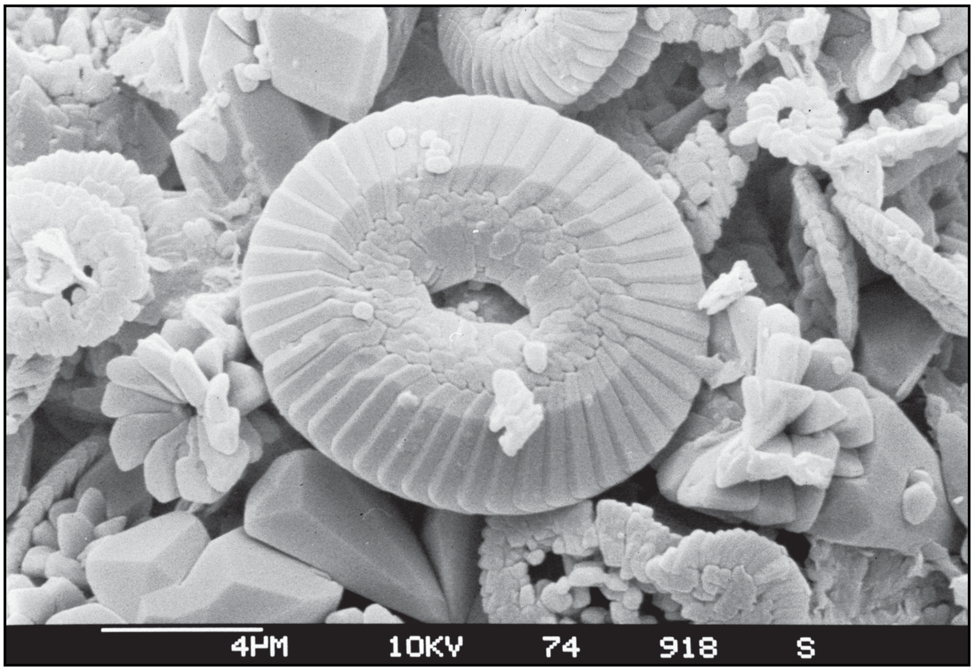


Figure 3.39: Microscopic view of Cretaceous chalk, showing that it is composed almost completely of the shells of protists called coccolithophores. Scale bar = 4 nanometers (4 x 10^{-9} meters; approximately 0.0000001575 inches).

Dinosaur fossils are not common in Coastal Plain sediments, thanks to the absence of Cretaceous-aged terrestrial deposits, although they have been found in almost every state (*Figure 3.40*). The region's dinosaur fossils all come from marine sediments, and were preserved when dinosaur carcasses floated out to sea. Most of these finds are isolated bones or partial skeletons, and are therefore difficult to identify. Dinosaurs represented include both herbivores (mostly hadrosaurs or "duckbills") and carnivores (theropods) (*Figure 3.41*). Other reptile groups are also known from the Coastal Plain's Cretaceous sediment, including flying reptiles (**pterosaurs**) from North Carolina and Georgia, and the giant crocodilian *Deinosuchus* (*Figure 3.42*), which reached lengths of up to 12 meters (39 feet) and is found from New Jersey to Texas.

Despite the lack of terrestrial sediments in the Coastal Plain, fossils of Cretaceous and **Cenozoic** land plants are known from a number of localities (*Figure 3.43*). These deposits formed in near-shore environments where land plants washed into coastal marshes. They include fossil leaves, and some, such as those in the late Cretaceous Ingersoll Shale of eastern Alabama, are extremely well preserved. Late Cretaceous **amber** (fossil tree resin) is found in several places, including Russell County, Alabama and Tishomingo County, Mississippi. Cenozoic plant fossils are surprisingly common across the Coastal Plain (*Figure 3.44*); fossil leaves are especially abundant in deposits of early **Eocene** age in the **Mississippi Embayment** (portions of Alabama, Mississippi, Arkansas, Louisiana, Texas, Kentucky, and Tennessee), occasionally forming localized deposits of brown coal (**lignite**). Petrified wood can also be found in a number of places in the Coastal Plain—Mississippi even has its own "petrified forest" in the town of Flora in Madison County (*Figure 3.45*).

amber *• a yellow or yellowish-brown hard translucent fossil resin that sometimes preserves small soft-bodied organisms inside.*

Eocene *• a geologic time period extending from 56 to 33 million years ago.*

Mississippi Embayment *• a topographically low-lying basin in the south-central United States, stretching from Illinois to Louisiana.*

lignite *• a soft, brownish-black coal in which the alteration of plant matter has proceeded farther than in peat but not as far as in bituminous coal.*

3 Fossils

Region 3

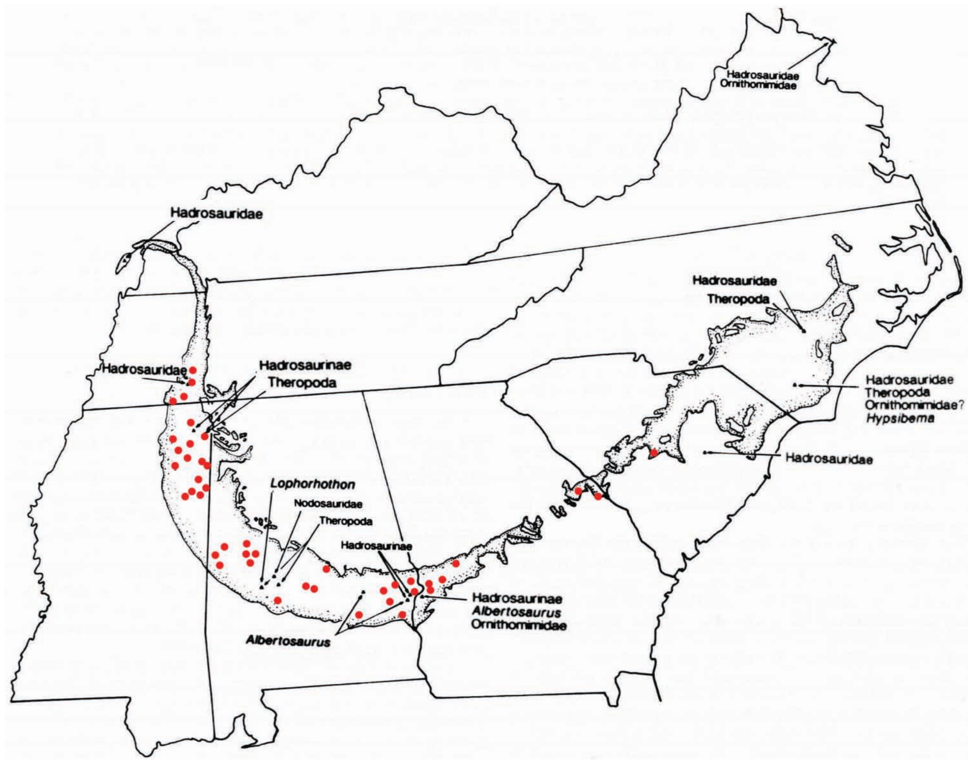


Figure 3.40: Map showing outcrop pattern of Cretaceous sediment and localities where dinosaurs have been found in the Southeastern US. (See TFG website for full-color version.)

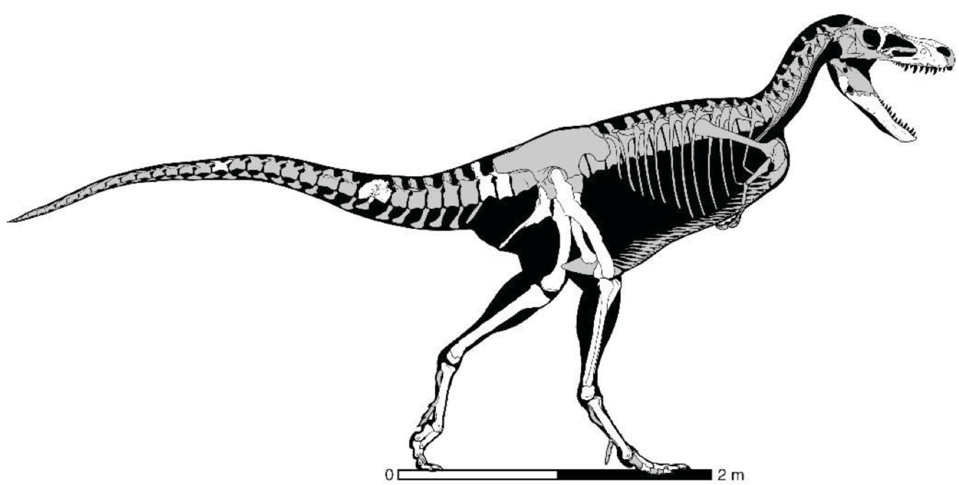


Figure 3.41: Skeletal reconstruction of the theropod dinosaur Appalachiosaurus montgomeriensis*, based on a juvenile specimen discovered in Alabama in 1982. The animal measured approximately 7 meters (23 feet) long and probably weighed approximately 590 kilograms (1300 pounds) in life.*

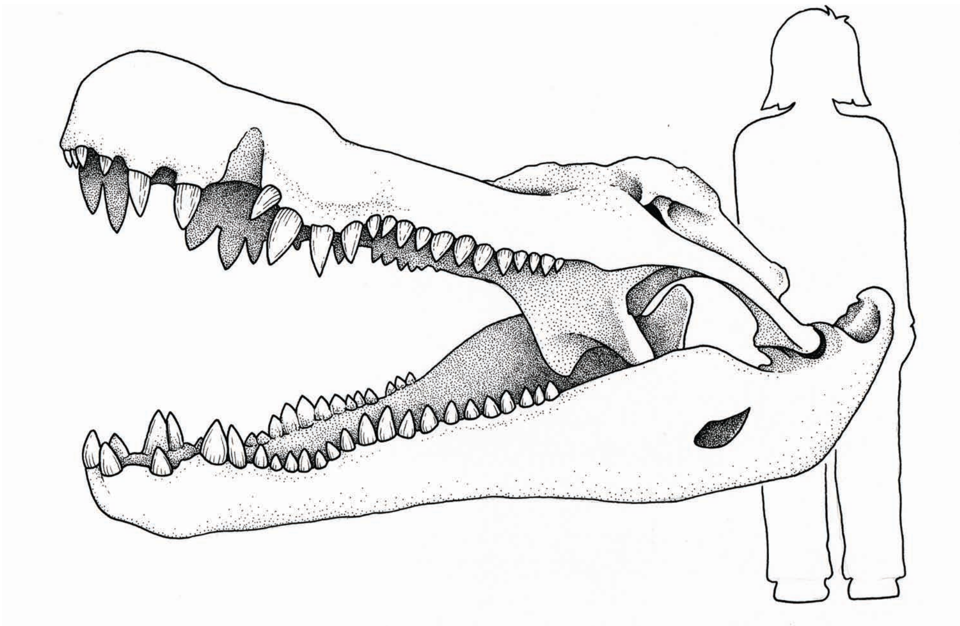


Figure 3.42: Reconstruction of the skull of the giant Cretaceous crocodillian Deinosuchus.

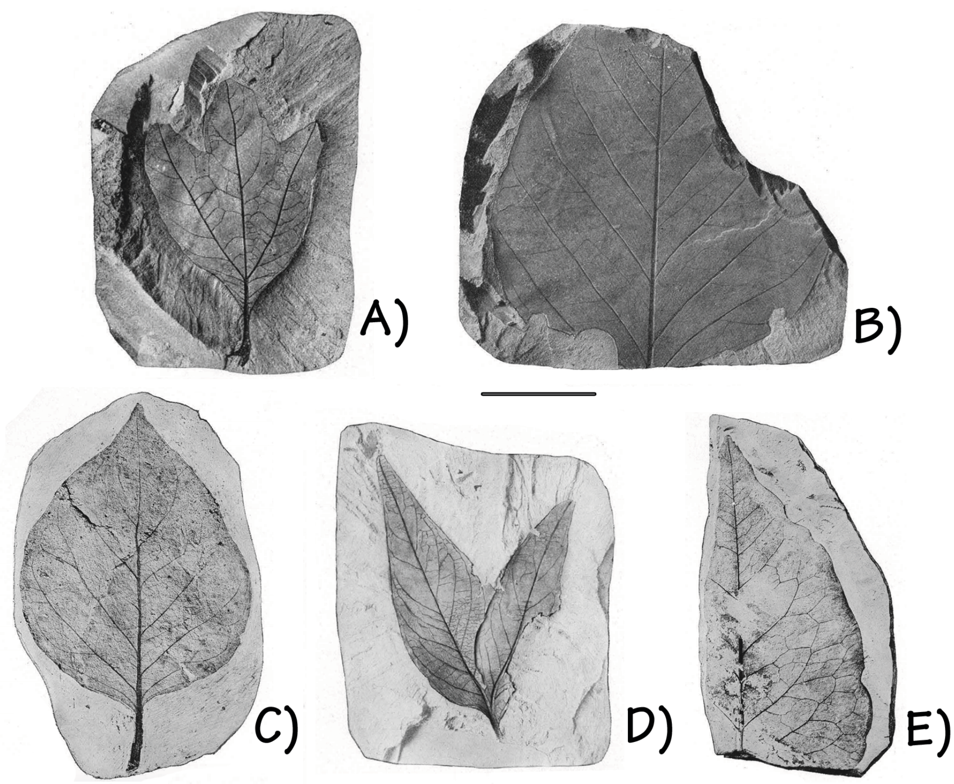


Figure 3.43: Cretaceous angiosperm (flowering plant) fossils from the Gulf Coastal Plain. All except E from Fayette County, Alabama. A) Platanus shirleyensis. *B)* Magnolia lacoeana. *C)* Cordia apiculata. *D)* Hymenaea fayetensis. *E)* Magnolia capellinii, *McNairy County, Tennessee. Scale bar is 1 centimeter (0.4 inch) long.*

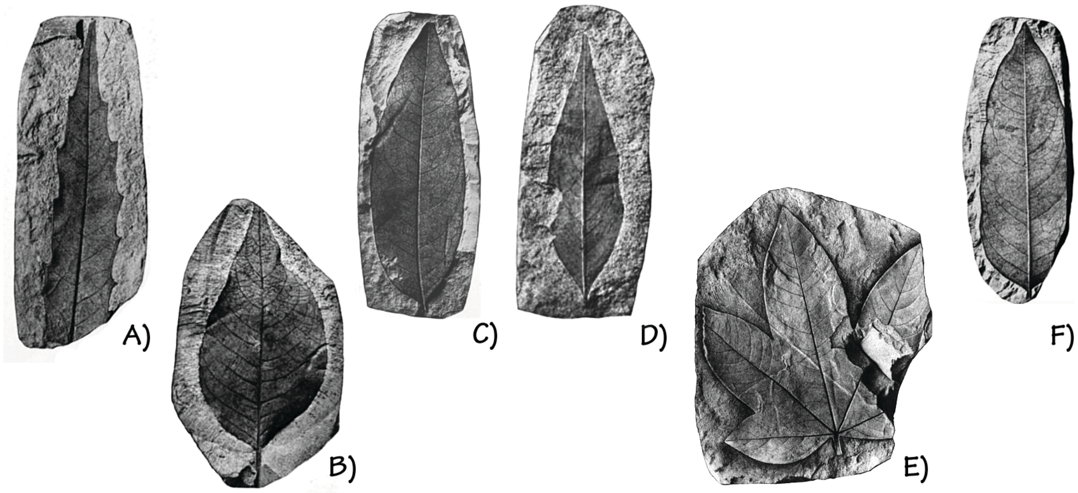


Figure 3.44: Cenozoic fossil plant leaves from the Gulf Coastal Plain. A) Dryophyllum anomalum*, Wilcox, Puryear, TN. B)* Euonymus splendens*. Grand Junction, TN. C)* Ficus puryearensis*, Wilcox, Puryear, TN. D)* Cassia puryearensis*. E)* Stercula puryearensis*. F)* Banisteria repandifolia*.*

Paleogene *• the geologic time period extending from 66 to 23 million years ago.*

Figure 3.45: A permineralized log from the Mississippi Petrified Forest near Flora, Mississippi.

Paleogene sediments of the Coastal Plain are frequently extremely fossiliferous. Indeed, some deposits are among the most famous fossil beds in the world from this age, and have been studied since the early 1800s, longer than almost any other fossil-bearing sediments anywhere in America. For example, the late Eocene Gosport Sand in southwestern Alabama contains fossils of more than 500 species of mollusks. Fossil mollusks—mainly clams and snails—of

Paleocene, Eocene, and **Oligocene** age occur across the Gulf and Atlantic Coastal Plains, from Texas to Maryland, frequently in beautifully preserved shell beds that contain scores to hundreds of different species. More than 3000 different species of mollusks have been described from these beds (*Figures 3.46 and 3.47*). In Florida, Eocene limestones also contain abundant mollusks (usually only as molds and casts) and echinoids (sand dollars and sea urchins) (*Figure 3.48*).

Paleocene *• a geologic time interval spanning from about 66 to 56 million years ago.*

Oligocene *• a geologic time interval spanning from about 34 to 23 million years ago.*

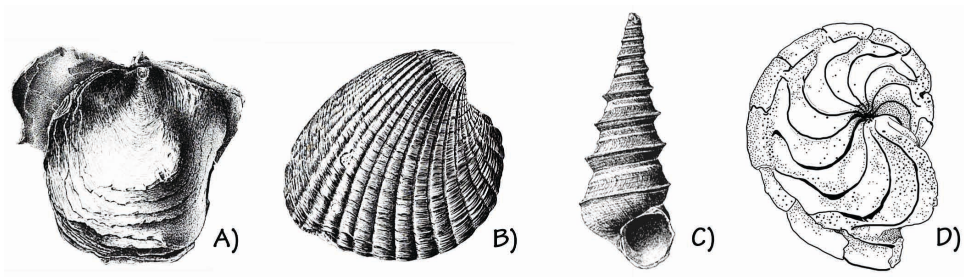


Figure 3.46: Atlantic Coastal Plain Paleogene mollusks; A–C: from the Paleogene Aquia Formation of northeastern Virginia; or D: the early Oligocene of Florida. A) Bivalve, Cubitostrea sellaeformis*, approximately 15 centimeters (6 inches) wide. B) Bivalve,* Venericardia *sp., approximately 7.5 centimeters (3 inches) wide. C) Gastropod,* Turritella mortoni*, approximately 10 centimeters (4 inches) tall. D) Nautiloid,* Aturia alabamiensis*, approximately 15 centimeters (6 inches) in diameter.*

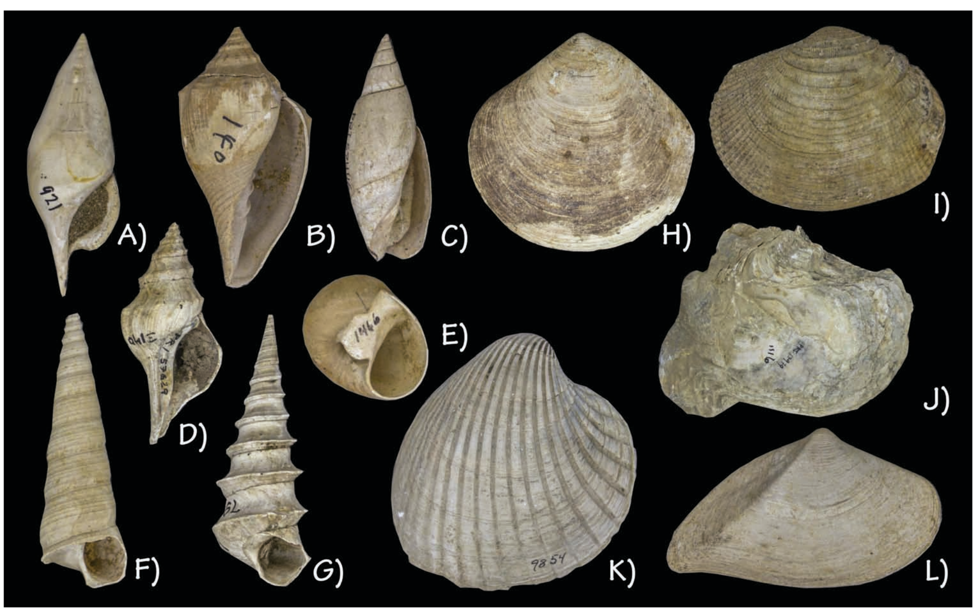


Figure 3.47: Gulf Coastal Plain Paleocene and Eocene mollusks from Mississippi and Alabama. A–G) Gastropods; H–L) bivalves. A) Calyptraphorus velatus*, late Eocene, 5 centimeters (2 inches) tall. B)* Athleta sayana*, middle Eocene, 5 centimeters (2 inches) tall. C)* Agaronia alabamensis*, middle Eocene, 4 centimeters (1.6 inches) tall. D)* Levifusus prepagoda*, early Eocene, 5 centimeters (2 inches) tall. E)* Neverita limula*, middle Eocene, 4 centimeters (1.6 inches) tall. F)* Turritella arenicola*, late Eocene, 3.8 centimeters (1.5 inches) tall. G)* Turritella mortoni postmortoni*, late Paleocene, 6 centimeters (2.4 inches) tall. H)* Crassatella alta*, middle Eocene, 10 centimeters (3.9 inches) wide. I)* Corbis distans*, middle Eocene, 4.5 centimeters (1.8 inches) wide. J)* Cubitostrea sellaeformis*, middle Eocene, 10 centimeters (3.9 inches) wide. K)* Venericardia planicosta*, early Eocene, 5.5 centimeters (2.2 inches) wide. L)* Crassatellites protextus*, middle Eocene, 5 centimeters (2 inches) wide.*

passive margin • *a tectonically quiet continental edge where crustal collision or rifting is not occurring.*

Pangaea • *supercontinent, meaning "all Earth," which formed over 300 million years ago and lasted for almost 150 million years.*

embayment • *a bay or recess in a coastline.*

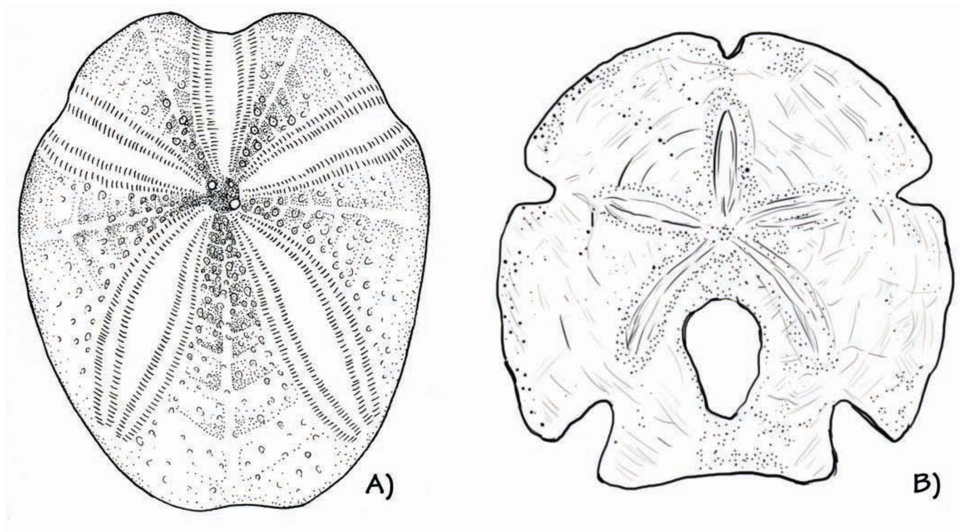


Figure 3.48: Cenozoic sand dollars (echinoids) of Florida. A) Eupatagus antillarum*, Eocene, 4 centimeters (1.6 inches) in diameter. B)* Encope tamiamiensis*, Pliocene, 10 centimeters (4 inches) in diameter.*

Echinoids

Echinoids (sea urchins and sand dollars) are echinoderms, related to sea stars and crinoids. All echinoderms have external skeletons made of numerous plates of the mineral calcite (a form of calcium carbonate), and a unique water vascular system that drives most of their motion. Echinoids have rounded or flattened shells, called tests, which bear numerous spines. Tiny tube feet, connected to the water vascular system, extend through holes in the test and allow the animals to move on or within the sea floor. All echinoids exhibit the characteristic five-fold symmetry of echinoderms.

The Gulf and Atlantic coasts of North America are **passive margins**, formed when the supercontinent **Pangaea** broke apart between 200 and 100 million years ago. The continents did not break smoothly along a straight line, but rather along an irregular line with curves pointing outward (promontories) and inward

See Chapter 1: Geologic History for more on how siliciclastic deposition shaped the Coastal Plain.

Region 3

(**embayments**). As the Cenozoic passed and erosion of the land continued, the embayments along the Atlantic coast became locations of **siliciclastic** deposition, as well as semi-restricted areas that developed their own particular kinds of organisms. Geologists and paleontologists studying the **Neogene** geology of the Atlantic Coastal Plain frequently study the area's sediments and fossils one embayment at a time, then attempt to connect them together to form a larger story. These shallow marine deposits contain many abundant and diverse fossil beds, especially mollusks (clams and snails), but also corals, barnacles, and many other organisms (*Figures 3.49–3.53*). In Florida, the geographic setting for sedi-ment accumulation included more carbonate, and its fossil-bearing deposits vary from shelly **sand** in the northern and central parts of the state to reef limestone in the far south and throughout the Florida Keys (*Figures 3.54 and 3.55*).

See Chapter 4: Topography to learn more about embayments.

See Chapter 7: Soils to learn about sandy Entisols, a common soil type found throughout the Coastal Plain.

siliciclastic *• pertaining to rocks that are mostly or entirely made of silicon-bearing clastic grains weathered from silicate rocks.*

Neogene *• the geologic time period extending from 23 to 2.6 million years ago.*

sand *• rock material in the form of loose, rounded, or angular grains, and formed as a result of the weathering and decomposition of rocks.*

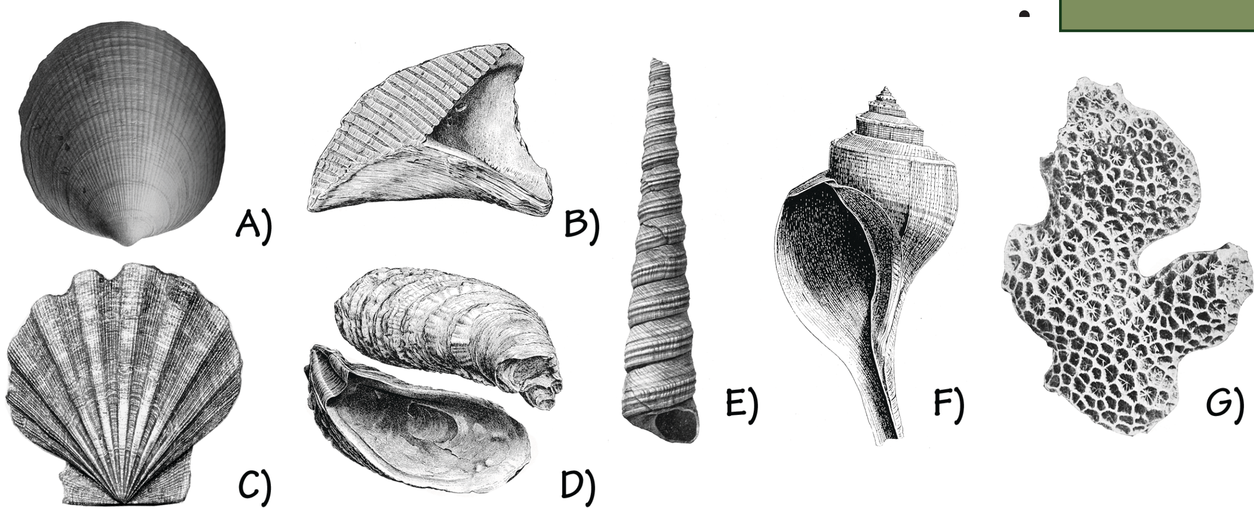


Figure 3.49: Miocene-Pliocene marine invertebrates from Virginia and the Carolinas. A) Bivalve, Glycymeris americana, *approximately 8.5 centimeters (3.5 inches) wide. B) Bivalve,* Isognomon maxillata, *approximately 16 centimeters (6.5 inches) tall/wide. C) Bivalve,* Chesapecten jeffersonius, *approximately 12 centimeters (5 inches) tall/wide. D) Bivalve,* Crassostrea virginica, *approximately 16 centimeters (6.5 inches) tall/wide. E) Gastropod,* Turritella eichwaldiella, *approximately 10 centimeters (4 inches) tall/wide. F) Gastropod,* Busycon canaliculatum, *approximately 20 centimeters (8 in) tall/wide. G) Scleractinian coral,* Septasrea marylandica, *approximately 7 centimeters (3 inches) tall.*

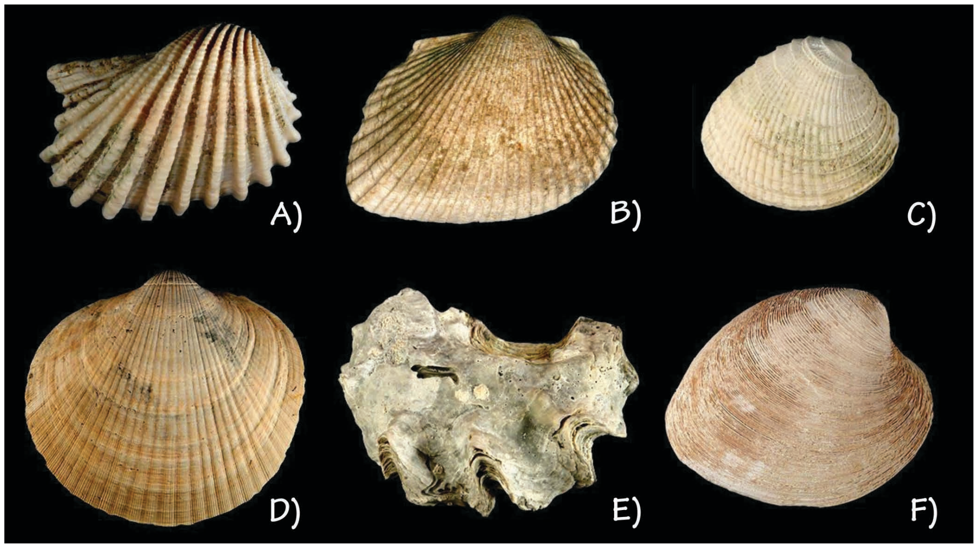


Figure 3.50: Pliocene-Pleistocene marine bivalves from Florida and the Carolinas. A) Anadara aequalitas*, approximately 3.5 centimeters (1.5 inches) wide. B)* Anadara callicestosa*, approximately 3 centimeters (1.2 inches) wide. C)* Chione erosa*, approximately 2 centimeters (0.8 inches) wide. D)* Glycymeris americana*, approximately 5 centimeters (2 inches) wide. E)* Undulostrea locklini*, approximately 4 centimeters (1.8 inches) wide. F)* Mercenaria campechiensis*, approximately 12 centimeters (7 inches) wide.*

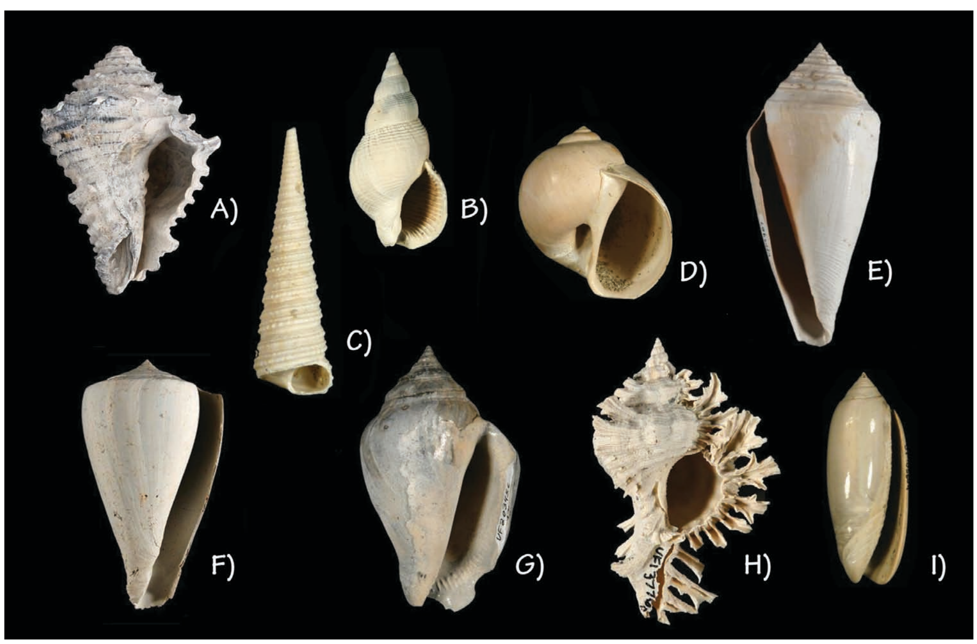


Figure 3.51: Pliocene-Pleistocene marine gastropods from Florida and the Carolinas. A) Vasum horridum*, 8 centimeters (4.5 inches) tall. B)* Calophos wilsoni*, 5 centimeters (2 inches) tall. C)* Turritella gladeensis*, 5 centimeters (2 inches) tall. D)* Euspira sayana*, 3.5 centimeters (1.5 inches) tall. E)* Contraconus adversarius*, 10 centimeters (4 inches) tall. F)* Conus haytensis*, 12 centimeters (5 inches) tall. G)* Strombus floridanus*, 6 centimeters (2.5 inches) tall. H)* Chicoreus floridanus*, 6 centimeters (2.5 inches) tall. I)* Oliva carolinensis*, 5 centimeters (2 inches) tall.*

Bivalves

Clams and their relatives, such as mussels, scallops, and oysters, are mollusks possessing a pair of typically symmetrical shells. Most are filter feeders, collecting food with their gills. Paleozoic bivalves typically lived on the surface of the sediment ("epifaunally"), but in the Mesozoic they evolved the ability to burrow more deeply into the sediment, becoming "infaunal." This innovation led to the rapid evolution of a large number of groups present in today's oceans.

Gastropods

Commonly known as snails, gastropod mollusks encompass terrestrial, freshwater, and marine species, and include varieties with and without shells (e.g., slugs). Gastropods are among the most diverse groups of organisms—only insects have more named species. The soft parts of gastropods are generally similar to those of bivalves, but the former typically have coiled shells and are usually much more active. Gastropods are present in Paleozoic and Mesozoic rocks, but are especially abundant and diverse in Cretaceous and Cenozoic sediments of the Coastal Plain.

Figure 3.52: Cluster of large barnacles, approximately 25 centimeters (10 inches) tall, Pliocene of Florida.

Figure 3.53: Pleistocene oyster reef at the Intracostal Waterway near Charleston, South Carolina.

Figure 3.54: Fossilized coral in the Key Largo Limestone, exposed at the Windley Key Fossil Reef Geological State Park in the Florida Keys.

Figure 3.55: Neogene corals from Florida. A) Silicified scleractinian coral (sawed in half to reveal "geodized" interior), late Miocene, Tampa Bay, approximately 9 centimeters (3.5 inches) in diameter. B) Manicina areolata*, approximately 15 centimeters (6 inches) wide. C)* Septastrea marylandica*, approximately 3 centimeters (1.25 inches) wide.*

Marine Mammals

Whales evolved from four-legged, land-living mammals during the Eocene epoch, beginning around 55 million years ago. Fossils discovered over the past few decades in Pakistan and Egypt have revealed numerous extinct forms that show the evolutionary steps in this remarkable transition, from an animal resembling a wolf (but more closely related to an antelope) to a fully aquatic animal with an elongate body, nostrils on top of its head, and little or nothing in the way of hind limbs. The earliest whale-like forms are called **archaeocetes**, and these animals were first discovered in the Eocene sediments of Alabama's Coastal Plain during the early 1800s. Many different species of archaeocetes lived in warm, low-latitude seas around the world. Their multicusped teeth with distinctive, yolk-shaped roots, as well as their large vertebrae, can be found from Maryland to Mississippi (*Figures 3.56 and 3.57*). Archaeocetes became

archaeocete • *a member of a group of primitive whales that lived during the Eocene and Oligocene epochs.*

Figure 3.56: Skeleton of the Eocene archaeocete whale Zygorhiza kochii *from Mississippi. This skeleton, mounted in the Mississippi Museum of Natural Sciences, is approximately 5.2 meters (17 feet) long.*

3

Fossils

Region 3

odontocete • *a member of the group of whales (cetaceans) that have baleen for feeding on fish, squid, and mammals.*

mysticete • *a member of the group of whales (cetaceans) that have baleen for feeding on plankton, krill, and small fish.*

extinct in the early Oligocene. From them evolved the two major groups of modern whales: the toothed whales or **odontocetes** (dolphins, porpoises, and the sperm whale), and the toothless baleen whales or **mysticetes** (the large plankton-feeding whales such as blue whales and right whales). Fossils of whales and dolphins can be found in Miocene and younger sediments along much of the Atlantic Coastal Plain and Gulf Coast of Florida (*Figure 3.58*).

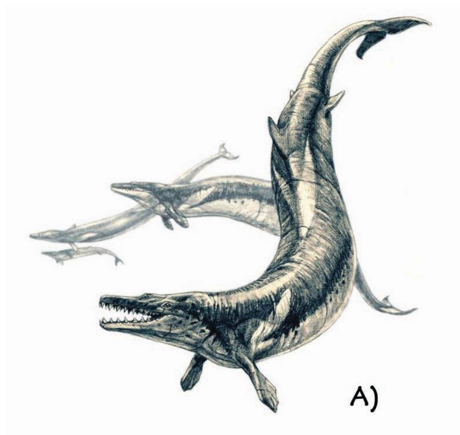
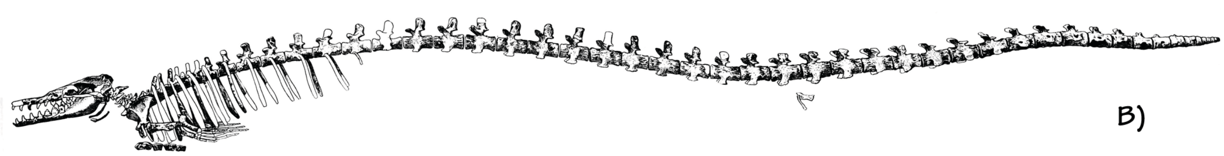
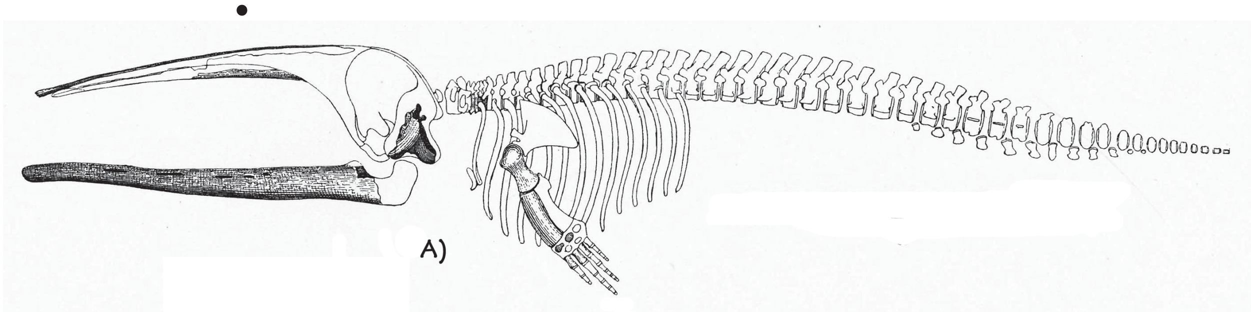


Figure 3.57: The giant archaeocete whale, Basilosaurus cetoides*, from the late Eocene of Alabama. A) Restoration and B) drawing of a skeleton mounted in the National Museum of Natural History in Washington, DC, found in Choctaw County. The skeleton is approximately 15 meters (50 feet) long.*





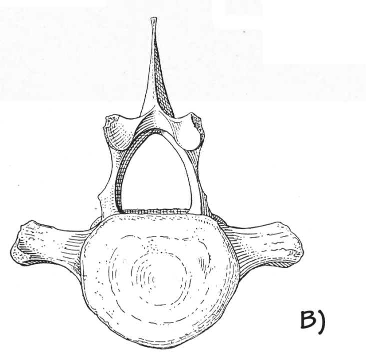


Figure 3.58: Neogene whales from the Coastal Plain. A) Skeleton of a small baleen whale, Miocene of Virginia, approximately 9 meters (29 feet) long. B) End view of a single whale vertebra, approximately 20 centimeters (8 inches) tall.

Manatees and dugongs belong to a group of aquatic mammals called **sirenians**. One species of manatee lives in Florida's rivers today. Many different kinds of sirenians, however, are represented by fossils found in the Coastal Plain, especially in Florida (*Figure 3.59*), where they are the most common fossil mammal. Manatees and dugongs are strict herbivores. Their bones tend to be easily recognized because of their high **density**, which provides them with ballast to counteract the buoyant blubber layer that covers their bodies.

sirenian • *an aquatic herbivorous mammal known as a sea cow, including dugongs and manatees.*

density • *a physical property of minerals, describing the mineral's mass per volume.*

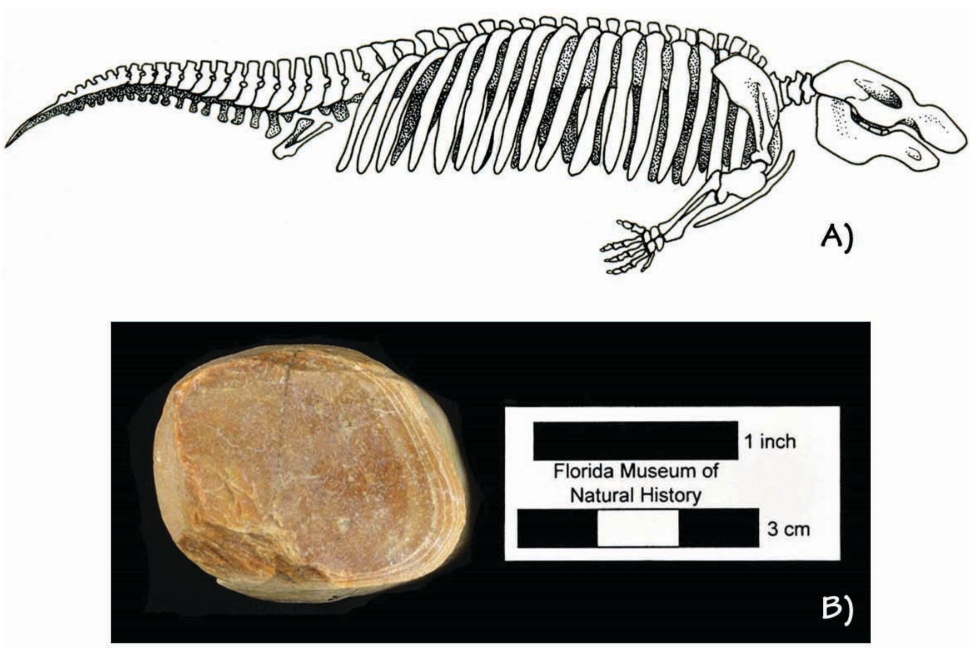


Figure 3.59: Fossil dugong, Metaxytherium floridanum, *middle to late Miocene of Florida. A) Skeleton, 3–3.5 meters (10 feet) in length. B) Cross-section through a rib, approximately 3 centimeters (1.5 inches) in diameter.*

Sharks and Rays

Sharks and rays have skeletons made of cartilage instead of bone, which means that their skeletons rarely are found as fossils. The teeth of sharks and rays, however, are much more resistant, and are common fossils in Cretaceous and Cenozoic sediments throughout the Coastal Plain. They are often found on beaches, where they may have washed in from offshore, or washed down in rivers from upland (*Figure 3.60*). Sharks shed their teeth constantly, and a single individual can produce as many as 35,000 teeth during its lifetime. You can tell the difference between fossil and modern shark teeth by their color: fossils are brown or black, whereas modern teeth are tan to white. Shark teeth come in many forms and sizes, but this can be misleading because not all teeth in the mouth of a single individual look alike.

The largest shark that ever lived was a species related to the modern great white shark, but much bigger. *Carcharocles megalodon* (frequently called just "megalodon") lived in the western Atlantic Ocean from approximately 16 to 2.6 million years ago (middle Miocene to late **Pliocene**). *C. megalodon* is regarded

Pliocene • *a geologic time interval extending from roughly 5 to 2.5 million years ago.*

as one of the largest and most powerful predators ever (*Figure 3.61*). Because its fossil record consists almost entirely of teeth (which are common fossils in the Coastal Plain), size estimates have varied widely, but it seems reasonable to estimate that *C. megalodon* reached lengths of up to 18 meters (59 feet). It likely fed on large whales.

Rays and skates are close relatives of sharks, with cartilaginous skeletons and hard, easily fossilizable teeth. Many ray species feed on hard-shelled prey, such as clams that they dig up out of sand bottoms, and their teeth therefore frequently have flat, ridged surfaces suitable for grinding. Ray teeth are common fossils found on beaches throughout the Coastal Plain (*Figure 3.62*).

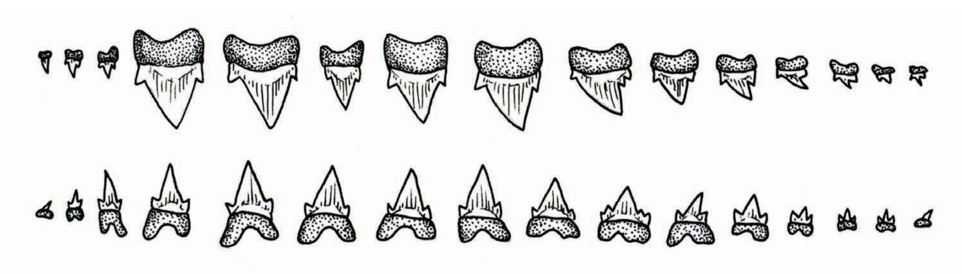


Figure 3.60: A generalized image of the teeth in a typical shark's upper and lower jaws, showing size and shape variation.

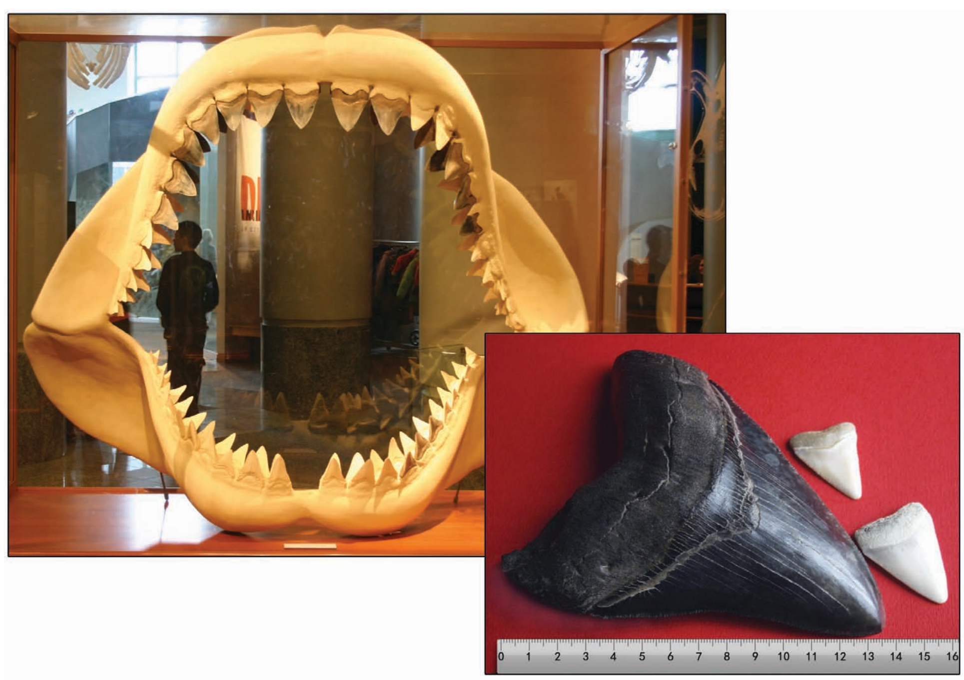


Figure 3.61: The giant great white shark, Carcharocles megalodon. *Reconstructed set of jaws, in the North Carolina Museum of Natural Sciences. Inset: Fossil tooth (left) next to two modern great white shark teeth* (Carcharodon carcharias).

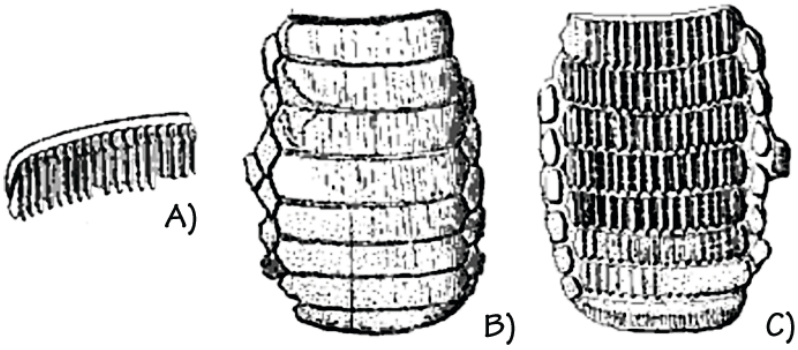


Figure 3.62: Dental plates of rays, adapted for grinding shells of mollusks. The "dental pavement" is made of numerous rows of plates, each with many ridges and grooves. A) Single plate, approximately 2 centimeters (0.8 inches) long. B and C) Entire pavement, upper and lower views, approximately 7 centimeters (3 inches) long.

Cenozoic Terrestrial Vertebrates (Birds & Mammals)

Many species of Pliocene birds are found in Florida. Most of these are marine (*Figure 3.63*), but some are among the largest land-living birds known. *Titanis walleri*, more commonly known as the North American "terror bird," is one of the largest known members of an extinct group of flightless carnivorous birds from the Cenozoic of South America. Of this group, the terror bird was the only one to migrate to North America, and probably the last known member of its lineage. Bones of this giant bird are found at several sites in Florida (*Figure 3.64*).

Figure 3.63: Bones of an extinct Pliocene species of cormorant from a shell pit near Sarasota, Florida. Hundreds of these skeletons were found in a single layer, apparently the result of a mass death due to red tide (a toxin-producing algal bloom that frequently kills fish and other marine life) followed by deposition in a storm.

Fossils

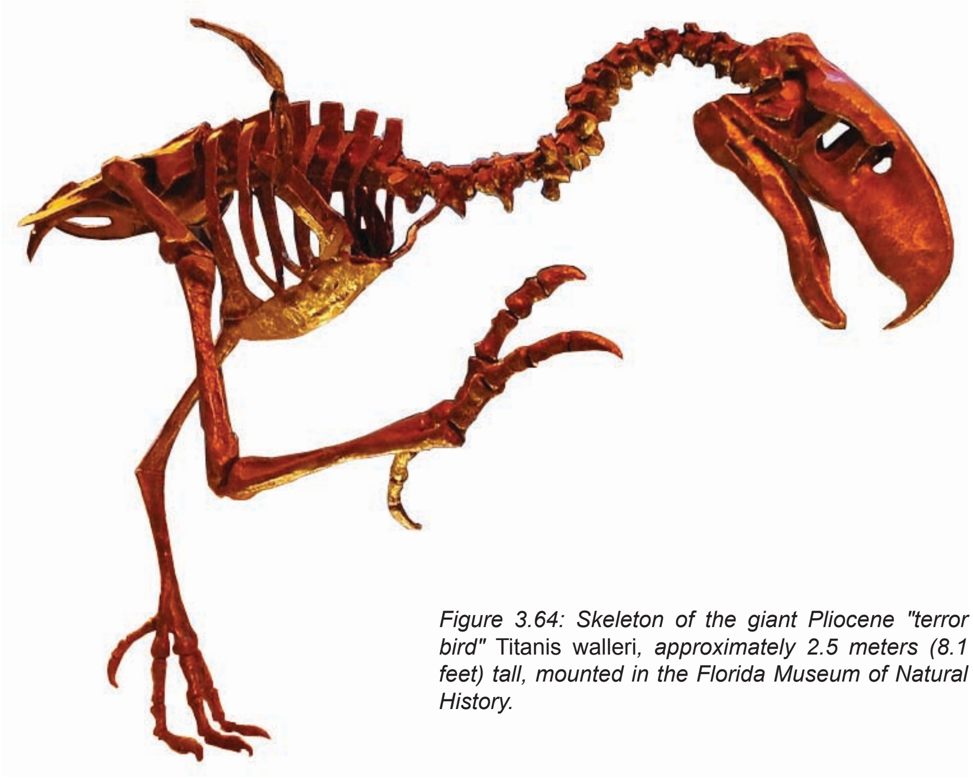


Figure 3.64: Skeleton of the giant Pliocene "terror bird" Titanis walleri*, approximately 2.5 meters (8.1 feet) tall, mounted in the Florida Museum of Natural History.*

Paleogene mammals are not common in the Coastal Plain, but a number of species have been identified from central Mississippi. These include a primitive primate and an early horse from the late Paleocene to early Eocene, and an early rhinoceros from the Oligocene. Fossils of Neogene mammals are abundant and diverse in the Coastal Plain—Florida has the richest fossil record of vertebrate animals in the eastern United States. For example, the Leisey Shell Pit in Hillsborough County, Florida (near Tampa Bay) has produced not only fossil shells, but was also one of the most important early Pleistocene fossil bone beds in the state. Fossils of many species of mammals and birds have been found there, including sabertoothed cats, tapirs, horses, and llamas (the quarry is now closed and flooded). Fossils of Pleistocene mammals are especially common throughout the Coastal Plain (*Figures 3.65 and 3.66*), from horse teeth on the coasts of the Carolinas to the bones of giant ground sloths, tapirs, horses, bison, and mastodons on the banks of the Mississippi River near Vicksburg, Mississippi. Among the most common Pleistocene vertebrate fossils in the Southeast are those of mastodons and mammoths (*Figure 3.67*). Both were common in the Southeast (and elsewhere in North America) during the Pleistocene, but they had different ecological preferences, and their fossils are usually found separately.

Figure 3.65 (AT RIGHT): Five genera of horses known from fossils from the Coastal Plain (mostly Florida). Restoration images all to same scale.

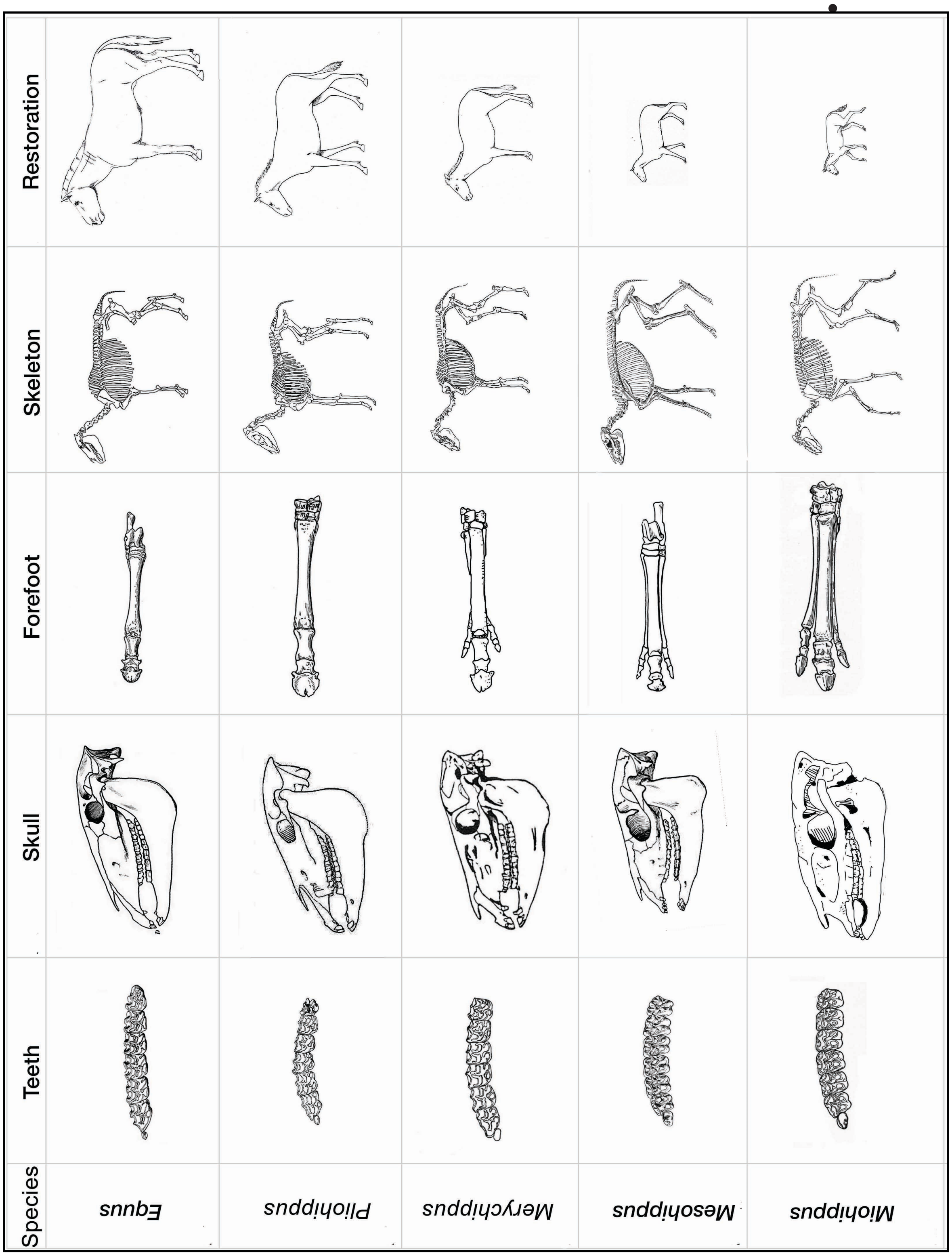

Restoration
Skeleton
Forefoot
Skull
Teeth
Species
Equus
Pliohippus
Merychippus
Mesohippus
Miohippus

Figure 3.66: Skeletal cast of the giant sloth, Megalonyx jeffersoni, *Pleistocene of the Coastal Plain. Approximately 3 meters (10 feet) tall.*

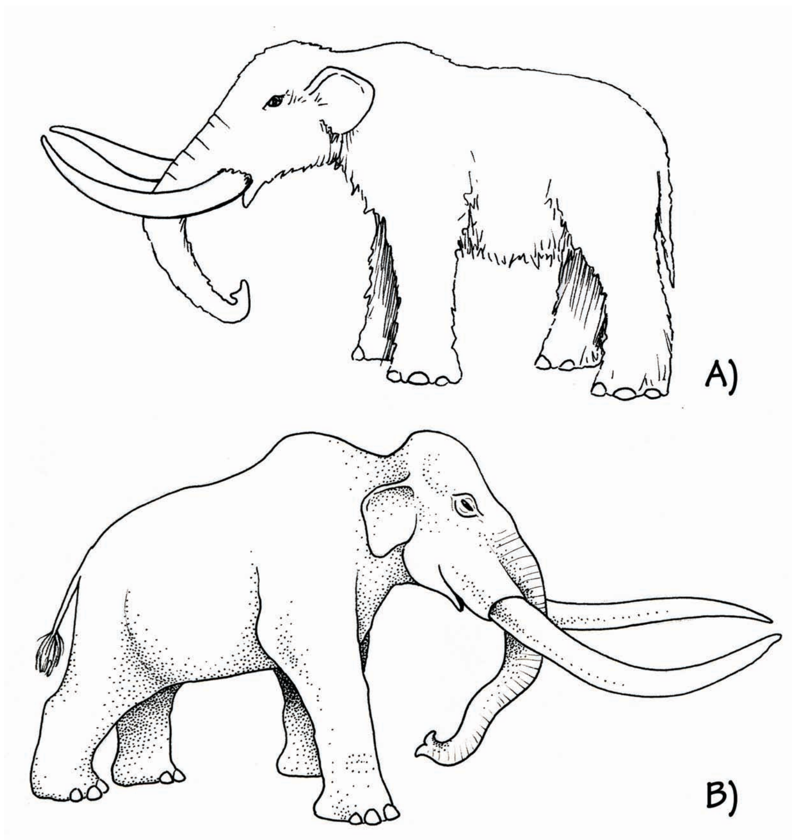
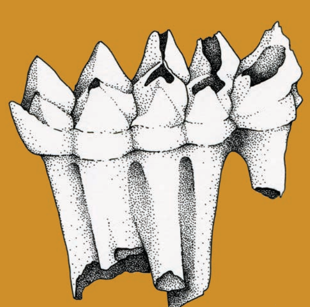


Figure 3.67: Restorations of A) American mastodon, Mammut americanum, *approximately 2.3 meters (7.5 feett) high at the shoulder. B) Columbian mammoth,* Mammuthus columbi, *approximately 4 meters (13 feet) high at the shoulder.*

Mastodons and Mammoths

These two kinds of ancient elephants (or, more technically, proboscideans) are frequently confused. Both were common during the Pleistocene, but they had different ecological preferences and are usually found separately. Mammoths are close cousins of modern African and Asian elephants; mastodons are more distant relatives, from a separate line of proboscideans that branched off from the modern elephant line in the Miocene. Mastodons have a shorter, stockier build and longer body; mammoths are taller and thinner, with a rather high "domed" skull. In skeletal details, the quickest way to tell the difference is by the teeth: mastodons have teeth with conical ridges, a bit like the bottom of an egg carton; mammoths, in contrast, have teeth with numerous parallel rows of ridges. The teeth are indicative of the two species' ecological differences. Mastodons preferred to bite off twigs of brush and trees, while mammoths preferred tough siliceous grasses. Thus, mastodon teeth are more suitable for cutting, while mammoth teeth are more suitable for grinding. Both mammoths and mastodons became extinct around 10,000 years ago.



A mastodon tooth, suitable for chewing twigs and tree leaves. Approximately 20 centimeters (8–9 inches) long.

A mammoth tooth, suitable for grinding grass and softer vegetation. Approximately 25 centimeters (1 foot) long.

State Fossils

Alabama
Basilosaurus cetoides (archaeocete whale; Eocene) (*Figure 3.57*)

Florida
Florida has no state fossil.

Georgia
Shark tooth (Cretaceous and Cenozoic) (*Figure 3.60*)

Kentucky
Brachiopod (Paleozoic) (*Figure 3.13*)

Mississippi
Basilosaurus cetoides and *Zygorhiza kochii* (archaeocete whales; Eocene) (*Figures 3.56 and 3.57*)

North Carolina
Carcharocles megalodon (shark; Miocene-Pliocene) (*Figure 3.61*)

South Carolina
Mammuthus columbi (Columbian mammoth; Pleistocene) (*Figure 3.67)*

Tennessee
Pterotrigonia (Scabrotrigonia) thoracica (bivalve; Cretaceous) (*Figure 3.35*)

Virginia
Chesapecten jeffersonius (bivalve; Miocene-Pliocene) (*Figure 3.49*)

West Virginia
Megalonyx jeffersonii (giant ground sloth; Pleistocene) (*Figure 3.66*)

Resources

General Books on the Fossil Record and Evolution

Allmon, W. D. 2009. *Evolution & Creationism: A Very Short Guide, 2nd edition*, Paleontological Research Institution (Special Publication 35), Ithaca, NY, 128 pp.

Benton, M. J. 2008. *The History of Life: A Very Short Introduction*. Oxford University Press, Oxford, UK, 170 pp.

Fenton, C. L., & M. A. Fenton. 1958. *The Fossil Book: A Record of Prehistoric Life*. Doubleday, Garden City, NY, 482 pp. (A well-illustrated classic.)

Fortey, R. A. 1998. *Life: A Natural History of the First Four Billion Years of Life on Earth*. Alfred A. Knopf, New York, 346 pp.

Knoll, A. H. 2003. *Life On a Young Planet: The First Three Billion Years of Evolution on Earth*, Princeton University Press, Princeton, NJ, 277 pp.

Prothero, D. R. 2006. *After the Dinosaurs: the Age of Mammals*. Indiana University Press, Bloomington, 362 pp.

Sampson, S. D. 2011. *Dinosaur Odyssey: Fossil Threads in the Web of Life*. University of California Press, Berkeley, CA, 352 pp.

Shubin, N. 2009. *Your Inner Fish: a Journey into the 3.5-Billion-Year History of the Human Body*. Vintage Books, New York, 256 pp.

Switek, B. 2010. *Written In Stone: Evolution, the Fossil Record, and Our Place In Nature*. Bellevue Literary Press, New York, 320 pp.

Thomson, K. S. 2005. *Fossils: A Very Short Introduction*. Oxford University Press, Oxford, UK, 147 pp.

Guides to Collecting and Identifying Fossils

Arduini, P., G. Teruzzi, & S. S. Horenstein. 1986. *Simon & Schuster's Guide to Fossils*. Simon and Schuster, New York, 317 pp.

Garcia, F. A., & D. S. Miller. 1998. *Discovering Fossils: How To Find and Identify Remains of the Prehistoric Past.* Stackpole Books, Mechanicsburg, PA, 212 pp.

Lichter, G. 1993. *Fossil Collector's Handbook: Finding, Identifying, Preparing, Displaying*. Sterling Publishing Company, New York, 160 pp.

Macdonald, J. R. 1983. *The Fossil Collector's Handbook: a Paleontology Field Guide*. Prentice-Hall, Englewood Cliffs, NJ, 193 pp.

Murray, M. 1967. *Hunting for Fossils: A Guide to Finding and Collecting Fossils in All Fifty States*. Macmillan Company, Toronto, Canada, 348 pp.

Nudds, J. R., & P. A. Selden. 2008. *Fossil Ecosystems of North America: A Guide to the Sites and their Extraordinary Biotas*. University of Chicago Press, Chicago, 288 pp.

Parker, S. 1990. *The Practical Paleontologist: a Step-By-Step Guide To Finding, Studying, and Interpreting Fossils*. Simon and Schuster, New York, 159 pp.

Parker, S. 2007. *Fossil Hunting: An Expert Guide to Finding and Identifying Fossils and Creating a Collection*, Southwater, London, 96 pp.

Ransom, J. E. 1964. *Fossils In America: Their Nature, Origin, Identification and Classification and a Range Guide To Collecting Sites*. Harper and Row, New York, 402 pp.

Thompson, I. 1982. *The Audubon Society Field Guide To North American Fossils*. Knopf, New York, 846 pp.

Walker, C., D. Ward, & C. Keates. 2009. *Fossils*. Dorling Kindersley (Smithsonian Handbooks), New York, 320 pp.

Fossils of the Southeast

Burns, J. 1991. *Fossil Collecting in the Mid-Atlantic States*. Johns Hopkins University Press, Baltimore, MD, 216 pp.

The Paleontology Portal, http://paleoportal.org. (North American fossil record and geologic and climate histories, by state.)

Ward, L. W. 1992. Molluscan biostratigraphy of the Miocene, middle Atlantic coastal plain of North America. *Virginia Museum of Natural History Memoir* 2, 159 pp.

Alabama

Copeland, C. W., Jr. 1963. Curious creatures in Alabama rocks: a guide book for amateur fossil collectors. *Geological Survey of Alabama Circular* 19, 45 p.

Ebersole, S. M., & J. L. King. 2011. A review of non-avian dinosaurs from the Late Cretaceous of Alabama, Mississippi, Georgia, and Tennessee. *Bulletin of the Alabama Museum of Natural History*, 28: 81–93.

King, D. T., Jr. 2003. *Alabama Dinosaurs, 3rd edition*. Parsimony Press, Auburn, AL, 147 pp.

Kopaska-Merkel, D. C., & R. J. Buta. 2012. *Field-trip Guidebook to the Steven C. Minkin Paleozoic Footprint Site, Walker County, Alabama*. Alabama Paleontological Society, 31 pp.

Late Cretaceous Dinosaurs of the Southeastern United States, by D. T. King, Jr., http://www.auburn.edu/~kingdat/dinosaur_webpage.htm.

Thurmond, J. T., & D. E. Jones. 1981. *Fossil Vertebrates of Alabama*. University of Alabama Press, Tuscaloosa, 244 pp.

Florida

Brayfield, L., & W. Brayfield. 1993. *A Guide for Identifying Florida Fossil Shells and Other Invertebrates, 3rd edition*. Florida Paleontological Society, Gainesville, FL, 112 pp.

Brown, R. C. 1996. *Florida's Fossils: Guide to Location, Identification, and Enjoyment, revised edition*. Pineapple Press, Sarasota, FL, 208 pp.

Fuqua, R. L. 2011. *Hunting Fossil Shark Teeth in Venice, Florida: the Complete Guide: On the Beach, Scuba Diving, and Inland*. Robert L. Fuqua, Venice, FL, 80 pp.

Hulbert, R. C. 2001. *The Fossil Vertebrates of Florida*. University Press of Florida, Gainesville, FL, 384 pp. (Technical.)

Renz, M. 1999. *Fossiling in Florida: A Guide for Diggers and Divers*. University Press of Florida, Gainesville, FL, 216 pp.

Renz, M. 2002. *Megalodon: Hunting the Hunter*. PaleoPress, Lehigh Acres, FL, 170 pp.

Georgia

Martin, A. 2013. Life *Traces of the Georgia Coast: Revealing the Unseen Lives of Plants and Animals*. Indiana University Press, Bloomington, 692 pp.

Life Traces of the Georgia Coast: Unseen lives of the Georgia Barrier Islands, by A. Martin, Emory University, http://www.georgialifetraces.com/tag/trackways/. (Blog.)

Paleontology of the Coastal Plain Province, by D. R. Schwimmer, 2006, New Georgia Encyclopedia, http://www.georgiaencyclopedia.org/articles/science-medicine/paleontology-coastal-plain-province.

Kentucky

Cincinnati Dry Dredgers, http://drydredgers.org/. (An unusually active fossil club that visits Kentucky and other regional sites.)

Finding Fossils in Indiana and Kentucky: Falls of the Ohio State Park, http://www.fallsoftheohio.org/collecting.html.

Fossils of Kentucky, Kentucky Geological Survey and University of Kentucky, https://www.uky.edu/KGS/fossils/.

Hedeen, S. 2008. *Big Bone Lick: The Cradle of American Paleontology*. University Press of Kentucky, Lexington, KY, 182 p.

Meyer, D. L., & R. A. Davis. 2009. *A Sea Without Fish: Life in the Ordovician Sea of the Cincinnati Region*. Indiana University Press, Bloomington, 346 pp.

The Stratigraphy and Fossils of the Upper Ordovician near Cincinnati, Ohio (including Kentucky), UGA [University of Georgia] Stratigraphy Lab, http://strata.uga.edu/cincy/index.html.

Mississippi

Dockery, D. T., III, & D. E. Thompson. 2016. *The Geology of Mississippi*. University Press of Mississippi, Jackson, 692 pp. (Contains extensive coverage of fossils.)

North Carolina

Aurora Fossil Museum, http://aurorafossilmuseum.org/.

Carter, J. G., P. E. Gallagher, R. E. Valone, & T. J. Rossbach, with contributions by P. G. Gensel, W. H. Wheeler, & D. Whitman. 1988. Fossil collecting in North Carolina. *North Carolina Department of Natural Resources and Community Development, Geological Survey Section, Bulletin* 89, 89 pp.

Chandler, R., & J. Timmerman. 2011. *Neogene and Quaternary Fossils of North Carolina—A Field Guide*. North Carolina Fossil Club, Raleigh, 58 pp.

Olsen, P. E., & A. K. Johansson. 1994. Field guide to Late Triassic tetrapod sites in Virginia and North Carolina. In *In the Shadow of the Dinosaurs*, edited by N. C. Fraser & H.-D. Sues. Cambridge University Press, Cambridge, UK, pp. 408–443.

Ray, C. E., ed. 1987. Geology and paleontology of the Lee Creek Mine, North Carolina, II. *Smithsonian Contributions to Paleobiology*, 61, 529 pp.

Timmerman, J., & R. Chandler. 2008. *Cretaceous and Paleogene Fossils of North Carolina—A Field Guide, corrected edition*. North Carolina Fossil Club, Raleigh, 70 pp.

South Carolina

Cicimurri, D. J., & J. L. Knight. 2009. Two shark-bitten whale skeletons from Coastal Plain deposits of South Carolina. *Southeastern Naturalist*, 8(1): 71–82.

Howe, J. T., & A. S. Howard. 1978. Fossil locations in South Carolina. *South Carolina State Museum Bulletin* 3, 59 pp.

Tennessee

Brister, R., & R. Young. 2007. *The Fossils of Coon Creek: An Upper Cretaceous Mississippi Embayment Marine Site in McNairy County, Tennessee*. Coon Creek Science Center, Adamsville, TN, 66 pp., 65 pls., http://www.memphismuseums.org/coon_creek-overview/.

Corgan, J. X. 1976. Vertebrate fossils of Tennessee. *Tennessee Department of Conservation Bulletin* 77, 100 pp.

Corgan, J. X., & E. Breitburg. 1996. Tennessee's prehistoric vertebrates. *Tennessee Department of Environment and Conservation, Division of Geology, Bulletin* 84, 170 pp.

Gray Fossil Site in Tennessee, by M. Kohl, Tennessee Department of Environment and Conservation, https://www.tn.gov/environment/topic/geology-gray-fossil-site-in-tennessee.

Moore, H. 2004. *The Bone Hunters: the Discovery of Miocene Fossils in Gray, Tennessee*. University of Tennessee Press, Knoxville, 144 pp.

Schubert, B. W., & J. I. Mead. 2011. *The Gray Fossil Site: 10 Years of Research*. Don Sunquist Center of Excellence in Paleontology, East Tennessee State University, Johnson City, TN, 98 pp.

Virginia

Burns, J. 2014. *Virginia Through Time: a Natural History Atlas*. Pietas Publications, Waynesboro, VA, 74 pp.

McLoughlin, T. F. 2013. *A Guide to Pennsylvanian (Carboniferous) Age Plant Fossils of Southwest Virginia*. Trafford Publishing, Bloomington, IN, 138 pp.

Olsen, P. E., & A. K. Johansson. 1994. Field guide to Late Triassic tetrapod sites in Virginia and North Carolina. In *In the Shadow of the Dinosaurs*, edited by N. C. Fraser & H.-D. Sues. Cambridge University Press, Cambridge, UK, pp. 408–443.

Sethi, P., R. Whisonant, K. Cecil, & P. Newbill. 2014. *Selected Virginia Fossils*. Geology of Virginia CD-ROM Web Edition, by Radford University, http://www.radford.edu/jtso/GeologyofVirginia/Fossils/GeologyOfVAFossils3-4a.html.

West Virginia

Amjad, H. 2006. *Fossils of West Virginia, Vol. 1: Invertebrates & Vertebrates*. Ayne Amjad, Beckley, WV, 400 pp.

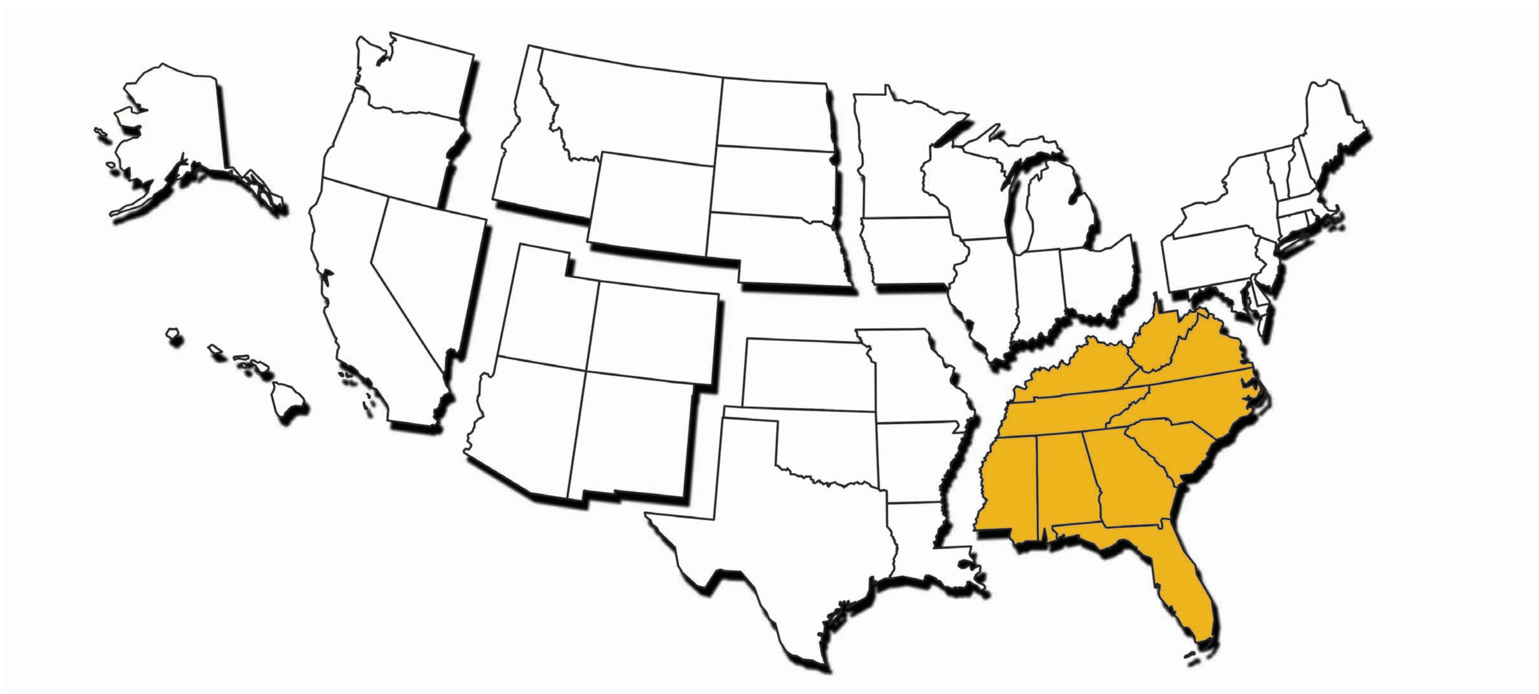
Amjad, H. 2006. *Fossils of West Virginia, Vol. 2: Plant Life & Paleobotany*. Ayne Amjad, Beckley, WV, 338 pp.

Concise Guide to Plant Fossils of West Virginia: Images from Plant Fossils of West Virginia, WVGES ED-3A; Gillespie, Clendening, and Pfefferkorn, 1978, Illustrations by B. Schleger, http://www.wvgs.wvnet.edu/www/geoeduc/AdaptiveEarthScienceActivities/Extras/ConciseGuideToPlantFossilsWV.pdf.

The *Teacher-Friendly* Guide™

to the Earth Science of the Southeastern US

2nd ed.



Edited by Andrielle N. Swaby, Mark D. Lucas, & Robert M. Ross

Paleontological Research Institution
2016

ISBN 978-0-87710-512-1
Library of Congress no. 2016930925
PRI Special Publication no. 50

1259 Trumansburg Road
Ithaca, New York 14850 USA
priweb.org

First printing January 2016

This material is based upon work supported by the National Science Foundation under grant DRL-0733303. Any opinions, findings, and conclusions or recommendations are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The publication also draws from work funded by the Arthur Vining Davis Foundations and The Atlantic Philanthropies.

The interactive online version of this *Teacher-Friendly Guide*™ (including downloadable pdfs) can be found at http://teacherfriendlyguide.org. Web version by Brian Gollands.

The Teacher-Friendly Guide™ series was originally conceived by Robert M. Ross and Warren D. Allmon. The first edition of this volume was published as Special Publication no. 42 in 2003 (online) and 2012 (hard copy). Original illustrations in this edition are mostly by Jim Houghton (The Graphic Touch, Ithaca), Wade Greenberg-Brand, and Christi A. Sobel.

Layout and design by Paula M. Mikkelsen, Elizabeth Stricker, Wade Greenberg-Brand, Katherine Peck, and Christine Dubé.

Cite this book as:
Swaby, A. N., M. D. Lucas, and R. M. Ross (eds.), 2016, *The Teacher-Friendly Guide to the Earth Science of the Southeastern US, 2nd edition.* Paleontological Research Institution, Ithaca, New York, 460 pp.

Cite one chapter as (example):
Allmon, W. D., 2016, Fossils of the Southeastern US. Pages 87–146, in: A. N. Swaby, M. D. Lucas, & R. M. Ross (eds.). *The Teacher-Friendly Guide to the Earth Science of the Southeastern US, 2nd edition.* Paleontological Research Institution, Ithaca, New York.

On the back cover: Blended geologic and digital elevation map of the Southeastern US. Each color represents the age of the bedrock at the surface. Adapted from Barton, K. E., Howell, D. G., Vigil, J. F., *The North America Tapestry of Time and Terrain*, US Geological Survey Geologic Investigations Series I-2781, http://pubs.usgs.gov/imap/i2781.