

# ANCIENT LIFE OF NEW YORK

## A Billion Years of Earth History

### Gallery Text and Labels

**Please take a stroll through a billion years of New York's "deep time."**

[Introductory panel outside of the gallery]

Like deep space, deep time takes us back through dimensions of life that are beyond the scope of human experience. Deep time is reconstructed by scientific evidence. **Paleontology** is the study of life through deep time.

American paleontology was born in the mid-1800s in the New York State Museum. The state's fossil-rich rock succession, the "New York System" devised by James Hall, State Paleontologist, is a reference for worldwide time correlation of the geologic record. Modern State Museum research reconstructs climate and sea-level changes, mountain-building in the geologic past, and helps explain the distribution of oil and gas in New York.

Ancient Life of New York exhibits some of the one million fossils in the Museum's collections and illustrates what we know about New York through deep time. These "silent" artifacts are our common heritage. Exploring the depth of time, the evolution of life, and the history of the earth gives us an understanding of our own origins.

**paleontology** ("pay-lee-un-tahl-uh-jee")

**James Hall** [label for portrait of James Hall]

1811–1898

New York State Paleontologist, 1843–1898

First director of New York State Museum and one of the most important paleontologists of the nineteenth century.

#### Throughout this exhibition:

**Unfamiliar Words** - Some scientific terminology may be unfamiliar to you, so certain words within each panel are **bolded**. You can find these words either written out phonetically, or defined, or both, at the bottom of the appropriate panel.

**Fossil Names** - All living and fossil organisms are given a unique scientific name. This two-part, descriptive name consists of the **genus** (jee-nuss) and the **species** (spee-seez), usually Latin or Greek words. The genus is capitalized, but the species is not. Both names are always written in *italics*.

## **Continental Drift** [title of the interactive computer touch screen]

[wall text]

Have you ever looked at the Atlantic coasts of South America and Africa and seen how they fit like pieces of a puzzle? This and many other interesting facts mystified geographers, geologists and paleontologists for centuries, until the advent of the theory of plate tectonics in the 1960s.

According to the theory of plate tectonics, the surface of the Earth is broken up into large plates. The edges of the plates accumulate material, are destroyed or slide past adjacent plates causing them to move over the surface of the Earth. In this way the continents, which rise above sea level on some plates, "drift" over the globe.

Plate tectonics has revolutionized our understanding of the Earth and life. It explains earthquakes, the formation of mountain belts, the movement of the continents through time, and distribution of life over the planet, both at the present and in the past. For example, why are all of Australia's native mammals marsupials (pouched mammals) as opposed to placental (live-bearing mammals seen on other continents)? Because in the geological past, during the early evolution of mammals, Australia "drifted" away from the other continents due to plate tectonics. Marsupials, which originated before placental mammals, became isolated on the island continent and evolved separate from the placentals.

This **paleogeography** computer presentation illustrated the changing surface of the Earth over the past 750 million years. Notice the movement of the continents and ocean basins over time, and how parts of the continents, including North America, are at times flooded by shallow seas. The red dot, marking eastern New York, shows the long journey our home has taken from near the South Pole to its present location.

**paleogeography** (pay lee oh gee *ah* gruh fee) the study of the Earth's geography through geologic time.

## **Dividing Geologic Time** [title panel]

The great age of the earth was first understood by British and French geologists, many of whom were clergymen, in the early 1800s. These scientists used the succession of fossils to define "relative time" intervals (from older to younger). They also gave formal names to the major divisions of ancient prehistory. The geological periods and eras illustrated in this exhibit were first applied by James Hall in the mid-1800s to New York's rocks. It was only in the early 1900s, when scientists began to understand **radioactivity**, that geologists began to use radioactive substances, such as carbon-14 and uranium, to determine the "absolute time," or age in years, of rocks and fossils.

**radioactivity**, the giving-off of particles and rays by atoms as they decay into different atoms

## ***Coelophysis*** ("seel-oh-fy-sis")

Triassic period c 205 million years ago; Ghost Ranch, New Mexico

This is a life-size fiberglass cast of a skeleton of *Coelophysis*, a dinosaur which was similar to the early small carnivorous dinosaurs that lived in New York during the late Triassic Period.

A small, active predator, *Coelophysis* was capable of quick movement, both in pursuit of smaller prey and in avoiding larger predators. It probably fed on the small reptiles and amphibians that shared its world.

A full-grown individual like this one probably weighed about 110 pounds. A comparison of the bones around the eyes and in the ears of *Coelophysis* with similar bird bones indicates that it probably had very good vision and a fine sense of hearing, vital to any predator.

Quick and efficient, the *Coelophysis* ran on its toes with the heel well above the ground, similar to modern running birds like ostriches. Paleontologists studying the stride of the *Coelophysis* through its trackways estimate that the dinosaur was capable of maximum speeds of fifteen to twenty miles per hour.

(Lifestyle information from E. H. Colbert 1995, *The Little Dinosaurs of Ghost Ranch* )

### **New York State Fossil** [wall text panel]

Eurypterids, sometimes called "sea scorpions" are an extinct group of arthropods that lived during the Paleozoic Era [c. 490-250 million years ago]. Their closest living relative is the horseshoe crab. A combination of legs and large paddle like limbs allowed them to both walk and swim, a useful adaptation for navigating New York's ancient seas and freshwaters. Eurypterids are thought to have been ferocious predators, feeding largely on soft-bodied animals. New York Silurian rocks are known worldwide as the best source for Eurypterid fossils.

*Eurypterus rempis* [label for specimen in freestanding case]

Silurian period [c. 240 million years ago]

Litchfield, Herkimer Co. New York

Slab shows two complete *Eurypterus* fossils and parts of additional specimens. the larger fossil is upside down and shows the various appendages, including swimming paddles, and small pincers [cheherae, pronounced chel issa ray] used for feeding.

## **THE PROTEROZOIC EON** [Enter to the right, into the first area of the exhibit]

### **THE PROTEROZOIC: BILLION-YEAR-OLD ROCKS AND FOSSILS** [text panel]

[three graphics: Geological Period and Time; Map showing the Age of Bedrock in New York; a continental drift map showing Late Proterozoic 650 million years ago.]

#### **The Proterozoic in Geologic Time**

The **Proterozoic** featured the appearance and evolution of many bacterial, animal, and plant groups. Early Proterozoic life was limited to bacteria. Single-celled animal- and plant-like forms with a nucleus and other structures appeared a billion years ago. Multi-cellular large marine **invertebrate** animals appeared at the end of the Proterozoic.

**Proterozoic** (“*pro-tur-oh-zoh-ick*”), early geologic era, c. 2.5 billion to 543 million years ago. It means “first life.”

**invertebrate** (“*in-vur-tuh-brate*”), animals that lack a backbone

## **Proterozoic Rocks in New York - -The State's Basement**

New York's oldest rocks are in the Adirondacks, Hudson Highlands, and New York City metropolitan area.

These regions expose the ancient basement of New York at the earth's surface. This basement extends underground southwest into Mexico. The rocks included sediments and volcanics that were **metamorphosed** and almost melted during **Grenville** mountain-building events a billion years ago.

Adirondack and Hudson Highland rocks were produced at great heat and pressure forty kilometers (twenty-five miles) underground. With uplift and deep erosion, the Adirondacks show the types of rocks now forming deep under the Himalayas.

**metamorphose** ("met-a-more-foze), to change

**Grenville**, a place name in Quebec applied to a belt of billion-year-old rocks in New York, Quebec, and the eastern United States

## **Proterozoic Paleogeography**

A billion years ago, New York lay in the middle of a giant continent.

The earth's surface is not stable. Forces deep in the earth's **mantle** break its outer layers (the **lithosphere**) into large fragments, or plates, that move toward and away from one another. This process is known as **plate tectonics**, commonly called "continental drift." However, this process is so massive that ocean basins, as well as continents, move. A billion years ago, plate movements forced the continents together into one supercontinent called **Rodinia**, much of which was covered by seas. Note the location of Albany.

**paleogeography** ("pay-lee-oh-jee-og-raff-ee"), the distribution of oceans and continents through geologic time

**mantle**, dense part of the earth's interior, from the lower lithosphere down to the liquid core  
**lithosphere** ("lith-oh-sfear"), the brittle outer portion of the earth, to a depth of ninety miles  
plate tectonics ("teck-tahn-icks")

**Rodinia** ("row-din-ee-uh"), Precambrian supercontinent that included all modern land masses, c. 1.1 billion to 550 million years ago

**Stromatolites: Oldest Fossils from New York and the Eastern United States**[text inside case]  
New York's oldest fossils are **stromatolites**.

These stromatolites are found in marble (metamorphosed limestone) in the northwest Adirondacks. Stromatolites were formed by mats of **cyanobacteria** that grew on the floor of a shallow sea. Cyanobacteria are the "blue-green **algae**" that grow on the bottom of rain puddles and that give polluted lakes a bad smell in midsummer.

Comparisons with the geology of southern Ontario Province, Canada, suggest that Adirondack stromatolites lived on shallow sea floors 1.5 billion years ago. These stromatolites are the oldest fossils in the eastern United States. New York State Museum Paleontology Collection  
**stromatolites** ("stroh-mat-oh-lites"), layered rock structures produced by microorganisms  
**cyanobacteria** ("sy-an-oh-back-teer-ee-uh")  
**algae** ("aal-jee"), simple water living plants with red and green pigments

## THE CAMBRIAN PERIOD

### THE CAMBRIAN: DIVERSIFICATION OF MARINE ANIMALS AND PLANTS

[Text panel includes three graphics: Geological Period and Time; Map showing the Age of Bedrock in New York; a continental drift map showing Late Cambrian 514 million years ago ]

#### The Cambrian in Geologic Time

The Cambrian is the first geologic period with abundant fossils. It was named for rocks and their distinctive fossils in the Cambrian Mountains of Wales.

**Cambrian** (“*kamm-bree-un*”), geologic interval c. 543 to 489 million years ago

#### Cambrian Rocks in New York

Cambrian-age rocks occur in several belts in New York and have the oldest animal fossils in the state. The ancient Proterozoic basement of the Adirondack Mountains, Hudson Highlands, and Manhattan area is overlain by shallow-water sandstones and **carbonates** (limestones and **dolostones**) of Cambrian age. Deep-water Cambrian-age mudrocks and sandstones occur in the **Taconic** slate belt east of the Hudson River.

**carbonates** (“*car-bun-ates*”), minerals partially composed of carbon and oxygen

**dolostone** (“*dole-oh-stone*”), rock made of the mineral dolomite, which is calcium magnesium carbonate

**Taconic** (“*tuh-kahn-ick*”), hills and low mountains on the east side of the Hudson River north of Beacon, New York

#### Cambrian Paleogeography

New York was tropical and faced an open ocean in the Cambrian.

The Rodinia supercontinent broke apart at the end of the Proterozoic. **Laurentia** was one of many continents that resulted from the breakup.

New York lay at the seaward edge of this tropical continent. The **Appalachian** Mountains did not yet exist. Hot, dry environments meant that limestones, **halite**, and **gypsum**—minerals resulting from the drying up of shallow seas—occur in New York.

**Laurentia** (“*lore-en-shuh*”), ancestral North America; did not include the eastern Appalachians, Florida, or the present-day west coast of North America

**Appalachian** (“*app-uh-lay-chin*”), the chain of eastern North American mountains stretching from Alabama to Newfoundland, Canada

**halite** (“*hay-lite*”), mineral commonly known as table salt

**gypsum** (“*jip-sum*”), mineral of which plaster is composed

#### NEW YORK’ OLDEST ANIMAL FOSSILS [text panel on right of the Diorama]

The oldest animal fossils in the Middle Atlantic States are found in the slate belt of eastern New York. The 517 million-year old fossils from Claverack, Columbia County, include trilobites and microscopic remains of many other marine animals.

### **Exceptionally Preserved Fossils and the “Slate Belt”**

The “**Slate Belt**” extends from Poughkeepsie north to Washington County in eastern New York and on into Vermont.

“Slate Belt” rocks were laid down on the ancient **continental slope** of eastern North America as deep-water, marine muds and sands (the dots indicate sandstones). The “Slate Belt” features a thick (600 meter, 2,000 foot) rock sequence. Red, green, purple, and black slates from the belt are used for shingles, blackboards, and other purposes.

Exceptionally preserved early animal fossils are found in limestones that occur only in the black slates of the “Slate Belt.”

**slate**, fine-grained metamorphic rock; originally laid down under water as soft mud, then compacted into **shale** (fine-grained sedimentary rock that breaks parallel to bedding, i.e., parallel to the old sea bottom), and later folded and heated by mountain-building so that new minerals form; slates generally do not break parallel to bedding

**continental slope**, part of the submarine margin of continents, forms a great slope into the deep ocean seaward of the shallower (to 200 meters, 600 feet) continental shelf

### **Finding the Microfossils**

The Claverack site was found in the early 1980s by an amateur paleontologist who noted limestone beds and collected larger fossils of trilobites in the rock.

Acids were used to break down the limestone for microfossils. This technique destroys calcareous fossils, but reveals many other fossils. Many microfossils (those in the right picture above) were recovered with acid treatment as some of the animals used phosphate minerals (which make up bones and teeth) to construct their shells. Many of these specimens are magnified over a hundred times life size.

The fossils also include specimens (in left picture above) that were once calcareous. These are replaced by phosphatic minerals. Some of these fossils (upper right specimen, magnified c. 2,000 times life size) show impressions of the cells that secreted the shell or very fine shell details. These are exceptionally well preserved fossils.

**calcareous** (“kal-kher-ee-us”), composed of the chemical calcium carbonate (i.e., the “lime” in hard water, clam shells, and limestone)

**replaced**, process of fossilization by which original hard or soft parts are changed into mineral compounds

### **Ancient Global Warming and Exceptional Fossils**

Research at the State Museum has developed a model that relates slate color and a number of types of exceptional fossil preservation, like that at Claverack, to long-term, ancient climate cycles.

This model is based on the fact that bottom water on continental slopes has low oxygen—the water is too deep and dark for photosynthesis and oxygen production. Dark, organic-rich mud is laid down where oxygen levels are very low as bacterial decay slows without oxygen. In addition, warm climates greatly reduce oxygen on the slope as: 1) warm water holds less oxygen in solution, 2) storms that mix surface water with oxygen down to great depths are less intense,

and 3) warm North and South Poles are not a source for the dense, near-freezing water that sinks and brings oxygen into the deep sea.

Thus, the black intervals in the “Slate Belt” are believed to reflect 3–4 million year-long warm climate cycles with black, organic rich mud deposition. Shells swept off the continental shelf and onto the slope are replaced by phosphatic minerals by bacterial processes in oxygen-poor, black mud. Detailed correlations of the black intervals in the “Slate Belt” show that they correspond to times of exceptional fossil preservation in Greenland, China, western North America, and elsewhere.

### **Cambrian Seas at Lester Park** [text panel description for the Diorama]

One of the most famous Cambrian localities in the eastern United States is at Lester Park near Saratoga Springs, NY. The Cambrian was a time of rising sea levels. Shallow tropical seas with abundant life forms covered New York and eastern Laurentia west to the Mississippi River. This diorama shows Late Cambrian (c. 495 million years ago) life at Lester Park. Note the many organisms that lived on this very shallow sea floor. Dome-like stromatolites similar to those from the Proterozoic, along with snails, **hyoliths**, and **trilobites**, are found on the bottom.

**hyoliths** (“*hy*-oh-liths”), extinct tube-forming animals

**trilobites** (“*try*-low-bites”), extinct segmented animals related to insects, crabs, and spiders

### **Cambrian Fossils** [text inside case]

Match these fossils with the animals in the “Cambrian Seas at Lester Park” diorama

#### **-Stromatolite**

Upper Cambrian, c. 495 million years ago, Hoyt Limestone

Lester Park, Saratoga County, New York

Underside of a small stromatolite showing growth layers.

Scientists now understand that many types of microbes make up stromatolites, and that environment (wave and current strength, water depth, etc.) determines their form. Scientists call this a “domal [as in a dome] stromatolite.” New York State Museum Paleontology Collection, locality 8852

#### **-*Lingulella acuminata*** (“ling-gyou-*l*ell-uh uh-*kew*-min-ah-*tuh*”)

Upper Cambrian, c. 495 million years ago, Hoyt Limestone

Lester Park, Saratoga County, New York

A small brachiopod (“brack-ee-oh-pod”, a marine animal with two shells that resembles a clam) characteristic of very shallow water environments in the Upper Cambrian. New York State Museum Paleontology Collection, E 1684

#### **-*Prosaukia hartii*** (“*pro*-saw-*kee*-uh har-*tie*”)

Upper Cambrian, c. 495 million years ago, Hoyt Limestone

Lester Park, Saratoga County, New York

Heads (upper specimens) and broad tails (lower specimens) of a trilobite (“try-low-bite”), an extinct marine relative of lobsters, crab, insects, and spiders. Waves and currents separated the hard external skeletons of most trilobites into isolated heads, body segments, and tails before burial and fossilization. New York State Museum Paleontology Collection, locality 3656

### **Cambrian Life in the Deep Sea** [text panel for fossil specimen]

Slate quarries in Washington County, New York, expose the oldest Cambrian rocks and fossils in the state.

This star-like fossil track is called *Dactyloidites*. The creature that made these tracks was one of the few animals that lived on the deep sea bottom represented by Early Cambrian (c. 517 million years ago) green slates.

*Dactyloidites* can vary in shape, and has five, six, or seven lobes. *Dactyloidites* seems to have been a shallow burrow and not the actual fossil of an animal's body. It is found in eastern New York and northwest Vermont. New York State Museum Paleontology Collection

*Dactyloidites* (“dak-till-oy-dite-eez”), the genus name of this marine burrow

### **Cambrian “Mystery Animal” from Clinton County, New York** [center of the floor space]

Geologists and biologists have been puzzled for a hundred years about the identity of the animal that made these “motorcycle tracks” in northern Clinton County. It was a soft-bodied, snail-like creature with a wide foot. But scientists cannot determine the specific type of animal, and this type of track has never been seen in older or younger rocks.

The oldest Cambrian rocks in the northern Adirondack region are Potsdam Formation sandstones. Wave ripples, like the ones on this slab, suggest very shallow marine conditions. Fossils of shelled animals are rare and small in the Potsdam. This track, known as *Climactichnites*, is not a fossilized animal, but rather a fossil of its movement. *Climactichnites* is found in early Late Cambrian (c. 495 million years ago) rocks in New York and Wisconsin.

New York State Museum Paleontology Collection

*Climactichnites* (“kly-mack-tick-nite-eez”), the genus name of this marine track

## **THE ORDOVICIAN PERIOD** [text panel to the left of the entrance, clockwise]

THE ORDOVICIAN: MODERNIZATION OF MARINE LIFE [to the left of the entrance]

[three graphics: Geological Period and Time; Map showing the Age of Bedrock in New York; a continental drift map showing Middle Ordovician 458 million years ago]

### **The Ordovician in Geologic Time**

The Ordovician Period was first distinguished in southeast England on the basis of its distinctive fossils. It was named for a **Celtic** tribe, the **Ordovices**, that was never defeated by the Romans.

**Ordovician** (“or-duh-vish-un”), geologic interval c. 489 to 430 million years ago

**Celtic** (“kelt-ick”), ancient tribes of Britain and central Europe

**Ordovices** (“or-doh-vee-seez”)

## Ordovician Rocks in New York

Marine rocks of Ordovician age rim the Adirondacks and Lake Ontario and occur widely in the Hudson Valley.

Ordovician rocks overlie Cambrian rocks in the Adirondacks and Hudson Highlands. Soft Ordovician rocks were eroded during the "Ice Age" (c. two million to 10,000 years ago) to form the depressions of Lakes Ontario and Champlain, and the Mohawk and Hudson River Valleys. A second belt of deep-water Ordovician mudrocks and sandstones occurs in the Taconic slate belt east of the Hudson River.

## Ordovician Paleogeography

New York was tropical and was affected by the first Appalachian mountain-building episode in the Ordovician.

**Laurentia** remained in south tropical latitudes and grew in size later in the Ordovician. Plate tectonic processes caused an offshore volcanic island arc to collide and "fuse" with east Laurentia. This collision is called the Taconic **orogeny**, named for the Taconic Mountains of eastern New York.

The Taconic orogeny led to the first uplift of the Appalachians, which extended from Newfoundland, Canada, to Alabama. Modern Taconic-like mountain-building can be seen in the slow collision of Australia with the big island of New Guinea (a volcanic island arc) to the north.

**orogeny** ("or-ah-jen-ee"), mountain-building events

## Fossils from the Utica Sea [text inside specimen case]

Match these fossils with the animals in the "Utica Sea" diorama

### A. *Triarthrus becki* ("try-arth-russ beck-i") [label]

Upper Ordovician, c. 450 million years ago, Utica Shale

Rome, Oneida County, New York area

New York State Museum Paleontology Collection, E 41

### A. *Triarthrus* and Fossil Sexual Behavior [text panel inside case]

Abundant, complete trilobite (extinct marine arthropod) fossils like these are interpreted as 1) mass kills, or 2) external skeletons (molts) shed during reproduction. These specimens record reproductive behavior.

Trilobites reproduced like lobsters, crabs, and crayfish, their distant relatives. Crabs, for example, cluster together and molt when they reproduce. The females attach fertilized eggs to the undersides of their bodies when they are in a newly molted, "soft-shell" state. The outer skeleton then hardens, and the female protects the eggs.

Molting was complex in *Triarthrus*. The animal detached the spine-like right and left corners of its head, cracked the head's front margin, and pulled its entire body out. Observation shows that the corner spines are missing on all of the heads. These molts were shed just before reproduction.

The larger cracks in this specimen are a result of "pyrite disease", the breakdown of pyrite ("fool's gold") in the rock caused by high humidity. Fossils need climate-controlled conditions for long-term preservation.

**B. *Dicranograptus nicholsoni*** (“dy-cran-o-grap-tuss” nick-el-sohn-i”) [label]  
Upper Ordovician, c. 450 million years ago, Utica Shale  
Montgomery County, New York, from New York State Thruway cut 16 km (10 miles)  
east of Herkimer

New York State Museum Paleontology Collection  
Acquired via donation of entire SUNY Stony Brook fossil collection.

**B. *Dicranograptus Colonies*** [text panel inside case]

This slab shows large, well-preserved **graptolite** specimens (“grap-toe-lite”, an extinct colonial animal very distantly related to vertebrates). Graptolite means “written rock;” the specimens look like pencil markings.

Note the distinctive Y-shape of *Dicranograptus* colonies. Graptolites were organic-walled and flexible. The colonies on this slab were bent by bottom currents before their burial.

**C. *Geisonoceras tenuistriatum*** (“gee-sun-ah-sir-us ten-you-ee-stree-at-um”) [label]

Upper Ordovician, c. 450 million years ago, Trenton Group

Trenton Falls, Oneida County, New York

New York State Museum Paleontology Collection, E 3040

**C. *Geisonoceras the Predator*** [text panel]

*Geisonoceras* was the most common nautiloid **cephalopod** (“seff-luh-pod”), an early squid relative with a shell) in the Utica Sea. With strong beak-like jaws, it was a top predator.

*Geisonoceras* shells are poorly preserved in the Utica Shale. Most lost their lime content in the acidic waters on the sea floor and were crushed flat (look at the *Triarthrus* slab to see impressions of *Geisonoceras* shells). These uncrushed *Geisonoceras* shells are from western Utica Sea limestone.

**The Utica Sea and Taconic Mountain-Building** [text panel description of diorama]

Black shales in New York State Thruway road cuts from Schenectady to Utica are fossil-bearing deposits of the ancient Utica Sea.

Taconic mountain-building pushed the offshore volcanic island arc onto the edge of Laurentia. The island arc’s weight forced the continent down, so the depth of the sea increased across New York. Muds eroded from the Taconic Mountains were laid down on this deep-sea bottom.

Life in the Utica Sea included floating seaweed and swimming nautili’s near the surface (shown twice life-size at top of diorama). When they died, these organisms sank and were fed upon by animals that lived on the dark, muddy bottom.

The Utica Sea extended across New York and reached Minnesota.

**nautiloids** (“naw-till-oydz”), squid-like animals with shells, related to the modern *Nautilus*

**"Dumb" Predators and Predation in Geologic Time** [text inside case]

Giant fossils that resemble telephone poles are found in the Black River Valley of northwest New York. These are **endoceroids** (“en-doss-ur-oydz”), heavy-shelled early relatives of squids.

This fragment of the endoceroid *Endoceras annulatum* ("en-doss-ur-us an-you-latt-um") came from 470 million-year-old tropical sea limestones at Watertown, New York.

Although armed with the tentacles and sharp beaks of squids, endoceroids were slow-moving. Their thick-walled shells with many septa (vertical internal walls) were heavy. Long shells meant that endoceroids could not use jet propulsion, as squids do, in a chase requiring precision swimming.

Geerat Vermeij, an American paleontologist, views predator-prey relationships through geologic time as "escalation." This observation, based on the fossil record, shows that predator evolution led to greater speed, power, and efficiency. These adaptations were then matched in their prey by stronger shells, deeper burrowing habits, improved hiding ability, etc., until new counter-adaptations were "devised" by predators.

*Endoceras*, New York's top Ordovician predator, was "slow and dumb" compared to modern squids. But it was adequate for its environment, and survived for over five million years.  
New York State Museum Paleontology Collection, E 317

### **Earth's Oldest Coral Reefs** [text panel for free-standing case in the center floor of this area]

The oldest coral reefs on earth occur in the northern Lake Champlain valley in New York and Vermont. Reefs built by corals and **stromatoporoids** appeared in eastern New York before the onset of Taconic mountain-building. These Middle Ordovician coral reefs are relatively small, reaching three meters (ten feet high), and can be seen in quarries in the Plattsburgh, New York, area. Coral reefs, with cavities for animals to hide in, originated in the Middle Ordovician. They accompanied the increased diversity of marine animals during this period. New York State Museum Paleontology Collection

*stromatoporoids* ("stroh-mah-top-or-oydz") extinct group of calcified sponges

### **In separate case; along the wall -**

#### **Science Education from the Silurian** [text inside the case]

The new science of paleontology originated in the early 1800s, and pictures of fossils were vital for scientific accuracy, education, and communication. By mid-century, one of the most significant standards for paleontological research had been written by New York State Paleontologist James Hall. *Paleontology of New York* consists of thirteen profusely illustrated volumes published from 1843 to 1888. It is based primarily on fossils from New York State. This case displays a classic Silurian fossil and illustrations from this monumental work.

#### **Illustration from *Paleontology of New York*** [label]

This illustration shows detailed pictures of the upper and lower surface of *Eurypteris lacustris* and its growth stages. Rendering of such detail was possible by printing with steel-engraved plates. The thirteen volumes of *Paleontology of New York* were distributed worldwide, and are still an invaluable research tool for original descriptions and illustrations of fossils.

#### **Steel-Engraved Plate Used in Printing** [label]

This original plate, made of steel plating over copper, was used in printing the illustrations in Volume 3 of *Paleontology of New York* in 1861. Before the advent of photography, drawings

were the primary way of visually communicating features of fossil species. Scientific illustrations were accurately drawn by hand from original specimens, then were transferred to a plate by either hand-engraving or acid-etching. Loaned for exhibit by Timothy Schloemer

***Eurypterus lacustris*** (“yer-rip-tur-iss luh-cuss-triss”) [label]

Upper Silurian, c. 420 million years ago, Salina Group

Williamsville, Erie County, New York

Underside of *Eurypterus lacustris*. Fossils similar to this eurypterid are illustrated in the *Paleontology of New York*.

New York State Museum Paleontology Collection, E 66c

## THE SILURIAN PERIOD

**Late Silurian Life** [text panel description for the diorama]

Shallow sea deposits with few fossils characterize the end of the Silurian in New York.

Fossils are generally rare in New York’s Upper Silurian because seawater evaporation under the hot tropical sun often made environments too salty for marine animals.

Some layers in the Upper Silurian of western New York have abundant **eurypterids**.

These layers reflect times of lower, more normal salinity. This diorama made in the early 1900s by Henri Marchand shows the eurypterid *Carcinosoma* on a muddy bottom.

**Eurypterids** (“yer-rip-tur-idz”), extinct relatives of horseshoe crabs

**Carcinosoma** (*kar-sin-oh-so-muh*), the genus name of this eurypterid

### THE SILURIAN: LIFE IN SHALLOW SEAS

[three graphics: Geological Period and Time; Map showing the Age of Bedrock in New York; a continental drift map showing Middle Silurian 425 million years ago.

**The Silurian in Geologic Time** [text]

The Silurian Period was named for rocks with characteristic fossils that occur in a part of western England once occupied by the **Silures**, an ancient Celtic tribe.

**Silurian** (“sill-ur-ee-un”), geologic interval c. 430 to 418 million years ago

**Silures** (“sy-loors”)

**Silurian Rocks in New York** [text]

Tropical Silurian seas reached only as far east as the modern Hudson Valley. The low Taconic hills extended farther east into New England.

Silurian rocks overlie Ordovician rocks, and extend from Niagara Falls to Albany

County’s Thacher Park. They are very thin in the Catskill foothills, and thicken to form the **Shawangunk** Mountains in southeastern New York.

**Shawangunk** (“shawn-gunk”)

### **Silurian Paleogeography** [text]

Laurentia was tropical in the Silurian. The Taconic Mountains were eroded to low hills that ran from Alabama to Newfoundland, Canada. Mountain-building ceased through much of the Silurian in this region.

Farther offshore, plate tectonic processes gradually pushed **Avalon**, a small New Zealand-sized continent, toward Laurentia. Volcanoes appeared in the northern Appalachians, and their ash clouds blew across New York. Today Silurian ashes appear as thin layers in the rock at Niagara Falls.

**Avalon** (“*aav-uh-lahn*”)

### **Rocks Formed of Fossils** [text in free-standing case]

Older Silurian rocks in western and central New York are often so filled with fossil shells from marine animals that they have become the rock itself.

This slab from Clinton County, New York, consists of shells of the brachiopod *Pentamerus oblongus*. Brachiopods, a major group of clam-like marine animals, are abundant in older fossil-bearing rocks. Most brachiopods were fixed in one place on the sea bottom. The evolution of fish with jaws, and the inability of brachiopods to escape these predators, led to the decline of brachiopods after the Devonian. New York State Museum Paleontology Collection

**brachiopod** (“brack-ee-oh-pod”)

**Pentamerus oblongus** (“pen-tam-ur-uss ahb-long-uss” ), the genus and species name of this brachiopod

## **THE DEVONIAN PERIOD** [Enter left, into the second area of the exhibit]

### **THE DEVONIAN: TEEMING SEA LIFE AND CONQUEST OF THE LAND**

[three graphics: Geological Period and Time; Map showing the Age of Bedrock in New York; a continental drift map showing Early Devonian 390 million years ago.]

### **The Devonian in Geologic Time** [text]

The Devonian Period was named by British geologists for the rocks and characteristic fossils of Devonshire, a western county of England.

**Devonian** (“deh-vone-ee-un”), geologic interval c. 418 to 362 million years ago

**Devonshire** (“deh-vuhn-shur”)

### **New York, A “Devonian State”** [text]

Devonian rocks are exposed across a third of New York, and the Devonian is the most widespread and **fossiliferous** time period represented in the state.

**fossiliferous** (“foss-ill-if-ur-us”), fossil-bearing

## Devonian Paleogeography [text]

New York had mountains rising in the east and seas covering the west during the Devonian. The second orogeny in the Appalachians unfolded in the Devonian, when Laurentia collided with the Avalon micro-continent. This orogeny uplifted the **Acadian** Mountains in a belt from Alabama to Newfoundland, Canada. Sands and muds that eroded from the Acadian Mountains became the great Catskill Delta in New York and Pennsylvania. Volcanic ash layers were also common.

The modern Catskill Mountains were formed by much later erosion of these Devonian sandstones. The geologist views the Catskills as an erosional remnant of the Devonian Catskill Delta.

**Acadian** (“uh-kaid-ee-un”), second chain of mountains uplifted in the Appalachian mountain belt, named for the Acadian region of Maritime Canada

## Middle Devonian Seascape in Western New York [text panel to explain the diorama]

Middle Devonian rocks (c. 385 million years ago) from the Finger Lakes to Lake Erie are rich in fossils. This diorama shows animals that lived on sea bottoms near Hamburg, Erie County. Coiled and straight-shelled nautiloids were top predators. Shelled brachiopods and clams filtered tiny organisms out of the water. Coral relatives called **Plumulina** (with red stalks that look like seaweed) were predators that killed small swimming organisms by stinging them.

**Plumulina** (“ploom-uh-line-uh”), the genus name for this soft coral relative

## Middle Devonian Fossils [text inside the case in the corner]

Match these fossils with the animals in the “Middle Devonian Seascape in Western New York” diorama. Fossils help reconstruct what ancient animals looked like and which organisms lived together in the past.

### A. *Orthoceras?* (“or-thah-sir-iss”) [label]

Middle Devonian, c. 385 million years ago, Hamilton Group  
Lake Erie shore, Highland Acres, Erie County, New York

A question mark after a genus name means that the genus may or may not be correct for the specimen. New York State Museum Paleontology Collection, locality 8322

### A. Why Badly Preserved Fossils Are Valuable [text panel]

Straight-shelled nautiloid **cephalopods** (“seff-luh-podz”) like *Orthoceras?* are poorly preserved in Hamilton Sea deposits. The outer layer and internal structures of the shells are lost, and the fossil consists of a muddy fill of the shell, or is crushed.

Fossil preservation often reflects shell mineralogy. Corals, trilobites, and most brachiopods are made of the mineral calcite and are well-preserved in Hamilton beds. But nautiloids, snails, and bivalves are made of **aragonite** (“uh-rag-uh-nite”) and are poorly preserved. Although aragonite and calcite have the same calcium carbonate composition, aragonite is more reactive chemically. It tends to dissolve away early in the formation of rock.

### B. *Nephriticeras maximus* (“neff-rih-tih-sehr-us max-ih-muss”) [label]

Middle Devonian, c. 385 million years ago, Hamilton Group  
Borodino, Onondaga County, New York  
New York State Museum Paleontology Collection, E 348

### B. **Top Predator** [text]

This nautiloid, called *Nephriticeras*, was a top predator in the Hamilton Sea. Like its modern nautilus relatives, it had arms to catch its prey and a parrot-like beak for biting. It swam by jet propulsion, accomplished by squeezing water out of a cavity under its head.

### C. *Favosites hamiltoniae* (“fah-voh-site-eez ham-ill-tohn-ee-uh”) [label]

Middle Devonian, c. 385 million years ago, Hamilton Group

East Bethany, Genesee County, New York

New York State Museum Paleontology Collection, localities 7227 and 7235

### C. "Button Corals" [text panel]

Favosites is the only common tabulate (an extinct group of colonial corals) in the Hamilton Group of the eastern United States and Canada. Small button-like domes of *Favosites* were common in the clearer, less muddy waters of western New York, but rarer on muddy bottoms close to the Catskill Delta in eastern New York.

### D. **Burrowing Bivalves** [text]

*Goniophora* (with strong ridge on shell) and *Modiomorpha* (with elliptical shells) were common bivalves (scientists' preferred name for clams) in the Hamilton Sea.

Bivalves have many different life habits. One of these habits—burrowing into sea and lake bottoms—protects them from predators, such as fish. Bivalve shells showing strong ridges or elongate shapes are adaptations to burrowing.

### D. *Goniophora hamiltonensis* and *Modiomorpha mytiloides* [label]

(“gohn-ee-ah-for-uh ham-ill-tuhn-en-sis”)

(“moh-dee-oh-more-fuh mih-till-oy-deez”)

Middle Devonian, c. 385 million years ago, Hamilton Group

Pratt's Falls, Madison County, New York

New York State Paleontology Collection, E 1046

### E. *Mediospirifer* and **Number of Days in a Devonian Year** [text panel]

*Mediospirifer* is a common Hamilton Sea brachiopod. It lay on its broad hinge area and fed on plankton (microscopic plants and animals in the water).

In the 1950s, Dr. John Wells of Cornell University used *Mediospirifer* and other Hamilton Sea fossils to determine how many days there were in a Devonian year.

The earth rotates more slowly now than it did during the Devonian. This is because, through time, tides produced by the interaction of the earth and moon have slowed the earth's rotation, although the earth still takes as long (a year) to revolve around the sun. Thus the Devonian day was shorter, and there were more days in a year.

Since many Hamilton Sea fossils preserve fine details, Wells could count daily growth lines on their surfaces and group them into monthly and annual cycles. From them, he concluded that the Middle Devonian year had 400 days.

### E. *Mediospirifer audacula* (“meed-ee-oh-speer-ih-fur aw-dack-you-lah”) [label]

Middle Devonian, c. 385 million years ago, Hamilton Group

Bay View, Erie County, New York

New York State Museum Paleontology Collection, locality 7424

F. **Buried Alive by Hurricanes?** [text panel]

*Nucleospira* (on left) and *Camarotoechia* (on right) are common Hamilton Sea brachiopods. Brachiopod shells are more commonly found separated—either predators forced open the shells and scattered them, or the brachiopods died and the muscles that kept the shells closed decayed. These specimens preserve both shells.

Rapid burial and smothering of live brachiopods by mud and sand during storms explain these complete shells. These storms probably included hurricanes, because New York lay south of the equator in the hurricane belt during the Devonian.

F. *Nucleospira* ("new-klee-oh-speer-uh") and *Camarotoechia* ("kam-air-oh-teek-ee-uh")

Middle Devonian, c. 385 million years ago, Hamilton Group

Erie County, New York

New York State Museum Paleontology Collection

Locality 7410 (*Nucleospira*)

E 1953 (*Camarotoechia*)

G. **Devonian "Mystery Animal"** [text panel]

The leaf-like impressions of *Plumulina* contain remnants of a protein, not a cellulose, composition. This shows it was a marine animal, not a plant. Modern animals that look like *Plumulina* are colonial soft corals and hydrozoans ("hy-droh-zoh-unz"), marine and fresh-water relatives of corals with simple body construction.

*Plumulina* first appeared in the Hamilton Sea, but is more common in slightly younger rocks in New York.

G. *Plumulina plumaria* [label] ("ploom-uh-line-uh ploom-air-ee-uh")

Upper Devonian, c. 380 million years ago, Ithaca Formation

Ithaca, Tompkins County, New York

New York State Museum Paleontology Collection, locality 425

SPECIMEN CASE WITH FISH FOSSILS -[no text on the wall]

*Bothriolepis canadensis* [label]

Upper Devonian, c. 380 million years ago

Gaspé Peninsula, Quebec, Canada

An extinct Devonian placoderm (**plack-o-durm**) fish. Heavy, bony plates formed a layer of armor over the head, front fins, and abdomen. Compare the fossil with an artist's reconstruction of a pair of *Bothriolepis*.

Comment:

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*Scaumenacia* (scow-men-a-shuh) *curta* (kur-tah) [label]

Upper Devonian, c. 380 million years ago

Gaspé Peninsula, Quebec, Canada

A Devonian lungfish. The red lines outline the scales and large fins of this beautifully preserved fossil of *Scaumenacia*. An artist's reconstruction is also shown.

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**Fossil fish bone layer** [label]

Middle Devonian, c. 385 million years ago

Catskill Mountains, Greene County, New York

Note the very abundant dark-colored fish bones in this rock, which are preserved in a fresh water river or lake deposit. It is rare to find such a concentration of fish bones as this.

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### **Fish teeth and bones** [label]

Middle Devonian, c. 390 million years ago

Jamesville, New York

The dark- to light-colored, curved teeth belong to a predatory fish called *Onychodus* (on-ee-ko-dus). Some fish in this group may have been lurking predators, similar to modern moray eels.

### **“The Age of Fish”** [Text panel to describe the diorama]

An armored fish (a **placoderm**) and early bony fish swim with other fish above a sea floor carpeted with sponges in this Late Devonian seascape from the Ithaca, New York area.

The Devonian is called “The Age of Fish.” This is not because fish were common, but rather because they diversified at this time. Advanced fish first appeared in the Devonian.

The Devonian saw the earliest sharks, abundant shark relatives (placoderms), and the first bony fish (modern fish groups with a bony skeleton). By the end of the Devonian, salamander-like **amphibians** had evolved from air-breathing lungfish with leg-like fins.

**placoderm** (“*plack-oh-durm*”), extinct fish with bony head shields

**amphibians** (“*am-fib-ee-uns*”), cold-blooded animals with backbones and gills as juveniles

### **Cephalopod Graveyard** [label for low case of fossils in front of the “Age of Fish”]

An unusual fossil accumulation is found in the Schoharie Valley, eastern New York.

Limestones of the Cherry Valley Member (c. 390 million years old) have abundant coiled and straight shells of several types of **cephalopods**. Almost all of the shells are from large adults. Small shells of dead juveniles are found elsewhere, such as in southern Ontario, Canada.

Ancient cephalopods may have behaved like modern squids. Some adult squids swim together in dense schools when they reproduce. Afterwards they die and sink to the bottom. New York may have been where these Middle Devonian cephalopods reproduced and died, although during their lives they ranged throughout the seas of eastern North America. New York State Museum Paleontology Collection

**cephalopods** (“*seff-luh-podz*”), soft-bodied marine animals with arms that use jet propulsion to swim. Includes squids and their relatives.

### **LIFE EMERGES FROM THE OCEAN** [To the right, in second exhibit room]

Earth’s continents were desert-like before the appearance of land plants. The greening of the continents was a major revolution in the history of life and changed geological processes on land.

Without land plants, diverse land and fresh-water animals would not have appeared. Living plants, fallen plant debris, and soil enriched by plant debris provide food and habitats for

all land animals. In addition, roots and leaf litter stop soils from washing away during rains and keep soils from drying out. Equally important, fresh-water food chains that include fish and other vertebrate predators are based on bacteria and the nutrients they release from fallen leaves and wood.

### **Transitioning From the Water** [wall text panel]

Complex organisms emerged from the oceans and colonized the land and fresh water in the Silurian and Devonian Periods (c. 443–362 million years ago). However, this transition from the sea remained incomplete as these early plants and animals lived or reproduced in fresh water, swamps, or wet soil.

Land plants and animals were tied to moist and fresh-water habitats for almost a hundred million years. In this long interval, plants required wet soils, and most larger land animals were **carnivores**. Upland forests and land animal communities dominated by large **herbivores** appeared only shortly before the “Age of Dinosaurs” in the Permian Period. Completely terrestrial ecosystems with numerous herbivores have dominated tropical and temperate continents since the Permian.

**carnivores** (“*car-nih-vorz*”), organisms that eat animals

**herbivores** (“*er-bih-vorz*”), organisms that eat plants

#### A. *Archanodon catskillensis* (“ark-an-oh-don katz-kill-en-sis”) [label]

Late Middle Devonian, c. 385 million years ago, Gilboa, Schoharie Co., New York

#### A. **The Story: Earth’s Oldest Fresh-Water Clams** [text]

The oldest known fresh-water clam fossils are found in stream-deposited sandstones in the Catskill Mountain region, eastern New York. The shells of these *Archanodon* specimens are not preserved. The fossils consist of sandstone fills (i.e., molds) of the space between the shells.

As modern fresh-water clams, *Archanodon* fed by filtering bacteria-coated particles or small organisms out of the water or by using a tube-like siphon to “vacuum” mud off the stream bed. *Archanodon*, with long, flattened shells, was a rapid burrower. Burrowing helps clams avoid predators. It also helps them escape burial when sand and mud are deposited by floods. However, escape after burial is not always possible—note that the two specimens on the right are not laterally flattened, but are distorted. They were buried in life position, probably by a flood. “Life position” in *Archanodon* means the opening between the shells was vertical. The shells were then crushed by the weight of overlying sediment.

#### B. **Stream-deposited wood** [label]

Late Middle Devonian, c. 385 million years ago  
Gilboa, Schoharie County, New York

#### B. **Wood and Water** [text]

Ancient fragments of the **progymnosperm** plant *Archaeopteris* show the flow direction of a Devonian stream. As in modern streams and rivers, Devonian streams oriented water-logged, sunken wood fragments so that their long axes point down stream. Geologists have used

the orientation of wood fragments to show that Devonian rivers of the ancient Catskill delta flowed west across eastern New York.

Plant leaves and wood fragments that fall into water may have a long eventful history. Stream and lake food webs are based on the decay of water-logged woody fragments. Decay releases nutrients that are used by photosynthetic water plants, which are then eaten by herbivores.

**progymnosperm** (“pro-*jim*-no-sperm”), extinct land plants that reproduced by spores, had fern-like foliage that reproduced by spores, and had vascular tissue that resembled gymnosperms (i.e., pines and relatives)

***Archaeopteris*** (“ark-ee-*op*-ter-is”), the genus name of this plant

### C. **Fresh-Water Fish Bones** [label]

Late Devonian, c. 375 million years ago  
Miguasha Provincial Park, eastern Quebec, Canada

### C. **Fish Tale** [text]

The black pieces are the dermal (external) bones of the head shield of the fish ***Bothriolepis***. A few long woody plant fragments can also be seen in this sandstone slab.

The heavy head shield of this **placoderm** and location of its eyes on the top of its head suggest that it was not a very active swimmer. It may have lived on the bottom like a modern ray or an armored catfish.

*Bothriolepis* probably ate bottom-dwelling animals that first became abundant in fresh water in the later part of the Devonian. The famous fish beds at Miguasha, Quebec, were deposited in a fresh-water lake. *Bothriolepis* and associated bony fish at Miguasha were the top carnivores of this lake’s food chain.

***Bothriolepis*** (“booth-ri-oh-*lep*-is”), the genus name of this fish

**placoderm** (“plak-oh-derm”), extinct fish with jaws; they had heavily armored head shields and used the exposed edges of serrated jaw bones, not teeth, to capture prey

### D. ***Estheria* sp. and ostracodes** (“es-ther-ee-ah” “ahs-trah-*codz*”) [label]

Middle Devonian, c. 385 million years ago  
Oak Hill, Greene Co., New York

### D. **Why So Many Fresh-Water Arthropods?** [text]

Several groups of **arthropods** have colonized fresh water. All of the modern arthropods that live in fresh water made this transition from the ocean well before the “Age of Dinosaurs.”

Look closely and note the larger shells of the **branchiopod** *Estheria* (marked by orange arrow).

Far more abundant are the tiny shells of ostracodes. Branchiopods and **ostracodes** are **crustaceans**, a large group that has been very successful in fresh water.

The success of arthropods in fresh water contrasts with the failure of many marine invertebrates (e.g., corals, brachiopods, squids and relatives, starfish and relatives) to colonize fresh water.

**arthropods** (“*arth-roh-podz*”), invertebrate animals with segmented bodies and segmented limbs  
**branchiopod** (“*brank-ee-oh-pod*”), fresh-water crustaceans that have numerous limbs; the “sea monkeys” advertised for sale in magazines are branchiopods that live in high salinity lakes  
**ostracodes** (“*ahs-trah-codz*”), small marine and fresh-water crustaceans with body protected by two external shells  
**crustaceans** (“*krus-tay-shunz*”), arthropod group that includes lobsters, crayfish, crabs, shrimp, sow bugs, beach fleas, barnacles, ostracodes, and several smaller groups

## **Plants Invade the Land—Taller, Deeper, and Denser Through Time** [text panel] [Two Graphics show major changes in plants through Silurian and Devonian.]

Unicellular animal and plant-like organisms may have been **cryptobionts** in ancient soils 700 million years ago. Multicellular land plant spores appeared only much later in the early Late Ordovician (c. 460 million years ago). These first land plants were **bryophytes**.

The major developments in land plants occurred in the Silurian and, particularly, in the Devonian Periods (443–362 million years ago). In this interval, **vascular plants** first appeared. They gradually became taller, with deeper root systems and more numerous and wider leaves, and developed seeds.

**cryptobionts** (“*krip-toe-by-ontz*”), organisms that live hidden below the land surface or sea bottom in cavities; single-celled cryptobionts live between the grains of desert soils and in microscopic cavities just below the surface of desert rocks

**bryophytes** (“*bry-oh-fites*”), simple, non-vascular land plants that reproduce by spores, include mosses and liverworts

**vascular plants**, plants with internal tubes used to transfer water and other fluids

## **Early Land Plants** [title inside display case]

### A. **Cooksonia sp.** (“*cook-soh-nee-ah*”) [label]

Late Silurian, c. 420 million years ago  
Passage Gulf, Herkimer Co., New York

### A. **The Most Primitive Vascular Plant** [text]

Cooksonia is the oldest known vascular land plant. Its Y-shaped branches lack leaves and end in a round **sporangium**. Collision of North America with western Europe during the Late Silurian allowed this land plant to range from New York across Europe into western Russia.

**sporangium** (“*spore-an-gee-um*”), a spore-producing structure

### B. ***Psilophyton princeps*** (“*sye-loh-fye-tun prin-kipz*”) [label]

Early Upper Devonian, 380 million years ago  
Ithaca, Tompkins Co., New York

## B. Land Plants in Ancient Sea Deposits [text]

*Psilophyton* had the same Y-shaped form and sporangia as its much older relative *Cooksonia*. *Cooksonia* and *Psilophyton* are often found in ancient marine deposits. Their weakly developed roots allowed them to be up-rooted and swept into the ocean, where they waterlogged and were buried in sediment.

## C. *Archaeopteris jacksoni* (“are-kay-op-ter-is jack-sohn-eye”) [label]

Late Middle Devonian, c. 385 million years ago  
Martin Hollow, Delaware Co., New York

## C. Part and Counterpart [text]

Most fossil plants occur in brown- or gray-colored rocks. These colors reflect the higher organic content of stream, lake, or marine sediments. Red sedimentary rocks, often laid down on land, are low in organic content. These red rocks are colored by traces of ferric iron (a mineral similar to rust). The high oxygen content of land-deposited sediment generally leads to complete decay of plant material. Thus, the preservation of this attractive specimen in red siltstone is rare.

When a rock is broken along the plane of weakness made by a fossil, mirror images of the fossil—a part and a counterpart—appear. Important features may appear on one side that are not preserved on the other.

## D. *Archaeopteris hibernica* (“are-kay-op-ter-is hi-ber-nih-kah”) [label]

Upper Devonian, c. 375 million years ago  
Kiltorkan, County Kilkenny, Ireland

## D. Plants and “The Old Red Continent” [text]

Most land plants do not survive transport across oceans (coconuts and mangrove seeds are rare exceptions). Thus, the geographic range of fossil land plants helps reconstruct ancient geography and illustrates continental drift.

*Archaeopteris hibernica* is closely related to the North American *Archaeopteris jacksoni*. These relatives lived in forests that spread across a giant continent. This continent resulted from the collision of North America and western Europe in the Late Silurian and Devonian. Sands and muds were eroded from high mountains that extended from the Appalachians across central Britain and Norway. Some of these sands and muds were deposited on land and have a red color. The red color of these sandstones and shales led to the term “Old Red Continent” for this land mass. Red sandstone and shale of New York’s Catskill Mountains and western Europe are evidence of the “Old Red Continent.”

## E. *Tetraxylopteris schmidtii* (“tet-rah-zih-lop-ter-is schmid-tie”) [label]

Upper Devonian, c. 375 million years ago  
Hawks Nest, Sullivan Co., New York

## E. Mystery Plant Fossils [text]

The branch system of this plant is similar that of *Archaeopteris*, but has very small leaf-like structures. *Tetraxylopteris* is found with the large stumps called *Eospermatopteris* in this exhibit. However, *Eospermatopteris* is known only from stumps and wood fragments. Scientists have not

found leafy foliage attached to these stumps. *Tetraxylopteris* is one of several types of branching forms, each with its own scientific name, that might have been part of the *Eospermatopteris* plant.

***Eospermatopteris*** (“ee-oh-sper-mah-top-ter-is”), the genus name of this tree

### “Scale Trees” and Relatives [text inside free-standing case]

The trunks and long twigs of *Colpodexylon* have spirally arranged pits. These pits are where needle-like leaves were attached. *Colpodexylon* is a **lycopod** related to the modern ***Lycopodium***.

Although *Colpodexylon* was a low, shrub-like plant (ca. 60 cm [2 feet] high), other lycopods were tree-sized forms in the Middle–Late Devonian.

**lycopod** (“lie-koh-pod”), vascular plants with leaves and roots that reproduce by spores; modern lycopods are known as “club mosses” or “ground pines”

***Lycopodium*** (“lie-koh-poh-dee-um”), the genus name of this modern lycopod plant (specimen label)

***Colpodexylon deatsii*** (“coal-poe-deks-ah-lahn deet-see”) [label]

Early Late Devonian, c. 380 million years ago

Brooksbury, Greene Co., New York

***Lycopodium* sp.** [label] (lie-koh-poh-dee-um”)

A modern (living) specimen

Broome Center, Schoharie Co., New York

### A Living Lycopod [text]

*Lycopodium* is a “living fossil.” It has the same spiral arrangement of needle-like leaves, reproductive habit (by spores), and shallow root system as its extinct relative *Colpodexylon*. Shallow roots mean that lycopods must live in wet soils, and do not survive drying out.

### The Oldest Forests [wall text description of the diorama]

Earth’s oldest forests grew on the Catskill Delta. Some are now found near Gilboa Reservoir in the Catskills. This *Eospermatopteris* stump is one of the most common fossils.

***Eospermatopteris*** was an early land plant distantly related to **conifers**. Construction of the Gilboa Reservoir dam after World War I uncovered *Eospermatopteris* tree trunks at three levels in the rocks along Schoharie Creek.

The late Middle Devonian age (c. 385 million years ago) of the Gilboa forests marks the appearance of tree-like land plants. These plants were found only in swamps. Fallen trees turned into some of the oldest coal layers (up to 10 cm [4 inches] thick) in New York.

The Gilboa trees were found in life position, with the shallow roots attached. The fossils are made of sandstone, which fills the rotted-out stumps. This type of preservation is common. An early stage in production of sandstone “casts” of tree stumps can be seen along the modern Oregon coast. Here, pine forests are being buried and killed by sand that drifts in with sea-level

rise. The trees die, and the tops break off; the wood rots, and the hollow stump is filled with sand.

*Eospermatopteris* (“ee-oh-*spur*-ma-top-ter-us”), the genus name of this tree  
**conifers** (“*khan*-ih-furz”), trees and shrubs with cones and small seeds

## **Conquest of the Land** [text panel, photos and graphics]

Graphic - A Gilboa Forest Food Chain

Pictures courtesy of Linda Van Aller Hernick and William A. Shear.

### **The Animals**

Small animals began to invade the oldest forests at Gilboa. Food sources were plentiful, and the forests offered places to hide from predators. These greatly magnified pictures are of microscopic fossil arthropods from Gilboa. The specimens were recovered by dissolving rocks in acid. They are so well preserved that some researchers first thought they were modern animals washed into the rock samples.

Today, insects are the most common land **arthropod** group today, but only one insect species is found at Gilboa. However, diverse non-insect arthropods occur at Gilboa. These include:

- an eight-legged, spider-like **trigonotarbid**;
- a long centipede with a jaw preserved;
- a **spinneret** (silk producing organ) from a spider;
- a mite with fine hairs on its back

**arthropods** (“*are*-throw-pods”), animals without backbones and with hard external skeletons with jointed limbs; includes spiders, insects, crabs, trilobites, and other forms

**trigonotarbid** (“*trih*-go-no-*tar*-bid”), extinct spider relatives

**spinneret** (“*spin*-ner-et”), organ on the abdomen of spiders that produces silk for webs, trap lines, and egg cases. **This spinneret from Gilboa is the oldest one known.**

### **The Gilboa Ecosystem**

New York’s modern forests have communities with diverse bacteria, fungi, plants, and animals. Mammals, birds, amphibians, reptiles, and wide variety of arthropods occur. The **ecosystem** of the Gilboa forests had bacteria and fungi, but only primitive plants and a few arthropods.

Amphibians, a group that featured the first land vertebrates, appeared only later in the Late Devonian, and were not present at Gilboa.

The Gilboa forests grew on a great river delta near the sea coast, and had a mixture of low ground-cover plants, shrubs, and trees (including *Eospermatopteris*) up to 10 meters (31 feet) tall.

The Gilboa **food web** differed from modern forest food webs in that herbivores are unknown. Thus, the Gilboa food web included plants (primary producers) and **detritivores** (including mites and millipede-like animals). They were fed on by spiders, trigonotarbids, and other predatory arthropods.

**ecosystem**, the relationships between organisms and their physical environment in a given area

**food web**, the network of energy exchange between organisms in a community; includes primary

producers (plants and some bacteria)–herbivores (plant eaters)–predators (mostly animals)–decomposers (many bacteria, fungi)

**detritivores** (“dih-try-tih-vores”), animals and other organisms (fungi) that consume dead or decomposing plant debris and other biologic matter

## **THE CARBONIFEROUS PERIOD** [To the right, in third exhibit room]

### **THE CARBONIFEROUS: A MISSED ECONOMIC OPPORTUNITY**

[text panel and Three graphics: Geological Period and Time; Map showing the Carboniferous rock in New York; a continental drift map showing late Carboniferous 306 million years ago ]

#### **The Carboniferous in Geologic Time**

The Carboniferous Period is named for the coal-bearing rocks of southern Wales. Important coal deposits are found in **Carboniferous** rocks of all modern continents except Africa.

Mississippian and Pennsylvanian are traditional North American terms for the first and second halves of the Carboniferous.

**Carboniferous** (“car-bun-if-ur-us”), geologic interval c. 362 to 286 million years ago. It means carbon- or coal-bearing.

#### **Carboniferous Rocks in New York**

Carboniferous rocks probably covered New York. But erosion removed almost all of them, except for thin sandstones that cap hills near the Pennsylvania border. Thick Carboniferous rock sequences remain in Pennsylvania and Ohio and are a major source of coal.

#### **Carboniferous Paleogeography**

The Carboniferous marks the end of Laurentia. Plate tectonic processes led to the third and last mountain-building episode of the Appalachians. This episode is called the **Allegheny** orogeny.

The western African and northern South American margins of the giant **Gondwana** continent collided with eastern North America. Laurentia then became part of the **Pangea** supercontinent.

The Appalachians may have been as high as the Himalayas. Sand and mud that eroded from the Allegheny Mountains gradually filled all the seaways of eastern Laurentia and supported vast coal swamps.

**Allegheny** (“al-uh-gain-ee”), mountain belt extending from central Mexico to Newfoundland, Canada, that apparently continued into central Europe as far east as Poland. The third stage in the uplift of what are now called the Appalachian Mountains

**Gondwana** (“gahnd-wahn-uh”), an ancient continent made up of present-day Africa, South America, Antarctica, Australia, and India

**Pangea** (“pan-*jee*-uh”), supercontinent that included all modern land masses, c. 280 to 200 million years ago

**Life in a Coal Forest** [text panel description of the diorama]

**Archaic** plants, including ferns and **lycopsids** (essentially larger versions of Devonian trees), dominated Carboniferous coal swamps. The only sounds were the wind, falling vegetation, the calls of large insects like the giant cockroach, and the croaks of salamander-like amphibians. Small reptiles first appeared in these forests.

**archaic** (“are-*kay*-ick”), characteristic of an earlier evolutionary stage and time

**lycopsids** (“lie-*cop*-sids”), early land plants with simple leaves that reproduce by spores. Includes the small modern club mosses.

### **Fossil Specimens from the Carboniferous** [In a Free-Standing Case]

A. *Neuropteris clarksoni* (“nuhr-*ahp*-tur-iss *klark*-sohn-ee”) [label]

Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Mazon Creek, Will County, Illinois

Another pteridosperm species. Its large leaves are common in Mazon Creek collections.  
New York State Museum Paleontology Collection

B *Neuropteris flexuosa* (“nuhr-*ahp*-tur-iss *fleks*-you-o-suh”) [label]

Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Mazon Creek, Will County, Illinois

A specimen showing that *Neuropteris*' leaves formed part of large fronds. New York State Museum Paleontology Collection

C. *Neuropteris decipiens* (“nuhr-*ahp*-tur-iss *dih*-sip-ee-enz”) [label]

Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Mazon Creek, Will County, Illinois

A pteridosperm (tehr-id-oh-spurm) with small leaves. Pteridosperms were early seed plants with fern-like leaves. This plant lived on raised areas called levees (“*lehv*-eez”) along rivers.  
New York State Museum Paleontology Collection

D *Euphorbia tracta* (“you-*for*-be-uh *trakt*-uh”) [label]

Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Morris, Grundy County, Illinois

A millipede (a land-dwelling arthropod related to centipedes and insects; often called “thousand-legged worm”) washed from the coal forests and buried with the freshwater Braidwood fauna in the Mazon Creek region.

Loaned for exhibit by Ken Bartowski

E *Euproops danae* (“you-*props* *dan*-a”) [label]

Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Morris, Grundy County, Illinois

A small horseshoe crab thought by scientists to have hidden on trunks of lycopsid trees (“lie-cop-sid,” early land plants with simple leaves that reproduced by spores). It was buried with the freshwater Braidwood fauna in the Mazon Creek region.  
Loaned for exhibit by Ken Bartowski

F. *Tullimonstrum gregarium* (“tuhl-lee-mahn-struhm greh-gehr-ee-um”) [label]  
Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Pit No. 11, Peabody Coal Co., Kankakee County, Illinois  
Problematic animal from the marine Essex fauna of the Mazon Creek region. It is the Illinois State Fossil. *Tullimonstrum* (or “Tully monster,” named for Tully, Illinois) has been compared to swimming pteropods (“tehr-uh-podz,” a group of marine snails).  
Loaned for exhibit by Ken Bartowski

G. *Octomedusa pieckorum* (“ahk-toe-meh-doo-suh pik-ur-um”) [label]  
Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Pit No. 11, Peabody Coal Co., Kankakee County, Illinois  
Jellyfish from the marine Essex fauna of the Mazon Creek region. Note the short tentacles projecting from the edge of the fossil.  
Loaned for exhibit by Ken Bartowski

H. *Essexella asherae* (“s-x-l-uh ash-ur-a”) [label]  
Upper Carboniferous, c. 290 million years ago, Carbondale Formation  
Pit No. 11, Peabody Coal Co., Kankakee County, Illinois  
Problematic animal from the marine Essex fauna in the Mazon Creek region. Known as “the blob,” it may be a hydrozoan (“hy-droh-zoh-un”), a distant coral relative.  
Loaned for exhibit by Ken Bartowski

## THE MESOZOIC ERA [wall text panel]

### THE MESOZOIC: THE “AGE OF DINOSAURS” IN NEW YORK

[text panel with three graphics: Geological Period and Time; Map showing the Mesozoic rocks in New York; a continental drift map showing continental drift in the early Jurassic 195 million years ago.]

#### The Mesozoic in Geologic Time

The **Mesozoic** Era is the “Age of Dinosaurs.” Only parts of Mesozoic time—the **Triassic**, **Jurassic**, and **Cretaceous**—are represented by rocks in New York.

**Mesozoic** (“mess-oh-zoh-ick”), geologic interval c. 245 to 65 million years ago. It means “middle life.”

**Triassic** (“try-ass-ick”), early part of Mesozoic Era, c. 245 to 201 million years ago. Named for rocks in Germany that can be separated into three (“tri-”) vertical divisions by color.

**Jurassic** (“joor-ass-ick”), middle part of Mesozoic Era, c. 201 to 144 million years ago. Named for the Jura Alps (mountains) in eastern France, where many marine fossils are found.

**Cretaceous** (“kreh-tay-shuss”), late part of Mesozoic Era, c. 144 to 65 million years ago. Named for the chalk-bearing (“creta-”) strata of the cliffs of Dover, England.

### **Mesozoic Rocks in New York**

“Age of Dinosaur” rocks are found only in southeastern New York. Red sandstones, shales, and basalts of Late Triassic to Early Jurassic age occur in the lower Hudson Valley and on Staten Island. Middle Cretaceous rocks underlie much younger “Ice Age” sands on Long Island.

### **Mesozoic Paleogeography**

The supercontinent Pangea formed when western Africa and eastern North America collided in the Carboniferous Period. Plate tectonic processes stretched Pangea in the Early Mesozoic, and it started to break up.

The Atlantic Ocean opened south of New York during the late Triassic. Earthquakes uplifted the Ramapo Highlands and down-dropped the lower Hudson Valley. Small **basalt** volcanoes formed in the lower Hudson Valley, and liquid basalt was forced into Triassic sediments. This injected rock forms the Palisades cliffs in New Jersey and New York.

With the widening of the Atlantic, Cretaceous coastal sandstones were laid down from New Jersey throughout Long Island, and east to Nantucket Island off the coast of Massachusetts. The Atlantic is still widening five centimeters (two inches) a year.

**basalt** (“buh-salt”), dark-colored rock produced by melting processes deep in the earth. The liquid rock then flows up to the surface, where it cools and freezes.

### **New York’s Only Known Dinosaur** [text panel description of life-size model]

New York dinosaurs are known from Late Triassic (c. 205 million years ago) footprints made in soft mud in Rockland County. These footprints are on display in the Museum Lobby.

This model of the meat-eating dinosaur *Coelophysis* resembles the animal that produced the Rockland County tracks. *Coelophysis* is known from skeletons in Arizona that have longer toes than the Rockland County track-makers. For this reason, paleontologists have concluded that perhaps a different dinosaur actually made the tracks on display.

*Coelophysis* (“seel-oh-fy-sis”), the genus name of this dinosaur

### **Cretaceous Plant Fossils** [In a Free-Standing Case]

Cretaceous rocks were used in brick-making on Staten Island and western Long Island in the 1800s. Plant fossils are common in these rocks.

Middle Cretaceous plants from New York include some of the oldest-known flowering plants and trees. This modernization of forests, including the appearance of bees to pollinate the flowers, took place late in the “Age of Dinosaurs.”

Amber, the hardened tree sap featured in the movie *Jurassic Park*, occurs in the Cretaceous of Long Island and New Jersey and often has insects embedded in it.

#### A. *Sassafras mirabile* (“sass-uh-frass meer-ah-bill-ee”) [label]

Lower Cretaceous, c. 110 million years ago, Dakota Sandstone  
Fort Harker, Kansas

A species of sassafras tree with large leaves.

New York State Museum Paleontology Collection

B. *Sassafras cretaceum* (“sass-uh-frass krih-tay-see-um”) [label]  
Lower Cretaceous, c. 110 million years ago, Dakota Sandstone  
Ellsworth County, Kansas  
A flowering tree. Modern sassafras is used as a flavoring agent (in root beer, for example).  
New York State Museum Paleontology Collection

C. *Ficus willisiana* (“fy-kus will-iss-ee-an-uh”) [label]  
Upper Cretaceous, c. 90 million years ago, Raritan Group  
Glen Cove, Nassau County, New York  
A flowering deciduous tree (“deh-sij-you-us”, plants that shed their leaves in cold or dry seasons). The genus *Ficus* includes modern fig trees.  
New York State Museum Paleontology Collection

D. *Populus kansasensis* (“pop-you-lis kan-suhs-en-sis”) [label]  
Lower Cretaceous, c. 110 million years ago, Dakota Sandstone  
Ellsworth County, Kansas  
A flowering tree. *Populus* is the genus name for the poplar tree.  
New York State Museum Paleontology Collection

E. *Betulites vestii latifolia* (“bet-you-lite-eez vest-i lat-ih-fohl-ee-uh”) [label]  
Lower Cretaceous, c. 110 million years ago, Dakota Sandstone  
Ellsworth County, Kansas  
A flowering deciduous tree similar to the modern beech.  
New York State Museum Paleontology Collection

F. *Andromeda affinis* (“an-drahm-eh-duh uh-fin-iss”) [label]  
Lower Cretaceous, c. 110 million years ago, Dakota Sandstone  
Ellsworth County, Kansas  
A small shrub-like plant that lived in fens (wetlands that accumulate peat, which is partly decomposed, carbon-rich deposits of plant debris).  
New York State Museum Paleontology Collection

G. *Glyptostrobus brookensis* (“glip-toh-stroh-bus brook-en-sis”) [label]  
Lower Cretaceous, c. 110 million years ago, Lakota Group  
Blackhawk, South Dakota  
Accumulations of needles from a conifer tree. *Glyptostrobus* is now native only to Asia.  
New York State Museum Paleontology Collection

H. *Magnolia capellini* (“mag-nohl-yuh cap-ell-ee-nee”) [label]  
Upper Cretaceous, c. 90 million years ago, Raritan Group  
Glen Cove, Nassau County, New York  
A magnolia tree leaf.  
New York State Museum Paleontology Collection

## FROM DINOSAURS TO MODERN TIMES

[wall text panel with a mastodont skeleton photo]

The **Cenozoic** Era, made up of the **Tertiary** and **Quaternary** periods, follows the “Age of Dinosaurs.” The Quaternary includes the **Pleistocene** Epoch, or “Ice Age,” and the Recent Epoch (c. 10,000 years ago to the present). Very little of the 65-million-year Cenozoic interval after the extinction of the dinosaurs is represented by fossils and rocks in New York.

However, relatively common remains of **mastodonts** and mammoths (both elephant relatives), reindeer, and other cold-adapted animals are found in New York. These fossils date from the latest part of the “Ice Age” (c. 20,000 to 10,000 years ago). To see late “Ice Age” life, you can view the mastodont skeleton in the Museum Lobby and the mastodont diorama at the entrance to Native American Hall.

**Cenozoic** (“*sen-oh-zoh-ick*”), geologic interval c. 65 million years ago to the present

**Tertiary** (“*tuhr-sure-ee*”), geologic period of the early Cenozoic, c. 65 to two million years ago. The name refers to the third (“*ter-*”) interval of earth time, according to early geologists.

**Quaternary** (“*kwah-turn-ur-ee*”), geologic period of the late Cenozoic c. two million years ago to the present. The name refers to the fourth (“*quater-*”) interval of earth time, according to early geologists.

**Pleistocene** (“*plice-tuh-seen*”), geologic epoch composing the first part of the Quaternary. The name means “almost-modern life.”

**mastodont** (“*mass-tuh-dahnt*”), elephant relative with distinctive, high-capped teeth (“*mast*“ = breast-like; “*dont*” = teeth, dental)

[Moving counter clockwise]

## JEWELS OF THE FOSSIL RECORD IN THE STATE MUSEUM [wall text panel]

Fossils are common in many sedimentary rocks. However, fossilized articulated skeletons or soft tissues are as rare as jewels—they require special burial processes and conditions. Exceptionally preserved fossils provide unique insights into the evolutionary and ecologic relationships of life on earth. The perfectly preserved, ca. 505 million year-old Burgess Shale fossils described in many popular publications are only one example of these jewels of the fossil record.

Collections in the New York State Museum include many examples of exceptional fossil preservation through geologic time and from around the world.

Photo of *Urasterella asperula* NYSM #E1181

## THE STATE MUSEUM’S YOUNGEST AND OLDEST EXCEPTIONAL FOSSILS

**The Story: Earth’s Oldest Animals** [text inside the case]

These are the remains of some of the oldest animals known on earth.

These soft-bodied animals lived on the deep sea floor. They were preserved under thin layers of volcanic ash and mud that swept across the sea floor. Most of these fossils are incompletely studied and do not have scientific names.

Current research by the State Museum in collaboration with the Massachusetts Institute of Technology has shown that large, soft-bodied, multicellular animals appeared on deep sea floors 565 million years ago. Only somewhat later did these animals emerge from the deep sea and colonize shallow sea floors. A continuing question for scientists is why so many of these soft-bodied fossils are preserved. The lack of any hard parts should have made their preservation almost impossible.

**A. *Mallotus villosus*** (“ma-loh-tus ville-oh-sus”) [specimen label]

Early Recent Epoch, c. 9,000 years ago  
Green’s Creek, Ottawa, Ontario, Canada

**B. *Charnodiscus*** (“char-noh-diss-kuss”) [specimen label]

Late Proterozoic, 565 million years ago  
Mistaken Point, eastern Newfoundland, Canada  
This is the hold-fast that attached a large, feather-shaped animal to the sea floor

*Charnodiscus* (char-noh-diss-kuss), the genus name of this animal

**C. “Pectinate form”** [specimen label]

Late Proterozoic, 565 million years ago  
Mistaken Point, eastern Newfoundland, Canada  
This still scientifically undescribed animal resembles a comb (i.e., it has a pectinate [pek-tih-nate] shape). It may have been a colonial organism, with each thread-like impression a single animal.

**D. *Aspidella*** (“ass-pih-dell-ah”) [specimen label]

Late Proterozoic, ca. 560 million years ago  
Hewitts Cove, Quincy, Massachusetts  
These are the small hold-fasts that attached a small, tube-like animal to the sea floor.

**What are trilobites?** [wall text]

By the mid-1800s, scientists knew that trilobites were an extinct group of marine arthropods (a large group that includes insects, crabs, spiders, and other forms). However, the relationship of trilobites to living arthropods was unclear. Many scientists believed they were related to crabs and lobsters.

Only the hard upper surface of trilobites is usually fossilized. Details on the under surface—as the presence or absence of antennae or gills and the structure of the legs—were needed to determine their relationship to other arthropods.

This information came from a series of trilobite discoveries in central New York.

One of the most important discoveries was made about 1890 north of Rome, NY. Pyrite-replaced specimens that showed the legs, gills, and antennae of *Triarthrus becki* were carefully excavated by C.E. Beecher, a professor at Yale University. The presence of a single pair of antennae and a comb-like gill branch on each walking leg were used by C.D. Walcott, then head

of the U.S. Geological Survey, to show that trilobites were not closely related to any living arthropod.

These specimens and picture of the Late Ordovician (c. 460 million years ago) trilobite *Triarthrus becki* show the segmented antenna and walking legs. These specimens were among those prepared by C.E. Beecher in 1890.

## Exceptional Fossils from New York

Fossil discoveries in New York State over the last two centuries have helped direct the course of paleontologic research. This exhibit case shows only a few of the examples of exceptional fossil preservation known in New York. A,B,C, and D

### Algae And A Time Line [wall text]

Silurian age (430–418 million years ago) marine rocks form the cliffs at Niagara Falls and underlie large areas south of Lake Ontario in western New York. Several exceptionally preserved fossil assemblages are found in the Silurian of this area.

One of these assemblages is found in a thin layer (10–30 centimeters, 4–12 inches) that extends from Niagara Falls to Rochester. “Soft bodied” forms, including the large **alga** *Medusaegraptus* displayed here, and worms characterize the assemblage. Animals with hard shells, such as snails, clams, and arthropods, are rare.

Geologists use the *Medusaegraptus* layer for precise time correlation in the Silurian of western New York. This layer records the short-term (perhaps a thousand years or less) development of a habitat that encouraged growth of algae, excluded most organisms with hard shells, and preserved soft-bodied fossils. Thus, wherever this geographically widespread layer is exposed (as in a quarry or roadcut), geologists use it as an indicator of a very thin slice of Silurian time.

**alga** (“al-gah”), simple, single-celled, colonial, or multicellular plant with green, brown, or red chlorophyll, most live in fresh-water or marine habitats (algae, “al-gee,” plural of alga)  
*Medusaegraptus* (“meh-doo-sah-grap-tus”), the genus name of this alga

### New York’s “UFO” (Unidentified Fossil Object) [wall text]

It’s called *Paropsonema* (“pah-rop-so-nee-mah”). It comes from Late Devonian (c. 370 million year old) marine rocks near Naples, New York. It is disk-like with a raised central area and a radiating ornament with shallow depressions. Its soft body could be folded during burial. That’s all we’re certain about.

This fossil “UFO” was thought in 1902 to be an **echinoid** with a flexible outer skeleton. Since the 1940s, it’s been considered a jellyfish, a much simpler organism. Or, maybe it is the earliest known representative of the large sea cucumbers (a group related to starfish and echinoids) photographed on the deep-ocean floor by the *Alvin* and other submersibles. You’re free to speculate just as many other paleontologists!

**echinoid** (“eh-kin-oid”), starfish relatives with a box-like external skeleton, often called “sea urchins” and common along the seashores of the U.S.

## **The Messel Shale: Exceptional Preservation in the early Age of Mammals**

Note: Some of world's most famed fossils from the early Cenozoic Era (i.e., the Eocene Epoch of the "Age of Mammals", 49 million years ago) are found near Frankfurt, Germany. Freshwater and land animals and plants were buried and preserved in the sediments of a lake that formed within an extinct volcano. The ancient setting was similar to Crater Lake in California.

The site of the fossil discovery was an oil shale mine. Once threatened with becoming a waste disposal site, it is now preserved as a United Nations UNESCO World Heritage Site. These fossils are on loan from the Senckenberg Museum of Natural History in Frankfurt.

### **The Story: Fossils from an Ancient German Lake** [text inside of case]

The exquisitely preserved, 49 million year-old Messel Shale fossils represent over 40 species of animals and 30 kinds of plants. Many primitive, dog-sized fossil horses, including a female with an unborn foal preserved in the body cavity, have been found. The mammals, birds, crocodiles and other reptiles, amphibians, insects, fish, and water and land plants represent a tropical lake and jungle ecosystem.

Upon death, animals and plants that lived in the lake sank to the bottom. Land animals and plants from adjacent jungle environments were carried into the lake by streams, along with the clay sediments that buried them. A lack of oxygen in deeper waters of the Messel lake allowed soft tissues to be fossilized.

In these specimens, dark areas are impressions of soft body tissues. Note the skin of the bat *Palaeochiropteryx tupaiodon*. Within a female frog (*Eopelobates wagneri*), unfertilized eggs are visible as round specks in the abdomen. The dark, carbonized areas in each of these fossils are actually the imprint of soft tissues, and are made of layers of fossilized bacteria.

The Messel fossils and the shale rock they are found in are very fragile. Great care must be taken to preserve the fossils. When collected, a fossil is carefully exposed with needles and scrapers. The specimen is then dried, and many thin layers of resin are applied. When the block of resin has hardened, it is turned over and the other side of the fossil is exposed, and coated with another layer of colorless resin.

#### **Palaeochiropteryx tupaiodon** (specimen label)

("pay-leo-keer-op-ter-ix two-pie-oh-don")

A fossil bat

Note the dark-colored ears. X-rays showing the small bones in bat ears from Messel indicate that they already used sonar to catch insects 49 million years ago.

#### **Eopelobates wagneri** (specimen label)

("ee-oh-peel-oh-bates wag-ner-eye")

A fossil frog

Black specks in the abdomen are eggs

***Atractosteus trausi*** (specimen label)

("ah-tract-os-tee-us strow-si)

A fossil fish

A view of the under side of this primitive fish, related to modern gars. Modern gars are known from lakes and streams across North America.

***Messelornis cristata*** (specimen label)

("mess-el-or-nis cris-ta-ta")

A fossil rail (bird)

This wading bird, related to cranes, lived and fed along the lake shore. The neck was bent backward as muscles and tendons shrank following death.

**photo of *Propalaeotherium parvulum***

## **Exceptional Fossils And Middle East Oil** (case label)

### **The Story: Fossils, Oil, and Oxygen**

A relationship exists between oxygen content of the deep sea and oil formation through geologic time. If deep-sea water has very little oxygen, organic matter produced by marine animals and plants is not completely broken down by bacteria. This organic matter is then buried in sediment and is later changed into oil by heating with deep burial.

Thus, times when great amounts of organic matter were buried to form oil should also be times when low oxygen levels led to exceptional marine fossil preservation.

A number of giant oil fields and many exceptional marine fossil assemblages were formed in the later part of the "Age of Dinosaurs".

These c. 100 million year-old fossil fish and other organisms from Sahil 'Alma, Lebanon, lived in shallow sea water. Living and dead organisms were transported, perhaps by storms and waves, into nearby deeper water with low oxygen. The dead and dying animals were buried on a low-oxygen sea floor where they were preserved from scavengers. In this same time interval, enormous amounts of organic matter were buried in low-oxygen waters of the Persian Gulf region. This organic matter was changed into the oil and gas of the Middle East.

**A. *Cyclobatis*** ("sigh-klo-bah-tis") [specimen label]

Late Cretaceous, c. 100 million years ago

Sahil 'Alma, Lebanon

A small sting ray

**B. *Diplomystus*** ("dih-ploh-miss-tus") (specimen label)

Late Cretaceous, c. 100 million years ago

Sahil 'Alma, Lebanon

An abundant herring; the specimens were aligned on the sea bottom by waves.

**C. Prionolepis** (“*pry-oh-noh-lep-is*”) [specimen label]

Late Cretaceous, c. 100 million years ago

Sahil ‘Alma, Lebanon

An eel-like bony fish with heavy scales

**D. Spaniodon blondeli** (“*span-ee-oh-don blon-del-eye*”) [specimen label]

Late Cretaceous, c. 100 million years ago

Sahil ‘Alma, Lebanon

An active predator

**E. Decapod Crustacean** (“*deh-kah-pod krus-tay-shen*”) [specimen label]

Late Cretaceous, c. 100 million years ago

Sahil ‘Alma, Lebanon

A fossil crab

**GERMAN “FOOLS GOLD” AND FOSSILS** [case text]

**Fossils from Roofing Slates** [text inside case]

Quarries in the Hunsrück area of western Germany have long yielded exquisite marine fossils. Fossils of a few-soft bodied organisms and many forms with **skeletons** are found on surfaces of black roofing slate.

These animals did not live on the sea floor where they were preserved. They were swept from shallow water into a deeper-water, low oxygen environment that killed them. Some of these starfish have their arms pointing down-current.

Rapid burial in a habitat that lacked scavengers helped preserve the articulated skeletons of starfish, **crinoids**, and other organisms. Many of these specimens are bright yellow in color. Bacterial decay in a low-oxygen environment formed pyrite (“fool’s gold”) that replaced the limy skeletons of these fossils.

**skeletons** (“*skel-eh-tons*”) the rigid frameworks that form part of the body of organisms; skeletons can be separated into: 1) endoskeletons, which are produced within the body of animals and include bones and the plates of starfish, crinoids, and their relatives; 2) exoskeletons, the hard parts on the outside of organism’s body (e.g., clam and snail shells, the exterior of crabs, lobsters, and insects), and 3) hydrostatic skeletons, which are water-filled areas in the interior of animal bodies—earth worms move, elongate, shorten, and burrow by squeezing a hydrostatic skeleton with their muscles.

**crinoids** (“*kry-noids*”), starfish relatives, many of which are attached to the bottom with a stalk, that use arm-like structures to filter feed; see the *Parisocrinus* specimen

**A. Aspidosoma** (“*ass-pid-oh-soh-mah*”) [specimen label]

Early Devonian, c. 390 million years ago

Bundenbach, Germany

**B. Parisocrinus zaeformis** (“pah-riss-oh-kry-nus zee-ah-for-miss”) [specimen label]  
Early Devonian, c. 390 million years ago  
Bundenbach, Germany

**C. Urasterella asperula** (“you-rass-ter-el-ah ass-per-oo-lah”) [specimen label]  
Early Devonian, ca. 390 million years ago  
Bundenbach, Germany

**D. Euluidia** (“you-lou-ee-di-ah”) [specimen label, two specimens displayed]  
Early Devonian, ca. 390 million years ago  
Bundenbach, Germany

**END**

See below for fossil labels in the Main Lobby

## NEW YORK STATE MUSEUM

# LOBBY LABELS

### **BURIED ALIVE! A FOSSIL SEA BOTTOM** [Location: Lobby Desk, West End]

Middle Devonian Period, c. 388 million years ago  
Saugerties area, Ulster County, NY

Few ancient plants and animals were ever fossilized. Most were completely destroyed soon after death. Predators, scavengers, decay, waves and currents, and even the ultraviolet rays of sunlight decompose soft tissue, wood, shell, and bone.

Complete fossils, such as these starfish (*Devonaster*), some of which were caught in the act of feeding on clams (*Grammysia* and *Cornellites*), require special events for their preservation. Rapid burial and smothering of the sea floor is recorded by this slab. Sand stirred up and deposited by a storm fixed these bottom-living animals in life position. In the Middle Devonian, the eastern U.S. was about 35° south of the equator and exactly in the hurricane belt. This specimen, collected by State Museum paleontologists in the early 1900s, records one of these tropical storms.

### **FOSSIL “SEA LILIES”** [Location: Lobby Desk, East End]

Late Cretaceous Period, c. 80 million years ago  
Western Kansas

“Sea lily” is the name for starfish relatives formally called crinoids. The limy skeletons of modern crinoids fall apart within hours of their death. A problem lies in just how all these complete specimens of *Uintacrinus* were preserved.

Research suggests that *Uintacrinus* animals were swept by currents into deep water that lacked oxygen. Lack of oxygen meant death. It also meant that scavengers and even bacteria did not live on the sea bottom, and that the crinoids did not fall apart. Deep waters of the modern Black Sea, for example, lack oxygen, and nothing decays or is eaten on the bottom of this sea. Robert Ballard, who found the Titanic, recently reported a well-preserved wooden Greek ship (c. 400 B.C.) on the floor of the Black Sea.

### **FOSSILS AT THE BASE OF NIAGARA FALLS**

[Location: behind Lobby Desk area]  
Early Silurian Period, c. 440 million years ago  
Niagara River Gorge, Niagara County, NY

Rocks that represent almost twenty million years of earth history are exposed at Niagara Falls. The oldest rocks at the foot of the falls are called Grimsby Sandstone.

One type of brachiopod, a clam-like marine animal with a fleshy stalk for attachment to the sea bottom, is the only common fossil. This slab has hundreds of small shells of the brachiopod *Lingula*. Note that the tips of many shells point to the left or right of the slab. This indicates the role of wave action in moving the shells. If currents moved the shells, the tips would point in one direction (up-current).

**NEW YORK'S DINOSAURS** [Location: Along Lobby West wall]  
Late Triassic Period, c. 200 million years ago  
Blauvelt, Rockland County, NY

Tracks made by early dinosaurs are found in the Connecticut and Hudson River Valleys. In both areas, elongate lowlands formed with the separation of Africa from the eastern U.S. and the opening of the Atlantic Ocean.

The Blauvelt dinosaurs hunted small animals along the muddy margin of a lake in the southern Hudson Valley. Their tracks were deeply impressed into soft mud. If you look closely, you can see mud cracks that formed after the tracks were made. The drying-out of the mud preserved the tracks.

The ancient habitat at Blauvelt, based on a State Museum paleontologist's understanding of the geologic record. A much higher Ramapo Highland lay to the west of the lake in the lower Hudson River Valley. Dinosaurs similar to *Coelophysis*, known from fossils in the western U.S., hunted prey in a desert environment with lakes that dried up in the summer or during dry climate cycles.