Aspects of New Jersey Geology – 2010
New Jersey Fossils

Hadrosaurus foulkii: The Haddonfield dinosaur, New Jersey State Museum exhibit. This restoration has itself become something of an artifact. It was done in the 1930s as part of a federal jobs program. In today's reconstructions, the posture is more nearly horizontal and the skull is less ducklike. As is common with vertebrate fossils, the original skull was never found. The head is often the first part to fall from a rotting corpse and roll away or be destroyed. Dave Parris, New Jersey State Museum, for scale.

Unlike many other states, New Jersey has no easily accessible places where spectacular fossils can be picked up by the dozen. The Calvert Cliffs of Maryland and hundreds of roadside limestone outcrops in Ohio come to mind. What New Jersey lacks in abundance, however, is balanced by the historic importance and scientific value of its fossils. Outstanding among the historically important fossils, the Haddonfield dinosaur, Hadrosaurus foulkii, was excavated in 1858. Earlier that year, William Parker Foulke brought some unusually large fossil bones to Joseph Leidy of Philadelphia's Academy of Natural Sciences. Leidy recognized the bones as probably from a dinosaur and went with Foulke to the Haddonfield marl pit where they were found. Enough additional bones and teeth were found to make the world's first reasonably well founded interpretation of what a dinosaur looked like and how it lived. The fossil changed the understanding of dinosaurs when Leidy recognized soon after the discovery that the creature was built to stand on two feet, not all four as in all previous dinosaur reconstructions. Very soon after the 1858 discovery, anatomists further noticed similarities between the New Jersey skeleton and those of birds. Thomas Huxley, in the 1860s, in part based on the Haddonfield fossil, became the first to argue that birds evolved from dinosaurs. In 1868, Waterhouse Hawkins at the Philadelphia Academy mounted casts of the bones in life position. This was the first time a dinosaur skeleton had ever been mounted for public display. Ten of thousands came to see the dinosaur. Through the efforts of Joyce Berry and her Haddon Township fourth grade classes, Hadrosaurus foulkii was designated the New Jersey State Dinosaur in 1991.

This calendar is available for free download from www.ganj.org, the website of the Geological Association of New Jersey. It could not have been produced without the assistance of William Crepet and Jennifer Svitko of Cornell University, David Grimaldi of the American Museum of Natural History, Kathleen Lake and William Boyd Wood, of a Holgate Beach fossil find, Carl Mehling of the American Museum of Natural History, David Parris of the New Jersey State Museum, and Scott Stanford of the New Jersey Geological Survey. Some images were generously provided for this single use. Some are under copyright. Please contact the photographer if you would like to use images other than for non-commercial downloading of single copies of this calendar.

David Harper

<u>Mosasaurus</u> <u>maximus,</u> Inversand glauconite mining pit, Sewell, Gloucester County. The photo was taken at a fossil preparation lab of the NJ State Museum. The opening towards the back of the lower jaw is not a broken bone. It is a hinge that allowed this fierce predator to open its mouth wider than a fixed jaw could to allow larger and more agile prey to be caught.

Until the vast accumulations of dinosaur bones in Colorado and Wyoming were discovered in 1877, the Cretaceous reptiles of North America were known primarily from bones of sea-going animals from the greensand marl pits of southern New Jersey. Greensand gets its color from the mineral glauconite. It was dug by the millions of tons through the 1800s for use as a conditioner for the sandy soils of southern New Jersey. Potassium in the glauconite and lime and phosphorus in other greensand minerals were the primary beneficial components. Glauconite forms slowly, usually miles offshore on continental shelves. Fossils of turtles, mosasaurs, and sea-going crocodiles are more common in this oceanic sediment than are dinosaur bones. Bones and teeth of land dwelling dinosaurs are found from time to time, but the 1858 Haddonfield dinosaur on the cover of this calendar is still the only reasonably complete dinosaur skeleton ever found in New Jersey. There is only a single greensand marl pit still operating anywhere, the Inversand pit in Sewell, New Jersey. Fossils are still found there, and are donated to the NJ State Museum. The skull shown above was found at the Inversand Pit in the 1960s.

January 2010

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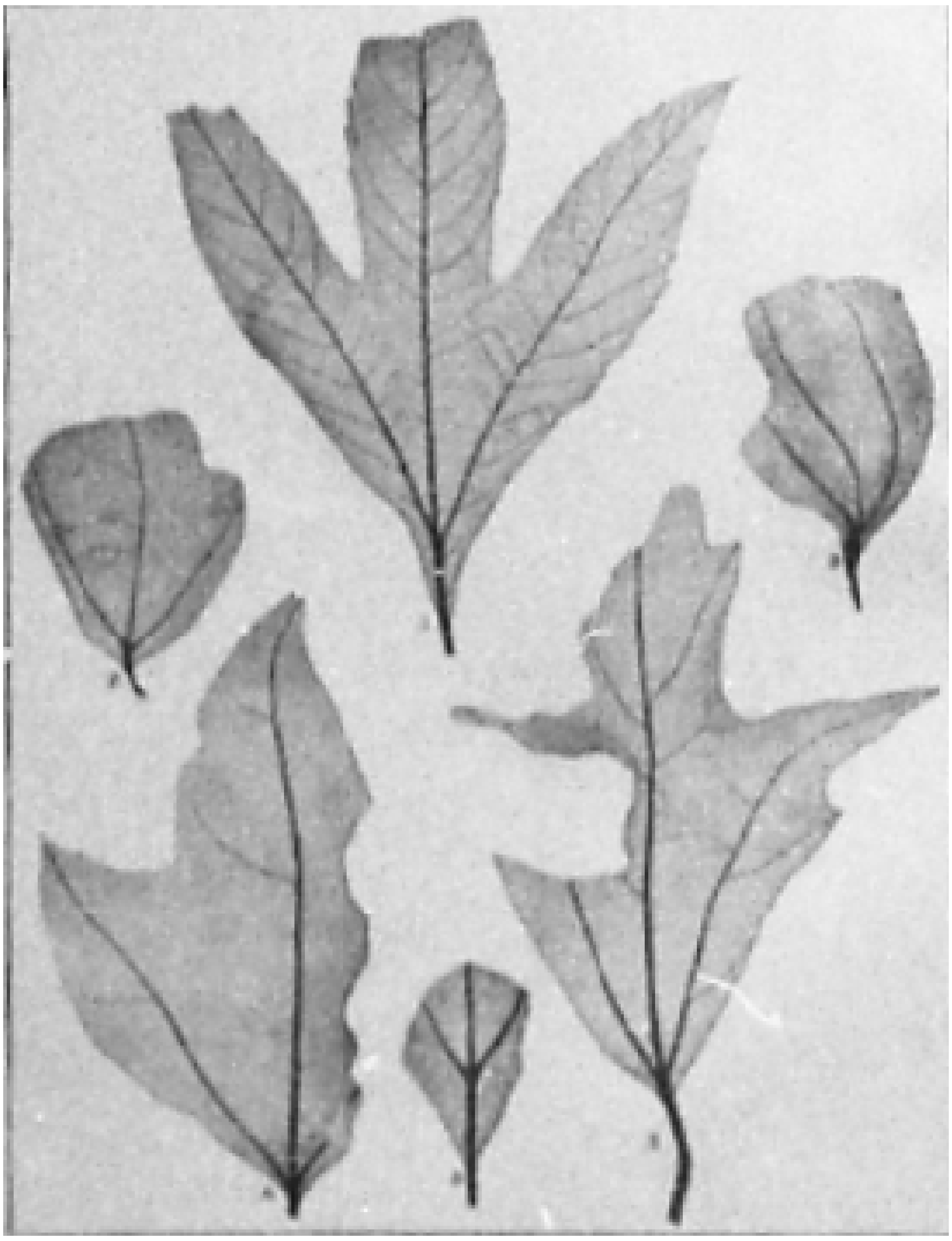

Fossil leaves, Cretaceous, Woodbridge, Middlesex County. From J. S. Newberry, 1895, The Flora of the Amboy Clays: U.S. Geological Survey Monograph 26.

Clay mining was important in central New Jersey through much of the 19th century and well into the 20th, and plant fossils are common in some of the Cretaceous clays. The fossil leaves shown here are from Woodbridge, likely from large clay pits where Woodbridge Mall now stands. Fossil plants provide insight into past climates and ecosystems of the ancient world, and New Jersey fossils are important to the understanding of conditions in eastern North America in the Cretaceous Period. Also, the distribution of plant communities in the ancient world has been important in deducing past positions of land masses and identifying times when interconnections between lands allowed the spread of plants.

Even though fossil leaves are common in New Jersey's clays, they are difficult to collect, even more difficult to preserve, and are seldom seen in collections. The film remaining from the leaves flakes away and the clay crumbles from beneath the fossils. George Cook, the New Jersey State Geologist and President of Rutgers College, assembled a large collection of fossil leaves in the mid 1800s. By the time John Newberry, collector of the leaves shown here, was working in the 1890s, Cook's leaf collection had become practically useless for scientific work.

February 2010

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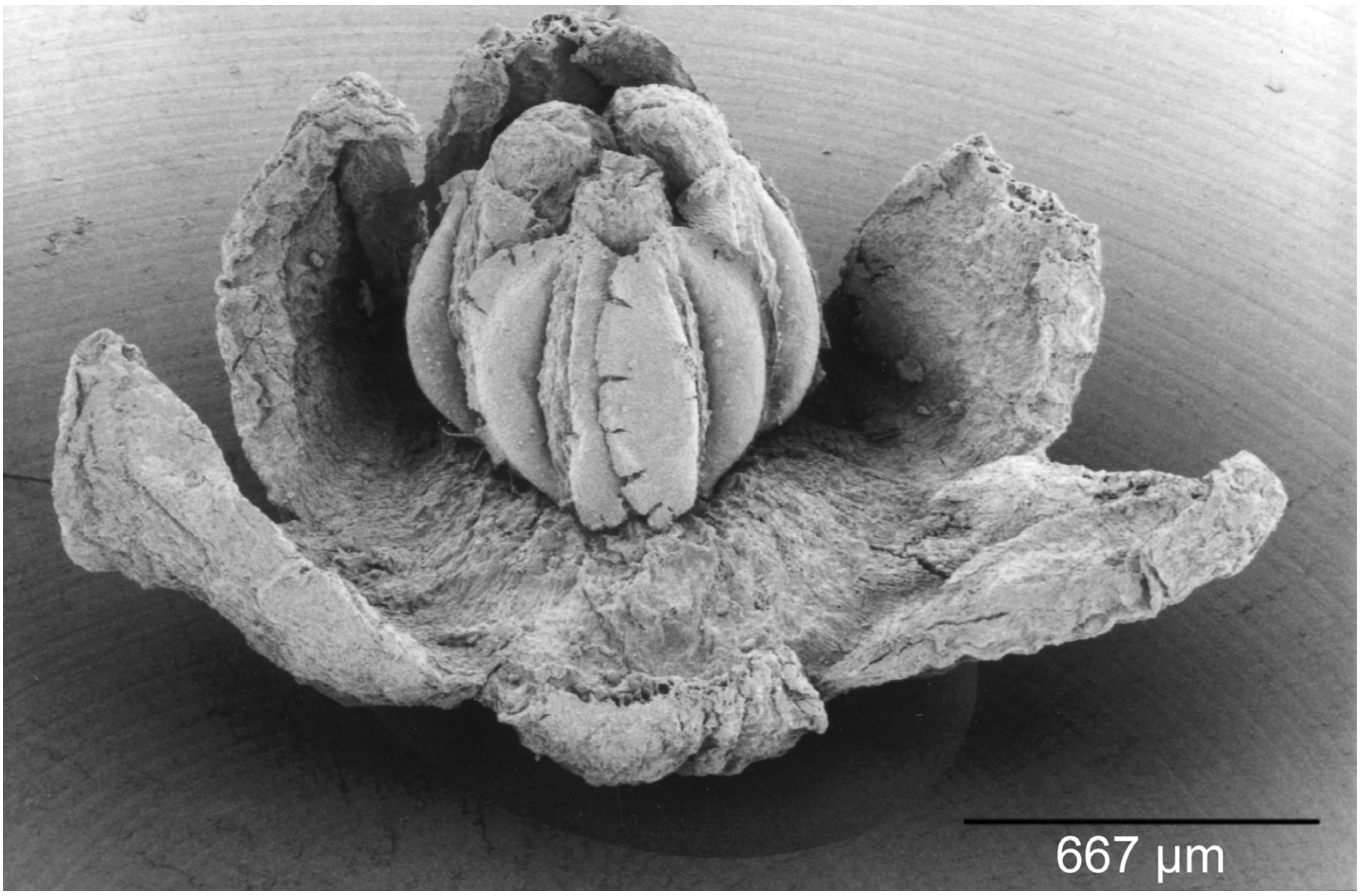

Mabelia archaia flower, Cretaceous, Sayreville, Middlesex County. Image courtesy of William Crepet, Cornell University. The flower is about 1/10th inch across.

Because flowers are temporary, delicate features and usually face outward, more directly exposed to destructive forces than other parts of plants, they are rarely fossilized. Our understanding of the relationships among plant groups has traditionally been based in good part on the structure of flowers, and the near absence of fossils has been a major hindrance to understanding plant evolution. In a rare deposit in the Crossman sand and clay pit in Sayreville, cellulose and other easily decayed plant materials were reduced to nearly inert, much more easily fossilized charcoal by a Cretaceous forest fire, then buried in silty clay and preserved for 90 million years. A greater variety of Late Cretaceous fossil flowers has been found here than anywhere else in the world, and the site has become a benchmark in tracing plant evolution. The clay pit has become a residential development, but before the construction 26 tons of the fossil bearing clay was salvaged for future study.

March 2010

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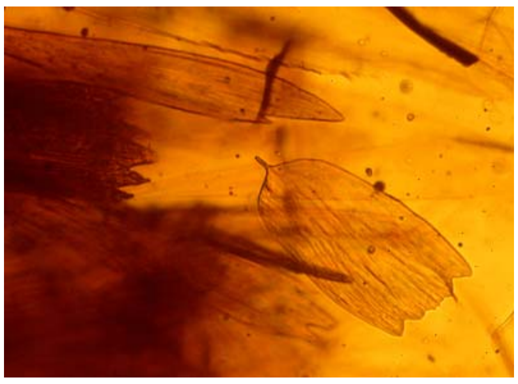

Moth in Amber, Cretaceous, Sayreville, Middlesex County: The particles below the moth are wing scales like those that come off on your fingers when you rub against the wing of a moth you could find flying around a light bulb today. The photo above is an enlargement of the scales. Photos courtesy of David Grimaldi, American Museum of Natural History.

No account of plant evolution would be complete without consideration of insects and other pollen carriers. The Sayreville clay pits where fossil flowers were found (see the March calendar) also yielded amber which preserved some of the oldest known bees and ants. A bed rich in amber was discovered in the 1990s, and much of it was donated by amateur collectors for scientific study. Scientists from the American Museum of Natural History in New York, the New York Botanical Garden, Cornell University, Johns Hopkins University, and from as far away as Sweden have spent countless hours cataloging and interpreting fossils entombed in the amber. As well as bees and ants, there are spiders, spider webs, moths, millipedes, mushrooms, feathers, and even frogs and lizards. Some of the insects were preserved with their parasitic mites still attached! The moth shown here undoubtedly fed on flowers and carried pollen between plants. The flowers and insects together in the same deposits give an outstanding picture of flowers and their pollinators 90 million years ago. As with many broad-based investigations, studies of New Jersey's fossil plants, amber, and possible pollen carriers have led to new understandings of the original topic (the radiation of angiosperm plants and pollen carriers), and have raised at least as many questions as they answered.

April 2010

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Carnivore track about one foot long, Jurassic, Towaco, Morris County. One of about 50 dinosaur footprints in a trackway at the Rutgers Geology Museum. One of the half dozen or so mass extinctions in the Earth's history happened at the end of the Triassic Period. Among the many plants and animals that died out were several groups of large non-dinosaur reptiles which had previously dominated the lands. This allowed the dinosaurs to emerge as the dominant animals in the next geologic period, the Jurassic. The Newark Basin of New Jersey (inset map) has turned out to be a good place to investigate the end-of-Triassic extinctions and the life before and after for two reasons. First, cyclic patterns of layering in the sedimentary rocks of the basin allow geologic history before and after to be studied in increments of as little as 1,000 years, an exceptionally small time span for rocks over 135 million years old. Second, while there are limited numbers of fossil bones, plant spores, pollen, and footprints are abundant. Footprints have been collected by the hundreds at several places. Our best-known trackway, now at the Rutgers Geology Museum, was collected in the 1870s in a quarry at the base of Towaco Mountain. A track from there is shown above.

Taken together, the footprints, pollen and other evidence show that the end-of-Triassic extinctions were geologically instantaneous, that carnivorous dinosaurs rapidly increased in size within 10,000 years of the extinctions, and that plant-eating dinosaurs radiated into the newly vacant ecologic space much more slowly. Without the large herbivores, the carnivores needed something else for their meals. There were large lakes and an abundance of fish in the Newark Basin, and it has been suggested that the land ecosystem was based on aquatic plants and fish rather than the usual land plants and herbivores.

May 2010

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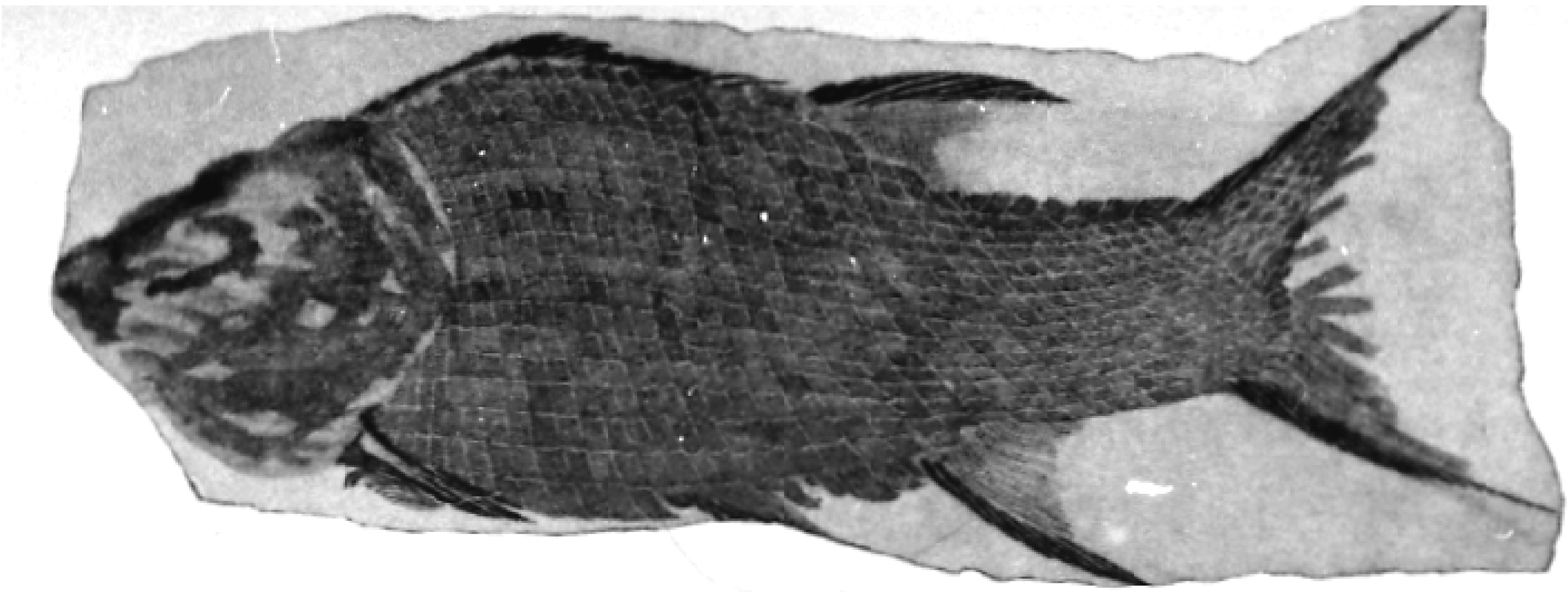

Fossil fish (Ischypterus lineatus) Boonton, Morris County. Image from John S. Newberry, 1888, The Fauna and Flora of the Trias of New Jersey and the Connecticut Valley: U.S. Geological Survey Monograph 14.

Through the late Triassic and early Jurassic Periods, the supercontinent Pangaea was beginning to split into today's continents. The Atlantic Ocean had not yet begun to open. New Jersey was still contiguous with North Africa, but long, narrow rift valleys similar to today's Great African Rift Valley paralleled most of what is now the US east coast. The valleys held linear lakes similar in some ways to the 418-mile long Lake Tanganyika and 347-mile-long Lake Nyasa in today's African rift valleys. Lakes in the Newark Basin rift valley, which crossed New Jersey as shown on the May calendar, were usually shallow, but deepened to several hundred feet when the climate was moist or the valley was subsiding faster than it could fill with sediment. Because the lakes were in a year-round warm climate and because the water was most of the time heavy with dissolved solids, there was no "turnover" of water similar to the seasonal mixing which carries oxygen downward in New Jersey's lakes today, and no way to replenish the exhausted oxygen in bottom waters. When the lakes were deep, fish could live only towards the top where waves mixed oxygen downward. After periodic fish kills from natural causes, dead fish would settle onto the bottom. Decay was so slow in the oxygen-poor bottom water that fish were buried intact by the thousands. Good exposures of these "fish kill" layers are by no means common. The best known fossils were found in the 19th century in quarries now flooded by the Boonton Reservoir, during construction of the reservoir between 1902 and 1904, and during construction of Princeton University's Firestone Library in the late 1940s.

June 2010

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“Matilda” Mastodon, NJ State Museum, found in Vernon, Sussex County, 1954. One does not usually think of New Jersey as home to free-roaming elephants, but teeth and bones of mammoths and mastodons have been found in the sands and gravels of southern New Jersey, in the ice age peat deposits of northern New Jersey, and in fishing dredges miles offshore. Mastodons are the most common of the elephants, and most of the complete fossils are from peat bogs. The peat bog elephants are of all ages, including young, and are commonly uninjured. This is consistent with their being drowned after getting mired in the peat. Mastodons are some of the best-loved fossils in our museums. The mastodon at the Rutgers Geology Museum is unusual in being from southern New Jersey muck rather than northern New Jersey peat. George Cook, the State Geologist and president of Rutgers College, bought it from a travelling circus in 1870. For years he worked to have the skeleton mounted, but it was not put on display until after his death. Matilda, shown here, was discovered in a Sussex County peat bog. Dozens of volunteer workers showed up to help with the recovery, and managing the volunteers became a substantial part of the recovery effort.

July 2010

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Cervalces scotti found in 1885 at Mt. Hermon, Warren County. The photo was taken at the 2009 New Jersey State Museum exhibit “Rising Tide: Climate Change and New Jersey”.

While mastodons are the best-known of our peat bog fossils, an extinct ice age moose, Cervalces scotti, is more closely associated with New Jersey. Cervalces antlers and, less commonly, bones have been found throughout eastern North America from Arkansas to southern Canada, but there are only two nearly complete skeletons, one found in 1885 in Mt. Hermon, Warren County and one unearthed in 1980 near Blairstown, only a few miles to the north. The animal is closely related to mooses, about the same size but taller and without the long, broad snout and prehensile lips of the modern moose. Its face more closely resembled that of a deer or elk. Similar animals are known from the early Pleistocene of Europe, and Cervalces likely migrated across the Bering land bridge sometime before the glaciers of the Wisconsinan ice age reached their maximum extent. The species died out about 10,000 to 15,000 years ago, when the Wisconsinan glaciers melted back and the modern moose migrated to North America. The modern moose and Cervalces occupy similar ecologic niches and the moose may have displaced Cervalces.

August 2010

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Icarosaurus seifkeri, North Bergen, Hudson County. Photo © Carl Mehling, 2009, Courtesy of the American Museum of Natural History: This 4-inch-long fossil, found in 1960 by 16-year-old Alfred Seifker and two companions, pushed back the age of vertebrate flight by 10 million years. Unlike birds and bats, which fly using wings developed from forelimbs, and flying squirrels, which glide on skin stretched from forelimbs to hind limbs, Icarosaurus and the unrelated flying dragons now living in Southeast Asia glided on a widened, flattened torso. A look at the fossil may convince you that the arms were not wings. Instead, elongated ribs separate from the main rib cage supported an airfoil. Both sets of ribs show clearly in this photo. Alfred Seifker acquired the fossil from his companions, then donated it informally to the American Museum of Natural History in New York. Later, in hard times, Seifker recovered the fossil and put it up for auction. Fortunately, the fossil was purchased by Dick Spight, a retired businessman, and returned to the museum.

September 2010

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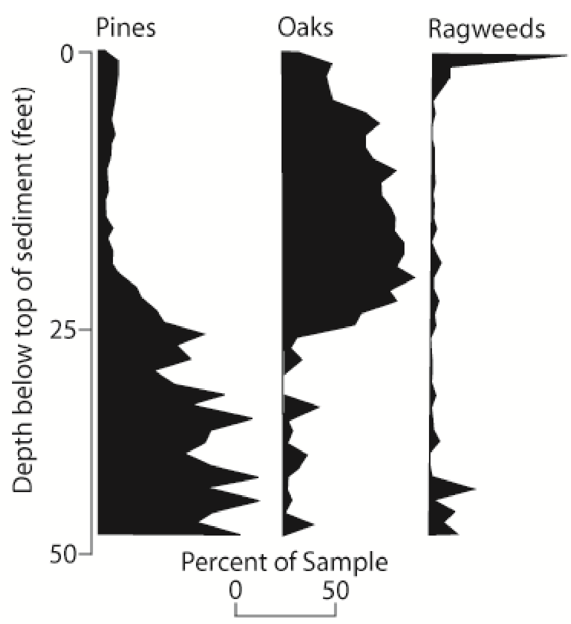
Large, well preserved fossils have contributed greatly to our understanding of the earth and its history, but their rarity limits their usefulness in many geologic applications. Microfossils like pollen grains, spores, diatoms, and the one-celled animals known as foraminifera are often much more useful. As an example, much of our knowledge of ice age and more recent climates is from pollen collected from peat bog and lake sediment cores. It would be unusual to find a complete tooth or bone in a 2-inch-diameter core, but pollen grains can often be recovered by the thousands. The pollen profiles below are from Budd Lake, Morris County. 29,662 pollen grains and spores from 66 types of plants were collected from a 45-foot core. Profiles for three of the plant types (pines, oaks and ragweeds) are shown below. The end of the Wisconsinan ice age, about 18,000 years ago is marked by a change from pines to oaks. About 25 feet of sediment has accumulated since then. The abundance of ragweed pollen in the top few feet of sediment has been attributed to the clearing of forests for agriculture. Ragweeds are wind pollinated and produce enormous amounts of pollen.

Above: Pollen grain from pine tree. Right: Pollen profiles from sediment core, Budd Lake, Morris County. Profiles modified from Kathryn P. Harmon, 1969, Pleistocene forest succession in northern New Jersey, PhD dissertation.



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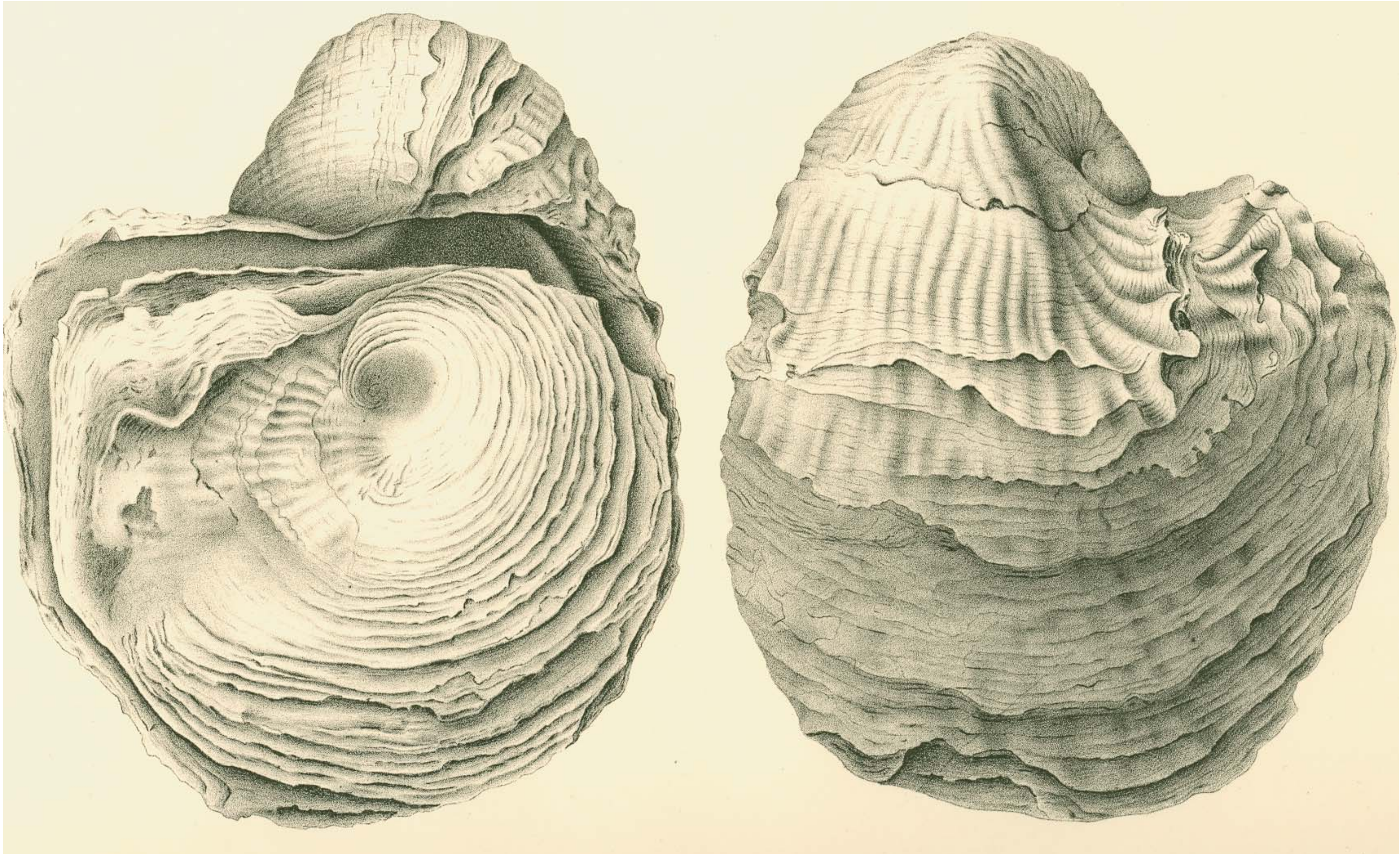

Oyster (Exogyra costata) from Robert P. Whitfield, 1886, NJ Geological Survey, Paleontology of New Jersey, v. 2, collecting locality not specified. Cretaceous and Tertiary fossils are abundant in southern New Jersey, and southern New Jersey is close to Philadelphia. Philadelphia was the pre-eminent center for the study of natural sciences in North American from the mid 1700s through the early 1800s. Most of the fossil sites close by Philadelphia were in New Jersey marl or clay pits or along our stream banks, and North American paleontologists and international paleontologists comparing the fossil record of North America and Europe became well acquainted with New Jersey fossils, particularly the mollusks. Most of the pits have long since grown over or been developed in this densely suburban area, and most of the stream bank exposures are covered by fill, landscaped as public parks, closed to the public, or have become otherwise unfit for collecting. Two sites, Poricy Brook and Big Brook in Monmouth County, both well known in the 19^{th} century, are still open to the public. The fossils wash from the stream banks and can be picked up from gravel bars or sieved from stream gravel using a kitchen colander, beach toy, or wire mesh screen. A visitor is practically guaranteed to find at least a few fossils.

November 2010

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Megalornyx jeffersonii vertebra, Holgate, Cape May County. This cell phone photo was sent to the NJ State Museum and confirmed that these pieces of bone picked up from the beach debris were scientifically interesting ice age fossils. Photo courtesy of Kathleen Lake and William Boyd Wood.

Fossils are still collected daily, often unexpectedly, in New Jersey. Most of the finds are of little scientific value, but numerous accidental finds by non-geologists have proven important. These bones were picked up by Kathleen Lake and William Boyd Wood on the beach at Holgate in March 2009. The 10-inch vertebra was too large to be from anything on land today, and they guessed from the color and lack of smell that these were fossils, not whale bones. David Parris of the New Jersey State Museum confirmed that these are indeed fossils. The large vertebra is from Megalornyx jeffersonii, a giant ground sloth first described from specimens collected in an expedition financed by President Thomas Jefferson. The smaller bone has proven more difficult to identify, but is clearly fossil. Both fossils are delicate and would have been quickly destroyed by waves if not collected. The fossils were loaned to the State Museum until January 2010 and were included in the exhibit “Rising Tide: Climate Change in New Jersey”. If you find an interesting rock, mineral, or fossil, you can bring it for identification to the NJ State Museum, NJ Geological Survey, or the rock identification room at the annual Rutgers Geology Museum Open House in New Brunswick. The open house is held on the last Saturday in January.

December 2010

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