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New York Paleontology

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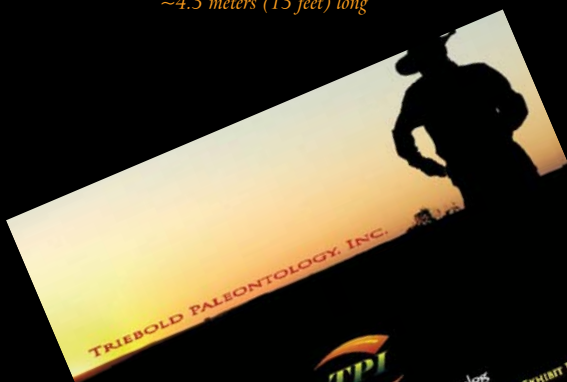
***Placerias** was a large herbivorous Dicynodont, possibly filling an ecological niche similar to that of the modern hippo. It was large with heavy limbs, barrel-chested and about 3 meters (10 feet) long.*



***Desmatosuchus**, is a heavily armored aetosaur with two rows of large spikes across the shoulders and neck, needed for protection against attack from predators such as Postosuchus. ~4.5 meters (15 feet) long*



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Group Therapy

By Paula M. Mikkelsen

Few things are more enjoyable to hobbyists than spending time with others who share their passion.

In early April of this year, I spent two days at Western Illinois University at the 31st annual MAPS Expo. MAPS (the Mid-America Paleontology Society) hosts this event once a year in the charmingly rural Midwestern U.S. as a venue for members and vendors and other friends (like PRI) to gather, show their latest specimens, talk about collecting, buy and sell, and wheel and deal. Eighty-four tables, filling the University's gymnasium, were covered this year with fossils – from Pleistocene to Cambrian, actual and cast, vertebrate and invertebrate, part and counterpart. Most were for sale, by dealers or individuals, but some were just for show, including a life-sized cast of a *Stegodon* (think mammoth) skeleton (provided by Michael Sincak of Treasures of the Earth). PRI has sent a representative to this show most years since the early 1990s. This year was my turn, and I had five goals in mind: (1) to interact with the avocational paleocommunity, (2) to sell PRI publications, and some store merchandise, (3) to present our annual Katherine Palmer Award (this year to Richard E. Petit, see page 4), (4) to seek potential users and donors for our collections, and (5) to generally promote PRI and its programs to Expo participants and attendees.

The trip began with a four-leg, twelve-hour journey from my home in Trumansburg, New York, to Macomb, Illinois, that included one delay (fog in Philly), brief rental car confusion (FYI, not all new compact cars come equipped with a power plug – AKA “cigarette lighter” – for a portable GPS), and a long, dark drive from Moline-Quad City Airport to WIU in Macomb along disconcertingly deserted highways despite the comfort of the long red line on my GPS. (My return trip was blissfully uneventful despite an unexpected Spring snowstorm threatening the Midwest, literally chasing me home.) The only person that I knew at MAPS initially was John Catalani, who frequent readers will recognize as the author of “An Amateur’s Perspective” in this magazine; the essay in this issue is the 54th that he has penned (for which I continue to be thankful – it’s always a great read!). John graciously received my mailed boxes of heavy books and *AP* issues (saving me from expensive overweight luggage) and offered other very helpful advice to a newbie. What I discovered in Macomb during the following two days, besides the anticipated buyers for our volumes, was an enthusiastic group of collectors who welcomed me into their midst in true hospitable Midwest fashion. In the short course of two days, I met at least a dozen people whom I now count as friends. I personally learned more about fossils and fos-



sil collecting (my own research is in living mollusks), and about fieldwork and “silver pick” collecting – a new phrase to me for collecting by purchasing. I spoke to several hundred adults, many teachers, and scads of children, explaining who and where we are and what we do, explaining membership and subscriptions, offering free stickers, tattoos, *AP* issues, bookmarks, and coloring sheets about crinoids, trilobites, other Devonian sea creatures, and Harry the Humblebee. And yes, I even sold a few books – oh yes, and a pile of plush trilobites, which some of my new friends said were the hit of the show! Evening events included a great keynote lecture by Dr. William Ausich (Ohio State University) on his crinoid research, our KVWP Award ceremony, and a lively auction to benefit student programs. All in all, a great time for me, and I think PRI left another very favorable impression.

OK, cool travel log, but let me get to my point. One of the reasons that I felt so “at home” at the MAPS Expo is that I spent many of my early years attending shell shows, where shell collectors gather to share their passion, convey it to others, and to buy, sell, and trade specimens. So this was a very familiar setting for me, simply with other kinds of specimens. I saw a myriad of membership pins from local fossil clubs being worn at MAPS, echoing the shell club pins so familiar to me. This all reminded me of the importance of such amateur organizations to our science – avocational paleontologists frequently collect with and/or provide specimens to professionals – and also to the growth of our field, especially by exciting young people about paleontology. How many university geologists recall with fondness their first fossilizing trip with a local club? Joining a local club can be and often is a turning point, transforming a casual interest into a passion, and perhaps into a career.

So whether your passion is shells, coins, stamps, or fossils, I’ll bet that there’s a club out there for you. If you’re lucky, there’s one in your own city or town. If not, there are newsletters and perhaps annual meetings that you can get to. In NYC, the New York Paleontological Society (<http://www.nyps.org/index.htm>) meets monthly at the American Museum of Natural History. In upstate New York, perhaps PRI can serve as your “club,” with this magazine, our programs, our publications, and Summer Symposium in August to help you along.

So don’t struggle to learn in isolation. Join and participate in a fossil club or other membership group near you. Whatever your background, and as far as you want to take it, a group can increase your knowledge exponentially. We want to help you – it’s why we’re here.



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On the cover: Photomontage by J Bret Bennington of north-eastern dinosaurs against a background DEM (digital elevation model) of the metro New York region. The historical marker and *Hadrosaurus* sculpture can both be seen in Haddonfield, New Jersey. See his feature article beginning on page 10.



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Richard E. Petit Receives Katherine Palmer Award



In a ceremony at the April 2009 Mid-America Paleontology Society Expo, at Western Illinois University in Macomb, Illinois, Richard E. Petit of North Myrtle Beach, South Carolina, was awarded this year's Katherine Palmer Award, presented annually to a non-professional who has made substantial contribu-

tions to the field of paleontology. The award was given this year by Associate Director for Science Paula Mikkelsen. Petit was lauded for his many publications on Recent and fossil mollusks (especially Cancellariidae) and on this history of malacology, for his service to the community as a used book dealer, and as a Past-President of the American Malacological Society. He was a personal friend of Katherine Palmer and served as a PRI Trustee from 1993-1996. The Katherine Palmer Award is named for PRI's second director, Katherine van Winkle Palmer, who held avocational paleontologists in high regard and collaborated with many during her long career.

Read the entire citation on our website (<http://www.museumoftheearth.org/research.php?page=888262>).

World's Largest Collection of Antarctic Invertebrates Comes to PRI

PRI Collections staff members Greg Dietl and Judith Nagel-Myers spent four days at Purdue University in Indiana in April, packing a donated collection from Dr. William Zinsmeister (pictured at right with Greg), a faculty member in the Department of Earth and Atmospheric Sciences at Purdue. The collection is spectacular, and includes what is probably the world's largest collection of invertebrates fossils from Antarctica (mostly collected by Dr. Zinsmeister himself), as well as the historic Hatcher collection of Patagonian fossils amassed during an expedition in the 1890s. Most of the collection arrived in archival-quality, standard "quarter-unit" collection cabinets. This is one of the most significant collections that PRI has received in recent years. Among the notable specimens is a 68-inch-long *Diplomoceras*, a hetero-



morph ammonite from the Upper Cretaceous of Seymour Island, Antarctica (pictured below with Judith).



Seismology Recognized at Museum of the Earth

Not many people realize that PRI has an outstanding set of seismological instruments, sending a variety of real-time data to the Museum exhibits and to a database at the Lamont-Doherty Research Observatory of Columbia University. Three individuals have who have been at the heart of making the seismology program work over the course of the last decade were honored in a brief ceremony on April 7. Cornell seismology professor (recently emeritus) Muawia Barazangi provided several analog instruments, which include seismographs of the sort that have a pen suspended over a turning cylindrical drum. Research Engineer George Hade spent hundreds of hours over the past decade on electrical work to install and maintain the instruments in the Museum. And long-time superstar PRI volunteer Curt Banta has been changing the paper and ink and tweaking the machines since the Museum opened. Muawia also held a seismogram record reading class at Cornell that Curt and numerous PRI staff have attended

over the years. Muawia also facilitated the loan of a state-of-the-art digital seismometer from Columbia University, which is a station within the Lamont Cooperative Seismology Network. The data from that machine are shown in near real time on a large screen monitor in the Museum and can be accessed by anyone at http://www.ldeo.columbia.edu/cgi-bin/LCSN/WebSeis/24hr_heli.pl (select station "PRNY" and click "submit").



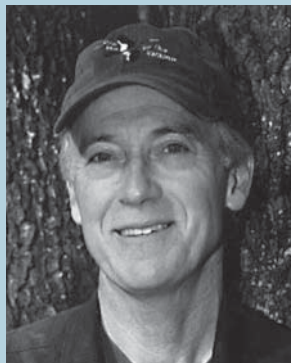
Mark Erickson is a paleontology professor at St. Lawrence University in Canton, New York. He published on Cretaceous snails in *Bulletins of American Paleontology* in 1977.



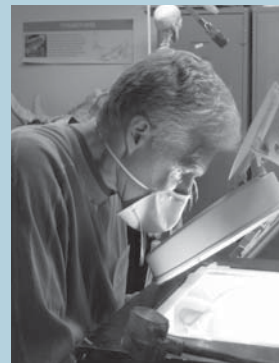
Jim Fogel is a retired Ithaca physician in obstetrics and gynecology, a member of PRI, and a frequent attendee at PRI events. He calls PRI his "favorite local non-profit."

New Board Members

PRI and its Museum of the Earth are pleased to welcome these four persons to our Board of Trustees. In addition, PRI Trustee Emeritus **David Taube** has agreed to come back onto the Board as an active member. We look forward to working with these talented people for the betterment of PRI and its many programs.



Tim Gallagher is an author and editor-in-chief of *Living Bird* magazine at Cornell Laboratory of Ornithology. He is author of, among other books, *The Grail Bird: The Rediscovery of the Ivory-Billed Woodpecker* (Houghton Mifflin Harcourt, 2006).



Don Wilson is a retired Ithaca cardiologist and a very active docent at Museum of the Earth. He recently arranged for a permanent access easement to his Cayuga Lake shore property for PRI educational programs.



Evolution and Darwin

Evolution, 2nd ed. by Douglas J. Futuyma. Revised edition of a comprehensive textbook on contemporary evolutionary biology directed toward undergraduate students. Sinauer, 695 pp., ISBN 978-0-87893-361-7, \$65.95 (hardcover; also available as an e-book), April 2009.

Why Evolution Is True by Jerry Coyne. With attention to scientific evidence and a wonderfully accessible style, an evolutionary geneticist at University of Chicago presents an overwhelming case for evolution. Viking Adult, 304 pp., ISBN 978-0-67002-053-9, \$27.95 (hardcover), January 2009.

Remarkable Creatures: Epic Adventures in the Search for the Origin of Species by Sean B. Carroll. A molecular biologist at the University of Wisconsin provides vignettes of some of the fascinating people who have made the most significant discoveries in evolutionary biology. Houghton Mifflin Harcourt, 352 pp., ISBN 978-0-15101-485-9, \$26.00 (hardcover), February 2009.

Paleobiology

Dinosaurs in Your Backyard: The Coolest, Scariest Creatures Ever Found in the USA! By Hugh Brewster. Did you know that the first dinosaur fossil ever found in the US was discovered in New Jersey? Or that the Great Plains used to be swarming with sea monsters? Imagine what was in your own backyard 70 million years ago as you read this one-of-a-kind dino adventure. Abrams, 32 pp., ISBN 978-0-81097-099-1, \$15.95 (hardcover), April 2009.

Pollution of Lakes and Rivers: a Paleoenvironmental Perspective, 2nd ed. by John P. Smol. This book demonstrates how paleolimnological approaches can be used to interpret the physical, chemical, and biological information stored in lake and river sediments, and how this information is integral to identifying key environmental stressors and setting targets for mitigation. Blackwell Publishing, 383 pp., ISBN 978-1-405-15913-5, \$59.95 (paperback), January 2008.

A Sea without Fish: Life in the Ordovician Sea of the Cincinnati Region by David L. Meyer & Richard Arnold Davis. A synthesis of more than 150 years of research on the Cincinnati-Ordovician treasure-trove, describing and illustrating the fossils, the life habits of the animals, their communities, living relatives, the rock strata in which they are found, and the environmental conditions of the ancient

sea. Indiana University Press, 346 pp., ISBN 978-0-25335-198-2, \$44.95 (hardcover), January 2009

The Paleontology of New Mexico by Barry S. Kues. In this updated and expanded version of his 1982 *Fossils of New Mexico*, Kues offers a detailed overview of the fauna and flora from Cambrian through Pleistocene times. University of New Mexico Press, 432 pp., ISBN 978-0-82634-136-5, \$45.00 (hardcover), December 2008.

Global Climate Change

Earth: The Sequel: The Race to Reinvent Energy and Stop Global Warming by Fred Krupp and Miriam Horn. A business-centric prescription for alleviating climate change by Environmental Defense Fund president Krupp and journalist Horn. A new paperback edition with a new afterword (hardcopy published in Feb. 2008). W. W. Norton, 304 pp., ISBN 978-0-39333-419-7, \$15.95 (softcover), March 2009.

The Discovery of Global Warming, revised and expanded edition, by Spencer R. Weart. An informed history of the global warming issue, including the internal conflicts in the research community and the role of government, plus solutions to consider. Harvard University Press, 240 pp., ISBN 978-0-67403-189-0, \$16.95 (softcover), October 2008.

Earth Science

Planetology by Tom Jones & Ellen Stofan. A stunning and completely new view of the solar system, written by an astronaut and a geologist. National Geographic, 224 pp., ISBN 978-1426201219, \$35.00 (hardcover), November 2008.

Status of the Geoscience Workforce, compiled by Leila Gonzales, Christopher Keane & Cindy Martinez. This report provides a comprehensive view of human and economic parameters in the geosciences, including supply and training of new students, workforce demographics and employment projections, and trends in geoscience research funding. American Geological Institute, 136 pp., ISBN 978-0-92215-283-7, \$50.00 (softcover), March 2009.

The Medea Hypothesis: Is Life on Earth Ultimately Self-Destructive? by Peter Ward. A provocative look at the history of Earth, offering a distinct perspective and arguing strongly that the only intelligent choice is to manage ourselves and the environment. Princeton University Press, 208 pp., ISBN 978-0-69113-075-0, \$24.95 (hardcover), April 2009.

By Stan Balducci

The Cretaceous-Tertiary (K-T) mass extinction is the most recent of Earth history's five major mass extinction events. It occurred about 65 million years ago. The other four major mass extinctions occurred at the end-Ordovician, late Devonian, end-Permian, and end-Triassic. All occurred during the Phanerozoic Eon. The K-T mass extinction was selective and abrupt with devastating consequences to life on Earth.

The K-T mass extinction event is popular because it ended the dinosaurs' existence on Earth. Other life forms died out also, including ammonites, ancient marine reptiles like mosasaurs and plesiosaurs, plankton, pterosaurs, and many mammals. Planktonic single-celled forams underwent almost complete extinction at the K-T boundary with about 97% of their species disappearing.

The K-T mass extinction event was selective, meaning that while many species went extinct, others survived, such as crocodiles, small mammals, frogs, turtles, and salamanders. In the oceans, most dinoflagellates survived the K-T boundary crisis, perhaps because of their ability to form protective cysts under unfavorable conditions.

Scientists now know that a large asteroid or comet approximately 6 miles in diameter struck the Earth's surface about 65 million years ago. The impact area was on the Yucatán Peninsula in Mexico near the town of Chicxulub (which means "tail of the devil"). Evidence for the impact includes a globally distributed clay layer enriched in the element iridium, which is rare in crustal rocks but is found in higher concentrations in asteroids and comets. The impact explosion opened a cavity about 160 kilometers (100 miles) in diameter. The huge Chicxulub crater is one of the largest impact structures produced in the last 4 billion years – since the interval in Earth's history when large impacts occurred frequently (called the Hadean Eon, 4.6 to 3.5 billion years ago).

Evidence for an impact also includes shocked quartz, known to occur in the solid material thrown from an impact crater. Grains associated with the boundary sediment of the K-T extinction contain shocked quartz. Other physical evidence for an impact are nearshore marine deposits that some say were caused by tsunamis (tidal waves 20 or more meters in height). Tsunami deposits more than 10 feet thick are reported around the Gulf of Mexico, and some scientists think that tsunamis are the only event that could have created these deposits.

The heat generated by the K-T boundary impact might have started global forest fires that added fine particulate matter to the atmosphere, which can be harmful to health if inhaled. Many K-T boundary deposits also show an increase in fern spores, known as the "fern spike." This indicates a sudden shift in vegetation such as occurs after a forest fire; ferns are "pioneer plants," among the first to colonize a disturbed area.

All of the debris and dust in the atmosphere following the Yucatán impact blocked the sunlight and temporarily halted photosynthesis. Food webs collapsed, and extinctions followed. Harmful gases containing sulfuric acid and nitric acid might have contributed to acid rain, further adding to the devastating effects on vegetation and marine organisms.

The selective nature of the K-T boundary extinctions has prompted disagreement about this crisis in Earth's history. The survival of certain groups is more compatible with a gradual extinction scenario than an impact-related one. Some geologists think that dinosaurs, many plants, and many marine organisms were on the decline and headed for extinction before the K-T boundary event,

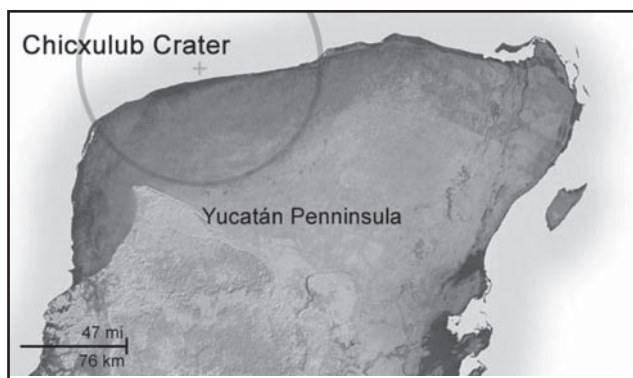
so that the impact simply hastened the process. In short, after more than 20 years of struggling with the inherent paleontological uncertainties of this best-studied mass extinction, we still must work to resolve the cause(s).

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Stan Balducci is a member of PRI, a retired master gardener, and a self-taught paleontologist. He has enjoyed distance-ed courses in paleontology, evolution, biogeography and historical geology. He is a single dad and a 3.5 tennis player, and resides in Mechanicsville, Virginia. Email hbalducci@comcast.net.



PaleoNews

The Latest News in Paleontology from the Library Shelf and the Web

Ithaca, N.Y., and the world

Summer 2009

Faster (Growing) is Better

The duck-billed hadrosaur was easy prey. Although an adult weighed as much as $3\frac{1}{2}$ tons, it had a soft body and short forearms. The long nasal crest on the head of many species probably looked intimidating, but hadrosaurs were practically helpless against its predators. *Tyrannosaurus* and its cousin *Albertosaurus* each saw the hadrosaur as an easy meal. However, research reported in August 2008 in the *Proceedings of the Royal Society of London* suggests that the hadrosaur had one advantage: it grew to adulthood very quickly. *Hypacrosaurus*, a hadrosaur that lived 67 to 80 million years ago, grew three to five times faster than its predators, evidenced by the presence of large blood chambers inside its bones. While *Tyrannosaurus* reached maturity in 20 to 30 years, the hadrosaur reached sexual maturity at the young age of 2 or 3 years, and stood at full size in only 10 or 12 years. This means that a hadrosaur was full grown when its predators, born at the same time, were only half way to adulthood. It could also reproduce more quickly than its predators and be safer in its larger groups. Scientists have found that prey growing more quickly than their predators is a common theme throughout Earth's history, and it is still true today in some amphibians and birds.



DINOSAUR LUCK

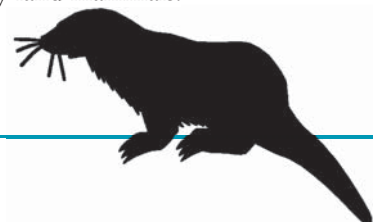
A team of scientists at Columbia University and University of Bristol (U.K.) report that dinosaurs dominated the Earth in the Jurassic and Cretaceous periods not so much because of size or prowess, but because they were lucky. From a database of hundreds of skeletal features of more than 60 dinosaurs, a new family tree showed that crurotarsans (crocodiles and their extinct relatives – major competitors of dinosaurs in the Triassic Period) were much more diverse in form and lifestyle, a feature usually associated with the ability to survive environmental change (as often characterizes mass extinction events). At the end of the Triassic, crurotarsans were wiped out, while dinosaurs survived and went on to flourish. Why? According to the scientists, "There was a certain amount of luck involved." Reported in *Science* in September 2008.

Oldest Fossilized Brain

About 300 million years ago, an iniopterygian – a close relative of modern-day ratfishes – died and dropped to the sea floor in what is now Kansas. The small fish, which could comfortably fit in the palm of your hand, had a pea-sized brain that should have quickly deteriorated or been eaten by scavengers. Instead, its brain was replaced by hard minerals. So when French paleontologists doing a routine tomography scan of the fossilized specimen found a nearly perfectly preserved brain, they were excited! The iniopterygian's brain is the oldest known fossilized brain ever discovered. Study of this rare discovery later showed that the fish had a large lobes for vision and fairly big eye sockets. Also, the hearing-related section of the brain was flattened, meaning that the fish could detect its own side-to-side movement, but probably not up and down. Reported by *National Geographic News* in March 2009.

THE WALKING SEAL

Pinnipeds, including seals, sea lions, and walruses, are ideally adapted for swimming, equipped with flippers instead of arms and legs. Yes, but "twas not always thus." *Puijila darwini*, a 23-million-year-old Miocene pinniped relative discovered in 2007 on Devon Island in the Canadian Arctic, looked more like a 3-foot-long otter. With its large feet, flattened toe bones (that suggest webbing) and its unspecialized tail, *Puijila* probably swam using all four limbs in a kind of "dog paddle" stroke. The species was described in April 2009 in the journal *Nature*, and was also on display to the public briefly in April-May at the Canadian Museum of Nature in Ottawa. The importance of this specimen is that it tells us that pinnipeds almost certainly originated in the Arctic, from terrestrial and semi-aquatic animals. *Puijila* is one of the critical transitional fossils that illuminate the pathways that evolution took to the forms that we find so familiar today, in this case the return to the sea by land mammals.



TURTLES ON THE HALF-SHELL

The shell of turtles and tortoises is a very specialized feature, and its origin has long been debated by scientists. Now we know a little more, though the path is still not clear. In the journal *Nature* in November 2008, the oldest turtle ever found – *Odontochelys semitestacea* ("half-shelled turtle with teeth") from the Triassic Period (220 million years ago) of southwestern China – was described as a 16-inch-long toothy aquatic animal. In place of a typically turtle-like shell, *Odontochelys* had a shell on its belly (the "plastron"), but none at all across its back (the "carapace"). Its backbone and ribs were already showing signs of the expansion and fusion that would ultimately evolve into a carapace, but at this point, *Odontochelys* was only "half" shelled. This evidence reportedly dashed the previous idea about the evolution of the turtle's shell by the fusion of osteoderms, the tough, bony skin plates now seen in crocodiles. But did it? Just a month before in October 2008, in *Proceedings of the Royal Society*, a 210-million-year-old shell of a terrestrial (land) turtle from New Mexico (the first Triassic turtle known from North America) was described with a thin carapace not quite connected to the ribs, and bony spines on the neck vertebrae, again suggesting the shell's origin in the skin of the turtle. Does this mean that turtle shells could have evolved along two different pathways? Maybe!



Most Ancient Octopus

In a recent paper in the journal *Palaeontology*, a team of scientists from Germany, Italy, and Luxembourg have described what they claim to be the earliest known representatives of the subclass Octopoda. The three new species are from the Late Cretaceous of present-day Lebanon, about 95 million years ago. Octopods are soft-bodied animals today, so these fossils are of exceptional preservation, showing features such as eyes, arms, suckers, muscles, gills, ink sacks, and even extruded ink. Each of the primitive octopuses also has a two-part vestigial gladius – the remnant of an internal shell nowadays possessed only by squids. This report provides valuable details for interpreting the early evolution of octopuses and other cephalopods.

NEANDERTHAL BIRTH

Successful childbirth in humans has much to do with the position and size of the comparatively large baby relative to the size of the mother's birth canal through her bony pelvis. Pelvic structure and the "birth mechanism" (the steps that need to occur during labor to correctly position the baby for birth) are therefore significant, so significant that these can in part help define the modern human subspecies, *Homo sapiens sapiens*. This has important implications for the interpretation of fossil hominids. The problem is that the pelvis is seldom fossilized, so very few data exist. In a paper published in a April 2009 issue of *Proceedings of the National Academy of Sciences*, researchers reconstructed the pelvis of a Neanderthal female from present-day Israel. The shape of the pelvis indicates that although Neanderthal women probably had similar levels of stress and discomfort during birth as modern humans, their birth mechanism was less developed. The scientists concluded that the modern birth mechanism probably did not evolve until about the last few hundred thousand years, which emphasizes the uniqueness of modern human birth as well as the earlier divergence of Neanderthals and the lineage leading to modern humans.



FUZZY DINOSAURS

Feathered dinosaurs, ancient relatives of modern birds, are thought to have appeared in the Late Jurassic, about 150 million years ago. However, a report in March 2009 in the journal *Nature* suggests that dinosaurs predating this epoch may have been covered by bristles, dubbed "protofeathers" or "dino-fuzz." A new cat-sized dinosaur from China, named *Tianyulong confuciusi*, was virtually covered by fuzz, but had especially long, hollow filaments in a crest extending from the base of its neck down to the end of its tail. The fuzz and filaments were probably used for warmth or for display, and might have even been brightly colored. Before this report, all feathered dinosaurs were theropods, members of the order Saurischia. Significantly, *Tianyulong* is an ornithischian dinosaur, so its discovery pushes back the origin of feathers to the origin of the Dinosauria, before the split of Saurischia and Ornithischia more than 200 million years ago.

PaleoNews is reported in part by Olivia Rebert, a writing major at Ithaca College in Ithaca, New York.

When Dinosaurs Ruled New York: The Significance of the Tri-State Region to Dinosaur Paleontology

By J Bret Bennington

If you want to find dinosaurs in New York City, just take the C train uptown to the American Museum of Natural History. There, in the great halls on the fourth floor, the skeletons of tyrannosaurs, sauropods, ceratopsians, and hadrosaurs pose frozen in time. Those who take a moment to read the kiosks in front of the exhibits discover that most of these specimens are transplants to the Big Apple from points west – places like Wyoming, Colorado, Montana, and Alberta. A few are immigrants from overseas, hailing from Europe, China, or Mongolia. None would be expected to have roared and bellowed with the distinctive accent of a native New Yorker. Yet certainly there were dinosaurs roaming the forests and coastlines of New York, New Jersey, and Connecticut back in the day. We know this because we have their fossils in the form of footprints, teeth, and bones recovered from regional rock formations. Dinosaurs are not easy to find in the east, buried as they are beneath soil, pavement, and housing tracts. Nevertheless, they are here, along with a pretty significant sedimentary record of the Mesozoic Era.

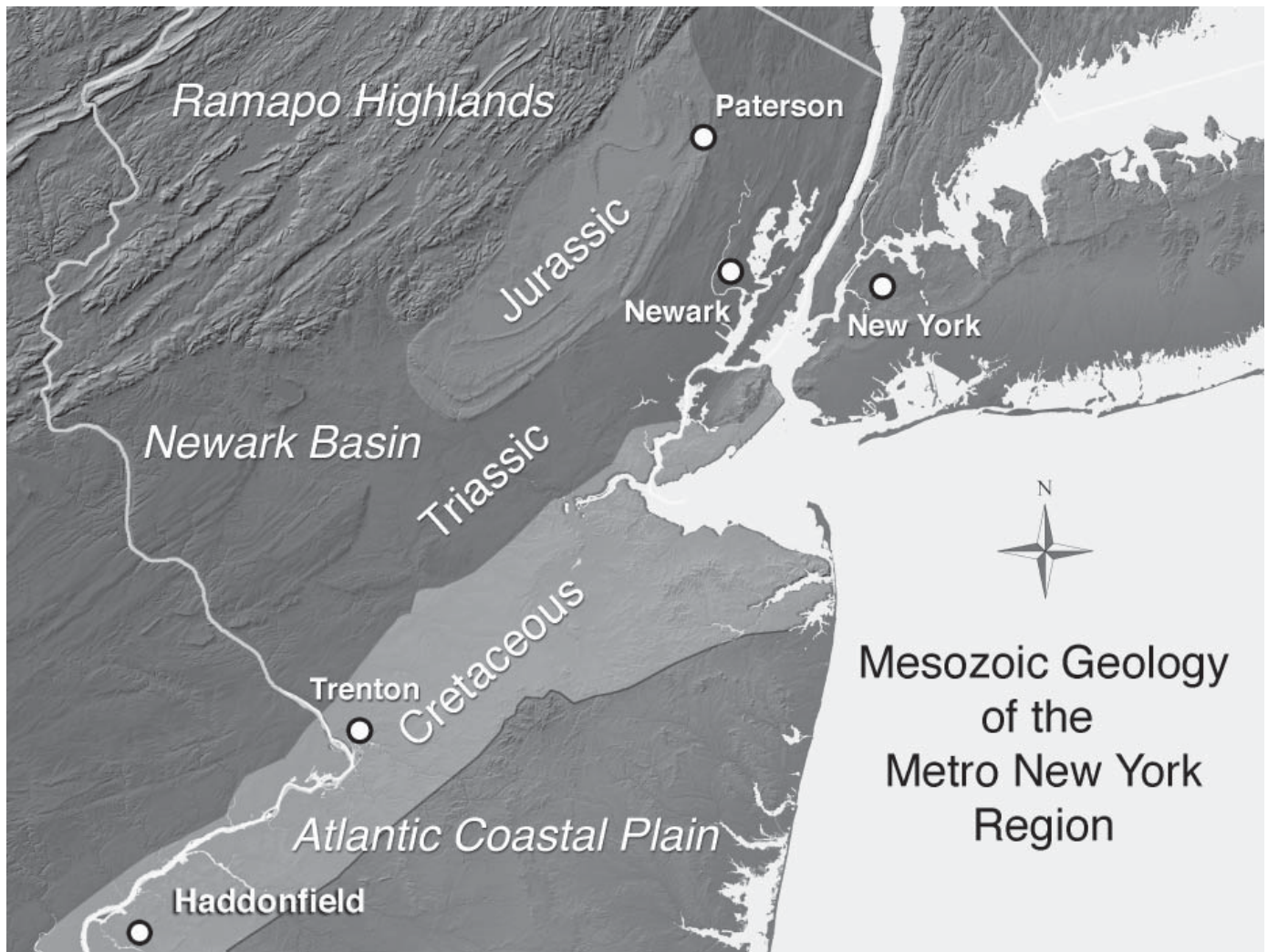
Those who know something about dinosaurs are probably aware of the abundant dinosaur tracks that have been unearthed in northern New Jersey and central Connecticut and Massachusetts. First noted in 1802 when a farmer named Pliny Moody unearthed a slab of reddish siltstone bearing the tracks of “Noah’s raven,” these distinctive three-toed fossil footprints were later systematically collected and studied in the mid-1800s by Edward Hitchcock, the president of Amherst College. Although Hitchcock believed these fossils to be the tracks of giant birds, his monograph describing them in 1858 remains a useful dinosaur reference to this day. A great place to see dinosaur trackways typical of the Northeast is at Dinosaur State Park in Rocky Hill, Connecticut. Here hundreds of footprints of the form *Eubrontes* (named by Hitchcock) make up one of the largest trackway sites in North America.

The other regional dinosaur find of great historical significance is the famous Haddonfield *Hadrosaurus*, the bones of which now reside at the Philadelphia Academy of Natural Sciences. In 1858, a lawyer and avid fossil collector named William Parker Foulke was vacationing in Haddonfield, New Jersey, when he inquired as to the source of some large fossil bones on display at the home of a local farmer named John Estaugh Hopkins. Hopkins led Foulke to an abandoned marl pit on his estate where Foulke established an excavation to

recover what remained of the skeleton. The heavily mineralized bones, including both sets of limbs, a pelvis, vertebrae, teeth, and two small jaw fragments, were then sent to the be examined by the American paleontologist Joseph Leidy in Philadelphia. Leidy recognized the skeleton to be that of an animal with teeth similar to those of the recently described English dinosaur *Iguanodon* and christened the new dinosaur *Hadrosaurus foulkii* (‘Foulke’s bulky lizard’). Even though the *Hadrosaurus* skeleton is relatively incomplete (the genus name is currently considered a “nomen dubium” because the partial skeleton lacks a skull and is too fragmentary to accurately classify), it was much more complete than *Iguanodon* or any



Edward Hitchcock, geologist and president of Amherst College in Amherst, Massachusetts, described the first dinosaur tracks in the region, although he believed them to be the footprints of a giant bird. (From “A History of Amherst College during the Administrations of its First Five Presidents,” 2nd ed., by William S. Tyler, 1895.)



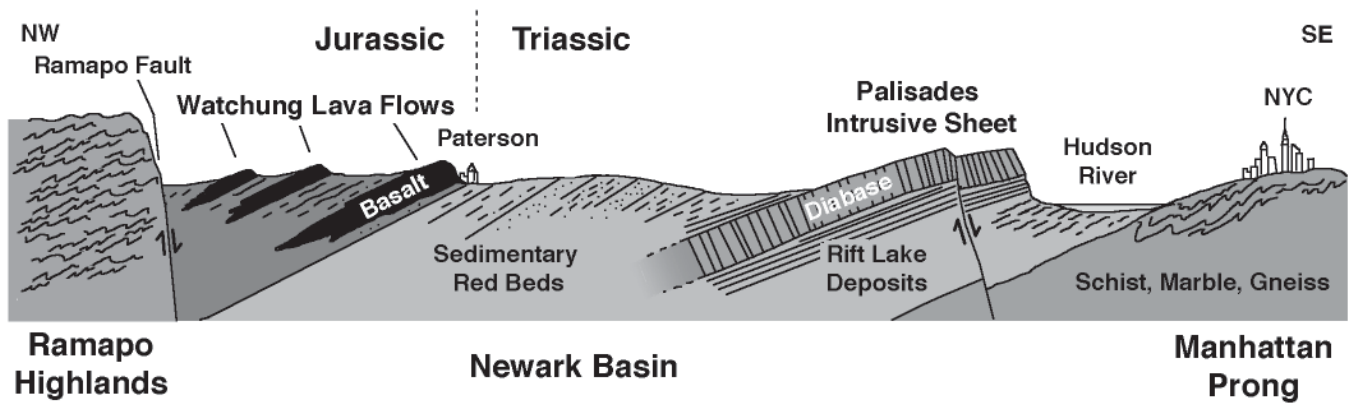
Geologic map showing extent and age of Mesozoic rock formations in the metro New York region.

other dinosaur skeleton known at the time. Most significant was Leidy's recognition that the forelimbs were significantly shorter than the hind limbs, which led him to reconstruct *Hadrosaurus* in a bipedal stance resting on its tail, somewhat like a kangaroo. The relative completeness of the fossil also led Leidy to attempt the first full mount of a dinosaur skeleton. To accomplish this, Leidy teamed up with the British sculptor Benjamin Waterhouse Hawkins, who in 1854 had created the first life-size reconstructions of dinosaurs for exhibition at the Crystal Palace in Sydenham Park, London. Waterhouse Hawkins' skeletal reconstruction of *Hadrosaurus* was a sensation that firmly established dinosaurs as bipeds in the minds of paleontologists and the public.

Dinosaurs and Plate Tectonics

Why are dinosaur fossils more common in the western regions of North America than they are in the East? For that matter, why do we have any dinosaur fossils at all in the Northeast? The simple fact is that if you want to find dinosaur fossils, you need to search in sedimentary rocks that were deposited

when dinosaurs were alive and roaming around – during the Mesozoic Era, from the Late Triassic Period to the end of Cretaceous Period. Finding rocks deposited in the correct environments is also important; most dinosaur fossils are found in terrestrial sedimentary rocks because dinosaurs inhabited terrestrial environments (marine rocks are better suited for finding the remains of marine reptiles such as ichthyosaurs, plesiosaurs, and mosasaurs). River channel and flood plain environments are particularly good for preserving skeletal remains, probably because flooding rivers were effective at both killing dinosaurs and concentrating and burying their carcasses. Dinosaur footprints and trackways are found in rocks representing a wide variety of environments, from shorelines, to lake margins, to floodplains. What controls when and where these kinds of sedimentary rocks are formed, and why should there be a discrepancy between the western and eastern regions of North America? The answer, it turns out, lies in understanding the role that plate tectonics plays in the formation of sedimentary rock, particularly in forming the thick sequences of terrestrial sandstone, siltstone, and



Geologic cross section of the Newark Basin in northern New Jersey.

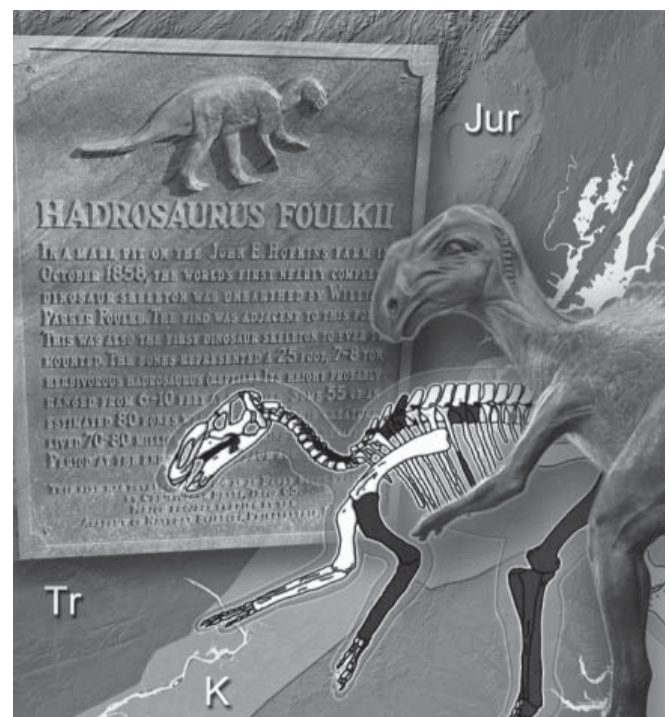
shale (detrital sedimentary rocks) that host the majority of dinosaur fossils.

To make sedimentary rocks, two things are required: a source of sediment and a depression in which to accumulate the sediment. To preserve millions of years of time and fossils in thick sequences of sedimentary rock requires making a lot of sediment and forming a depression in the crust of the Earth that continues to deepen as it is being filled. Both of these conditions are met by the uplift of large mountain ranges during plate tectonic collisions. During the Mesozoic Era, the western margin of North America was a convergent margin, meaning that the adjacent oceanic tectonic plate was advancing toward and colliding with the North American plate. As these two tectonic plates converged, the oceanic plate subducted beneath western North America. Periodically, small landmasses (microcontinents) and volcanic island chains embedded in the oceanic plate were brought into collision with western North America. These collisions pushed up mountains along the western margin of North America in a series of *orogenies* (mountain building events). As the crust on the margin of the continent was compressed and thickened during each orogeny, the growing mass of the mountain belt depressed the crust adjacent to the uplift, forming a foreland basin (imagine dropping a bowling ball on a mattress – the bowling ball forms an elevated mass on the mattress whereas the weight of the bowling ball depresses the mattress around it). Sediments eroding from the mountains were carried eastward by enormous river systems and deposited in the adjacent foreland basin, forming regionally extensive and thick sequences of detrital sedimentary rock. The dinosaurs inhabiting the forests and floodplains of these great depositional systems found themselves in the perfect set of circumstances to end up in the fossil record. On the eastern margin of North America, a comparable series of plate tectonic collisions also occurred as plate convergence closed up the ancient Iapetus Ocean. Each eastern orogeny generated massive deposits of terrestrial sediments in foreland basins from New York to Alabama. However, the orogenies

of the east occurred during the Paleozoic, much too early to fossilize dinosaurs. By the time dinosaurs evolved, orogenesis had finished in eastern North America.

The Geological Setting of Northeastern Dinosaurs

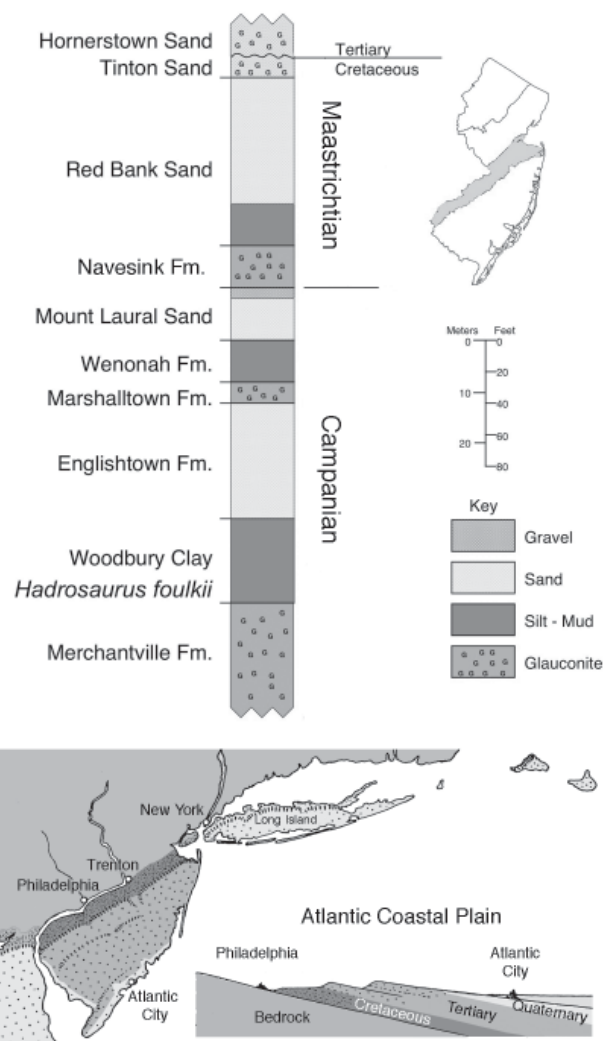
Near the end of the Triassic Period, around the time of the evolution of the first dinosaurs, the supercontinent Pangea began the slow process of breaking up, rifting along the suture formed during the collision between Africa and North America at the end of the Paleozoic Era. Plumes of hot mantle rock rising along the continental suture pushed upward on the lithosphere, extending and fracturing the



Hadrosaurus foulkii - Foulke's Bulky Lizard - is the most famous dinosaur from the New York area. See cover for full image and page 2 for photo credits.

crust. Blocks of continental rock dropped and rotated along vertical faults, forming elongated rift valleys up and down the continental margin. Like a tear propagating through fabric, the rifting commenced to the south and spread northward over time. Eruptions of basaltic lava along the main axis of rifting began laying the foundation of the incipient Atlantic Ocean basin. By the end of the Triassic, an enormous chain of rift valleys was opening up from northern Virginia, across eastern Pennsylvania, northern New Jersey, and up through central Connecticut and Massachusetts. The eroding highlands bordering the rift valleys sent pulses of sediment into the rift depressions, carried by gravity, flash floods, and braided streams. During intervals of wetter climate, large rift lakes pooled in the valleys. Dinosaurs roamed the lakeshores and floodplains, leaving their footprints in the sediments. As the rift basins filled with sediment, they continued to drop, eventually collecting several miles of stacked deposits. At the beginning of the Jurassic Period, magma found its way up through the deposits of the New Jersey rift valley, spreading out between some of the deeply buried layers as well as erupting to cover the surface in basaltic lava flows. As rifting progressed, the basin continued to subside along the bordering fault, eventually tilting the layers of sedimentary and igneous rock to the west. Erosion has cut deeply into these rift basin deposits, exposing Upper Triassic and Lower Jurassic sedimentary strata and fossils in a region of northern New Jersey known as the Newark Basin.

After the Early Jurassic, the next opportunity to fossilize dinosaurs in the Northeast came in the Late Cretaceous Period. By this time, the Atlantic Ocean basin was more than half its present width and the ocean floor crust erupting adjacent to the continental margin was close to 100 million years old. As this oceanic crust cooled, it subsided, pulling down on the margin of the continent and submerging the continental shelf. At the same time, exceptionally high global sea levels in the Late Cretaceous flooded the coastal plain as far west as the foothills of the Appalachian mountains. During this time of high sea level, a variety of Cretaceous marine sediments were deposited at different water depths and distances from the shoreline. Although dinosaurs did not inhabit the marine environments preserved in these rocks, their remains, on occasion, did end up buried offshore. Thus was the Haddonfield *Hadrosaurus* likely swept up in a flood and washed out to sea, its carcass eventually coming to rest on the seafloor in the muds that would eventually form the Woodbury Clay. Unfortunately, burial on the seafloor was a very rare event for dinosaur remains, so our record of Late Cretaceous dinosaurs in the Northeast is sparse. Besides *Hadrosaurus*, fossil collectors have happened upon the teeth, claws, and jaw fragments of a carnivorous dinosaur (possibly a tyrannosaur) named *Dryptosaurus*, as well as scattered bones, teeth, and fragments of a nodosaurid ankylosaur and an ornithomimosaur. The overall impression given by these fossils is that eastern North America hosted an assemblage of



Geologic column (top) showing Upper Cretaceous formations in New Jersey and a map (bottom) showing the extent of the Cretaceous outcrop on the Atlantic Coastal Plain.

dinosaurs in the Late Cretaceous similar to those found in the western regions.

The Big Questions – Dinosaur Dominance and Dinosaur Extinction

Although the record of dinosaurs and Mesozoic sediments in the Northeast might seem paltry in comparison to the famous dinosaur-bearing formations of the West, it is nevertheless significant to our understanding of some of the big questions in dinosaur paleontology. The reason for this is that the deposits of the Northeast just happen to span two of the most critical intervals in dinosaur history, the Triassic-Jurassic transition and the Cretaceous-Tertiary (K-T) extinction. In the Late Triassic, dinosaurs were just one of many groups of reptiles roaming the Earth in a menagerie that included other large beasts such as phytosaurs, aetosaurs, ornithosuchians, and rauisuchians. Dinosaurs were neither

the largest, nor the most ecologically dominant group. However, in the Early Jurassic, dinosaurs did become larger, more numerous, and more diverse following the extinction of most of these other reptilian groups. Exactly what happened at the beginning of the Jurassic to cede terrestrial ecosystems to the dinosaurs is difficult to study in detail owing to a lack of sedimentary sequences that preserve the Triassic-Jurassic transition. However, this time interval is recorded in detail in the Mesozoic rift basins of eastern North America, and a particularly detailed record of rocks spanning the Triassic-Jurassic boundary is found in the Newark Basin. In 2002, Paul Olsen of the Lamont-Doherty Earth Observatory of Columbia University and colleagues published a study of these rocks. They found abundant evidence for a geologically abrupt (50 Ka) extinction of Triassic reptiles and a subsequent increase in the size of dinosaur taxa based on changes in fossil footprints. Furthermore, they also located a modest iridium anomaly, as well as a spike in the abundance of fern spores, at the Triassic-Jurassic boundary. On the basis of the fossil footprint, fern, and iridium evidence, they concluded that the causes of the Triassic-Jurassic transition were similar to those of the Cretaceous-Tertiary extinction, namely impact of one or more extraterrestrial objects coupled with the environmental effects of massive volcanic eruptions.

At the other end of the reign of the dinosaurs, the sedimentary deposits of the Atlantic coastal plain preserve a record of the very end of the Mesozoic leading up to and across the Cretaceous-Tertiary (K-T) boundary. Richard Olsson and Ken Miller of Rutgers University and colleagues have located the K-T boundary in marine sediments obtained from boreholes drilled into the outer New Jersey coastal plain. Above layers of seafloor mud containing abundant Cretaceous marine microfossils, they reported finding a six-centimeter-thick layer of clay spherules that are the altered remains of glassy ejecta that rained down from the sky following the impact of a large extraterrestrial bolide, presumably in the Yucatan Peninsula. Above the spherule layer, the sediments lack most of the Cretaceous species found below and include a suite of new microfossil species characteristic of the Early Tertiary Period. Olsson *et al.* interpreted this sequence as unequivocal evidence tying a bolide impact directly to the K-T extinctions. However, they also noted the presence of small clasts of clay containing abundant Cretaceous microfossils above the spherule layer. The authors suggested that the clay clasts were eroded from below the spherule layer and emplaced above it, although they admitted that the exact mechanism of emplacement is not understood. Another intriguing possibility is that these Cretaceous clays were deposited after the bolide impact layer formed and then reworked into clasts, indicating that the K-T extinctions occurred sometime after the bolide impact in the Yucatan. Another recent body of research also argues for a gap between the terminal Cretaceous bolide impact and the K-T extinctions. Neil Landman at the American

Museum of Natural History and colleagues sampled a richly fossiliferous interval of Late Cretaceous marine sediments in Monmouth County, New Jersey, that includes the K-T boundary. What is interesting about these sediments is that they include the iridium anomaly marking the K-T boundary, but the anomaly occurs 20 cm below the changeover to Tertiary fossils, at the base of a layer rich in Cretaceous bivalves, gastropods, and ammonites. Unless the iridium fallout from the K-T bolide impact was somehow displaced downward through the sediments (a possibility the authors found unlikely), this means that a healthy Cretaceous open marine community continued to thrive on the seafloor for an unknown length of time after the impact that supposedly devastated the Cretaceous biosphere. No matter how you interpret the data, what both of these studies demonstrate is that the northeastern Atlantic Coastal Plain preserves an exceptionally good record of the K-T boundary in a variety of environmental settings. There is no doubt that these sediments will continue to provide important paleontological data for testing hypotheses about the nature and timing of events that occurred to bring the Mesozoic Era to a close 65 million years ago.

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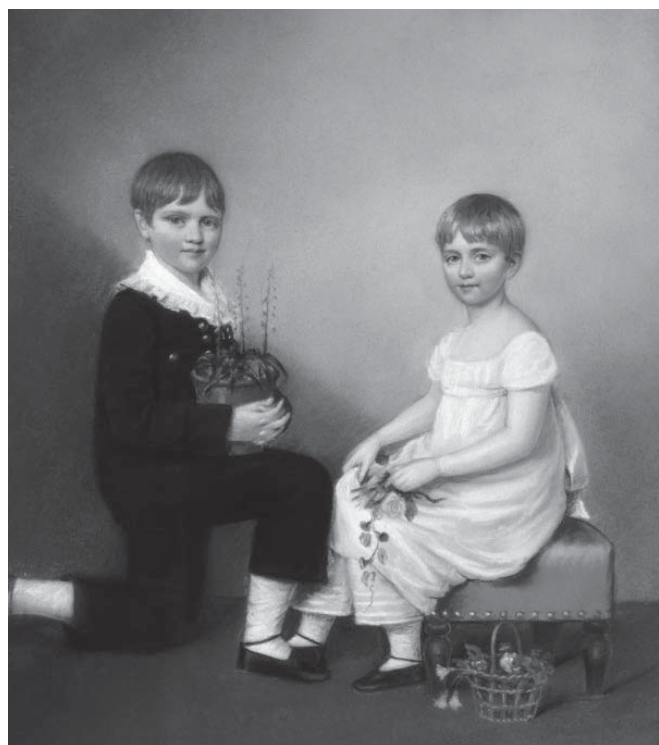
A Darwin Tourist in Shrewsbury, England, February 12, 2009

By Karl W. Flessa

Charles Darwin had his 200th birthday on February 12, 2009. Maybe that's why people usually think of him as this really old guy. After all, most of the portraits and statues depict him with his long white beard, with sunken eyes, and with the somewhat grim expression of a man in ill-health. And most of the publications by and about Darwin date from after his return from the voyage of the *Beagle* – when he was already 27 years old.

What about Darwin as a young lad?

It was Allister Rees, a paleobotanist friend now living in Shrewsbury, England, who told me that Darwin was born there. When I told my wife that Allister had mentioned that Darwin had been born in Shrewsbury, she suggested, half-seriously, “Oh, you should go to the birthday party!” A bit to her surprise, I checked and saw that I had an excess of frequent-flyer miles – more than enough for a mid-winter trip from Tucson to Heathrow. Nobody – not my seatmates on the flight, not the U.S. immigration officials, not the U.K. immigration officials, not the B&B hostess – nobody quite believed that I was making the trip to go to Darwin's birthday party.



Charles Darwin (aged six) and [his sister] Catherine by Sharples, ca. 1816. ©English Heritage Photo Library. Used with permission.

I wanted to get a sense of Charles Darwin as a boy. Was there something about his home town of Shrewsbury or something about his upbringing that destined him for greatness?

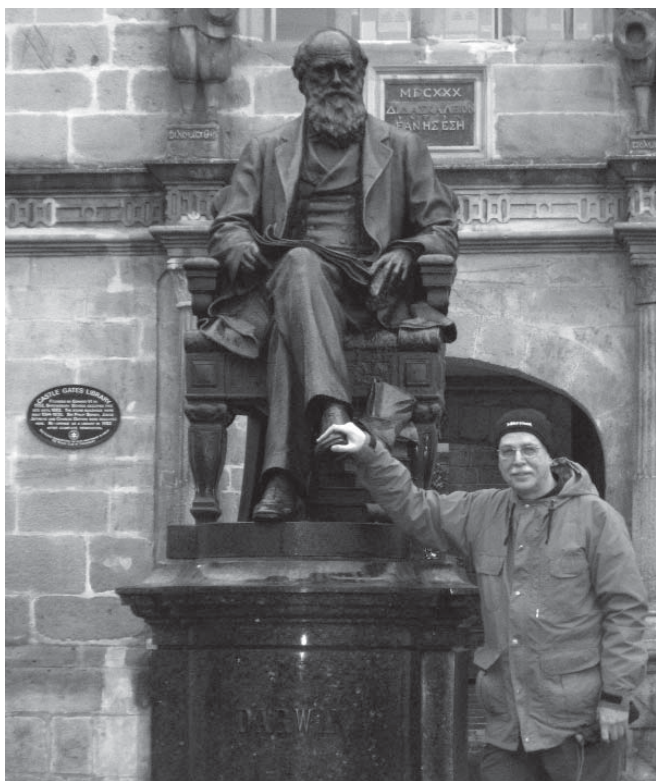
Shrewsbury, a pretty and very old town of about 100,000 in the West Midlands, is known for, well ... being a pretty and very old town of about 100,000 in the West Midlands. It has a castle, an abbey, picturesque timber-framed buildings, and lots of very friendly folk. Indeed, Shrewsbury might be more famous for the fictional Brother Cadfael, the 12th century Welsh monk and detective, than it is for its real 19th century scientific hero. The fact that Charles Darwin was born there doesn't yet figure very much in the tourist brochures. But some people are working on that, and Charlie's 200th birthday was a big boost for the Darwin industry in Shrewsbury.

I met up with Allister in Shrewsbury on Darwin's Eve to join in the first of the festivities, a lecture at the Shropshire Geological Society by Professor David Siveter on extraordinarily preserved fossils. The room was packed – a sign of good things to come. And after a celebratory pint afterwards to fight off the jet lag, it was time to rest up for the big day.

What better way to start the birthday than by visiting The Mount, the house where he was born. His father, Robert Darwin, a very successful doctor, had married into the very wealthy Wedgewood (as in china) family. He built the house about 1800. The building is now the town tax assessor's office. Although it's not exactly open for public tours, a ring of the front doorbell followed by a sheepish request to look around got us up the stairs to the room where he was born (it says so right there on the door). The room itself is empty – nobody has their office there. We looked at the room where he lived in as a boy, and we signed the guest book. We were the first to sign in on his birthday.

Celebrations back in town kicked off in front of what is now the town library. In Darwin's day, it housed the Shrewsbury School, where young Charles neither impressed his teachers nor enjoyed his studies. He wrote in his autobiography, “Nothing could have been worse for the development of my mind than Dr. Butler's school.” His statue, as an old man in a chair, surrounded by books, has his back to his old school – a symbol of his feelings toward it, some say.

Turns out that it's not the only Darwin statue in town. Across the river and up the hill, and in front of the present-day Shrewsbury School, is a most unusual statue of Charles Darwin. He's a much younger man, shown as a vigorous explorer in the Galápagos, striding across the lava, stepping



A statue of the old guy, at the original Shrewsbury School (now the town library), with the author at his feet. Photograph by Allister Rees.



A younger Darwin as the Galápagos explorer, in front of modern-day Shrewsbury School. Photograph by Karl Flessa.

around iguanas and scattering one of his famous finches before him. I don't know if the statue inspires the current generation of students at the Shrewsbury School, but it's a useful reminder that even Charles Darwin was young once.

On display back in town – on their first day of issue – were the spectacular Darwin stamps: six vividly colored stamps, with the old Darwin on the first class stamp, with images on the five others illustrating his contributions to anthropology, botany, geology, zoology and ornithology. The stamps link up through a clever jigsaw design, illustrating Darwin's immense skill at connecting disparate bits of evidence in support of his theories. The Royal Mail really knows how to do these things. Darwin has been on the ten pound currency note since the year 2000. You can also get a commemorative £2 coin from the Royal Mint. Imagine, if you can, such a thing in the U.S.A.

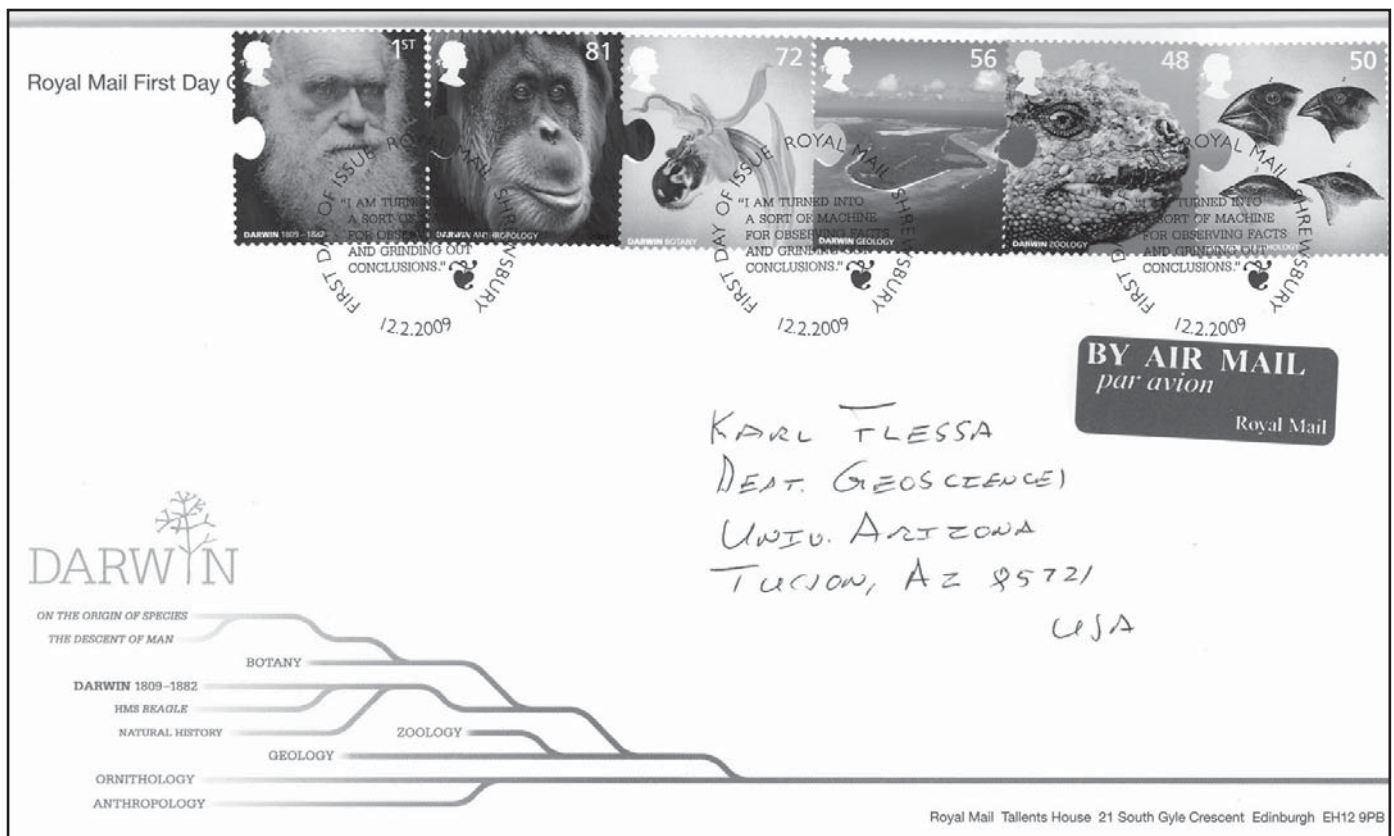
The mayor and the postmaster then unveiled one of the plaques in the pavement that mark Shrewsbury's new walking tour for Darwin aficionados. The walking tour took us past two churches important in Darwin's life. He was baptized at St. Chad's, of the establishment Church of England, but worshipped at the Unitarian Church with his mother and his siblings. His baptism in the C of E was important – without it, he would not be able to attend university, hold public office, or take part in many aspects of English society. And he did, after all, attend the University of Cambridge for a degree in

theology so that he could have a respectable profession as an Anglican parson. He had washed out of his medical training at the University of Edinburgh, and his father had despaired of young Charles ever amounting to anything, telling his 19-year old son, "You care for nothing but shooting, dogs and rat-catching, and you will be a disgrace to yourself and all your family."

The Unitarian Church was the traditional church of the Darwin and Wedgwood families. A "Happy Birthday" banner on the door marked the occasion and a plaque inside noted his constant worship there as a youth. Charles' record as a practicing Unitarian was not seen as an impediment to a planned career in the Anglican Church. This despite his grandfather Erasmus' comment that Unitarian beliefs were merely "a featherbed to catch a falling Christian." Erasmus was a freethinker.

The Lion Hotel was also on the Darwin trail. It was from there that Charles caught the coach to meet with Captain Fitzroy of the HMS *Beagle*. Darwin also slept there upon his return from the five-year voyage. He had arrived too late to return home that night, but surprised his family at breakfast the next morning. We couldn't figure out which room he had slept in, but we did have a pint in his honor in the hotel's pub.

At noon on Darwin Day – and on every Darwin Day since 2003 – a toast is offered in Charles' honor in a small



Darwin commemorative stamps, postmarked on the first day of issue, Shrewsbury, England, February 12, 2009.

courtyard near the center of town. Jon King, the organizer of the town's Darwin-lollapalooza, read the famous last paragraph from *The Origin* – “There is a grandeur in this view of life, with its several powers, having been originally breathed into a few forms or one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.” – and we raised our champagne glasses and cheered.

Despite all the ceremonies, the town didn't seem fully ready for the advent of serious Darwin tourism. I bought the very last Darwin refrigerator magnet at the Tourist Information Centre and it was only ten o'clock in the morning! Tea towels, coasters, shopping bags, and bottle openers were in good supply, but, alas, there was only one variety of Darwin postcard available.

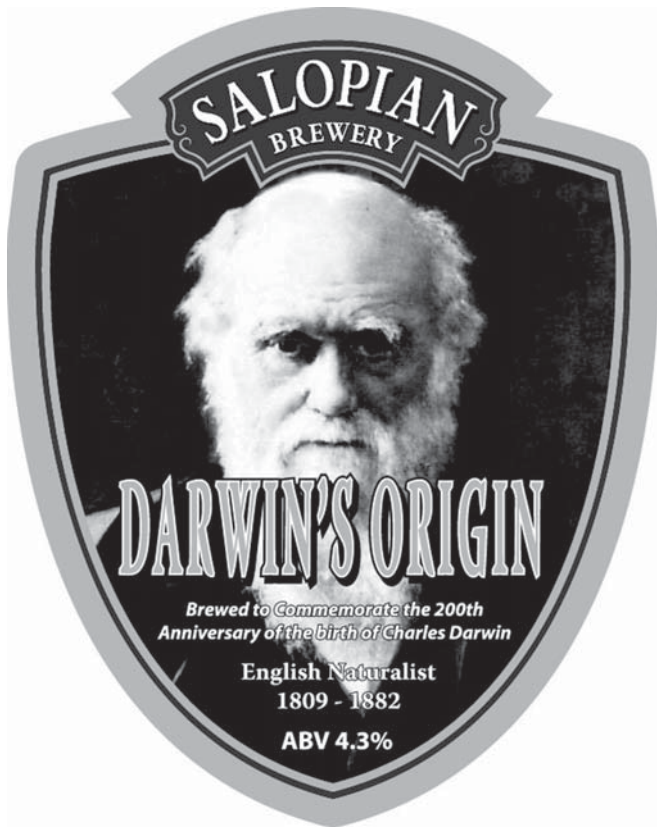
But this is not to say that commercialism was nowhere to be seen. We delighted in sampling “Darwin's Origin,” the special ale prepared by the nearby Salopian Brewery. As the back of the bottle notes, among other things, “Darwin's Origin has been brewed to commemorate the birth of one of Shrewsbury's most famous sons ... Darwin went on to become one of the most influential naturalists with his publication of *On the Origin of Species* in 1859. His work still influences society today.” “Always drink responsibly.”

Darwin on a beer bottle – for those of us who want to get the message of evolution out to the general public, that's just brilliant product placement!

Shrewsbury's downtown, indoor shopping mall is the Darwin Centre. The mall directory lists a shop called “Evolution,” but when I got there it was an empty storefront. Evolution, another victim of the recession.

What's a birthday without a birthday cake? At two o'clock in the town square, hundreds gathered – with kids at the front – for a piece of the two-hundred-candle cake. The fire department was on hand to light the cake and the town crier led a rousing rendition of “Happy Birthday” to Charlie, Shrewsbury's most famous son.

So, what did I learn about Darwin as a lad? He was decidedly normal: went to church with his mum, underachiever in the classroom, eager to explore his surroundings, unsure about what to do with his life, and a constant source of worry to his father. Normal, decidedly normal. So for those who would look to his childhood surroundings for a clue to his later greatness, I don't think it's there. For those who would look to his upbringing for a clue to his later greatness, I think the only thing there is that his family was wealthy enough and patient enough to allow him to become a late bloomer. And that might be the most important lesson of Shrewsbury. Not that we could all achieve what Darwin did



"Darwin's Origin," an ale produced for Charles Darwin's 200th birthday by Salopian Brewery, brewers of the "Finest quality ale from the heart of Shropshire." See <http://www.salopianbrewery.co.uk>.

if we were given the right opportunities, but that even great genius requires those opportunities.

So, the next time that you're visiting the United Kingdom and on Darwin's trail, don't just do the usual stuff: The Natural History Museum, his rooms at Cambridge, Down House, his grave at Westminster Abbey. Complete the tour; visit Shrewsbury. You've missed the big birthday party, but you can always celebrate by walking in the lad's footsteps.



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Did you know??

Another commemorative beer was issued in May 2009! **Shale Ale** was unveiled by Big Rock Brewery of Alberta, Canada, in recognition of the 100th anniversary of the discovery of the Burgess Shale, British Columbia's 500-million-year-old fossil site. Featured on the label are crablike *Canadaspis*, freakish *Hallucigenia* (the 14-legged, spiky-backed worm named for its bizarre, dreamlike features), and *Anomalocaris canadensis* (the meter-long, trilobite-predator of Cambrian-age Canada).

Cheers and à votre santé !



Charlie's birthday cake, with eager party-goers from his birthplace. Photograph by Allister Rees.

Fossils, Sites, and Changing Stratigraphy

By John A. Catalani

Many of us amateurs are a bit like the Roman god Janus – there are two sides to our collecting persona. We are both set in our ways and always looking for new stuff, particularly fossils and collecting sites. The localities that provide us with our fossil specimens are the ones that we continue to frequent for years (decades for some of us) even when they are past their prime. If these sites are, for whatever reason, no longer available, it is as if we have lost a best friend. However, we are also on the lookout for new sites, but unfortunately these new localities are often not as productive or as cherished as our originals – we are comfortable with that with which we are familiar. The same can be said of the taxonomic names of our fossils as well as the stratigraphy of the rocks containing them. For example, the name of a well-known Galena Group (Ordovician, see below) index fossil, *Receptaculites oweni*, was changed many years ago. Most of us, however, still use the old genus name, *Receptaculites*, instead of the new one, *Fisherites* – we are comfortable with it and know exactly what part of the Ordovician someone is referring to when that name is mentioned. Additionally, it seems that when a taxonomic name is changed it is the genus (the "first name" of the two-part taxonomic name) not the species name that is altered. That is understandable because a species is a natural unit of taxonomy and the genus is our assessment of the placement of several species. Unfortunately, as seen from the example above, we usually refer to a particular fossil only by the generic name for the sake of brevity. Fortunately for me, so few paleontologists are involved with nautiloids that taxonomic names are seldom changed. Even the monumental works by August Foerste published in the early 20th century remain valuable because the taxonomic names that he proposed are still valid.

Similarly, in past years the classification and assignment of Ordovician stratigraphic units (or layers) has undergone a drastic change culminating in the Global Ordovician Chronostratigraphic Chart. In addition to the establishment of the global stages (names, boundary definitions, and type sections), many other units were reassigned and/or renamed, thus altering how we subdivide the Ordovician. Although I am aware of modification of units in other geologic time periods, I cannot think of another time period that has undergone such drastic changes (but then again, I am a bit myopic when it comes to geologic periods). Clearly, any changes in Ordovician units are of importance to me because my main interest is the molluscan faunas, specifically the nautiloids, contained in the Ordovician Platteville Group rocks of the Midwest. Fortunately, the actual names of the

rock units (such as formations and members) seldom change. What does change is how these rock units fit into the overall picture of regional and global time scales. One problem that the amateur encounters is that during the modification process and for a time after the new system is approved, professionals are often inconsistent in terminology usage. I addressed this issue in a previous essay (*AP* 11(3), 2003) when I mentioned that several rock stratigraphic units were assigned to two different Series designations of the Ordovician and that both usages appeared in various papers included in the same "edited" volume. Therefore, I have been made aware that some amateurs are confused and apprehensive about this new stratigraphic nomenclature and question what, if any, effect the changes have had on their collections and collecting localities. Because most amateurs are not "in the loop" when it comes to the reasons and evidence used to determine the new stratigraphic assignments, these concerns are understandable.

As one might expect, the process of determining these new Ordovician stratigraphic designations and names was long and argumentative. Essentially two factors needed to be agreed upon by the International Subcommission on Ordovician Stratigraphy (ISOS) for each Global Stage – a type locality and stage boundaries. Type localities must show boundaries clearly and be accessible to future researchers. The lower boundary of each Stage is usually determined by the first appearance (termed First Appearance Datum or FAD) of a particular graptolite or conodont because these fossils are abundant and have worldwide distribution. This boundary is referred to as a Global Stratotype Section and Point (GSSP), more popularly known as a "golden spike." Not all researchers are comfortable with the "golden spike" concept and many would prefer a paleobiological event ("golden event") or a more flexible boundary to accommodate the acquisition of new data that could result from continued field work, a concept that I have for years termed a "golden bracket." In addition, dependable absolute ages are helpful in determining boundaries at all stratigraphic levels. Unfortunately, rocks that contain the appropriate isotopes needed to determine absolute ages are not always present in boundary rocks, hence the use of fossils. Also, absolute ages are often fraught with uncertainty although with new and refined techniques our resolution of these time boundaries has, and is, improving greatly.

One of the most helpful techniques in resolving the problems of determining absolute ages and correlations, at least in the Ordovician of eastern North America, was the use

FOSSIL STUFF

VOLUME 13
NUMBER 2

A NEWSLETTER FOR KIDS FROM
THE MUSEUM OF THE EARTH

SUMMER 2009

CREATED BY SAMANTHA SANDS, DIRECTOR OF PUBLIC PROGRAMS

A New York State of Mind

Do you remember your state's tree or maybe the state bird? What about the state fossil? This issue of *Fossil Stuff* will explore New York's state gem and state fossil as well as its unofficial state dinosaur!

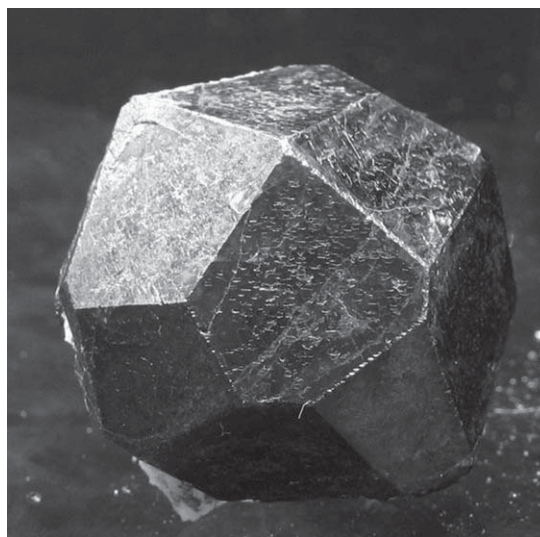


Photo by Kluka, via Wikimedia Commons.

New York's State Gem – The Garnet

In 1969, the garnet was adopted as the New York State Gem. Garnet is a dark-red mineral commonly used in jewelry and as an industrial abrasive. The Adirondack Mountains are home to these beautiful garnets. The Adirondack Mountains are young, only beginning to rise a few million years ago, but the metamorphic rocks that make up these mountains are over 1 billion years old. The beautiful garnet crystals are a result of millions of years of *metamorphism* – a process that changes the original rocks and minerals into new rocks and minerals through high temperatures and pressures. Barton Mines in North River, NY, which you can tour, is one of the foremost garnet mines in the world!

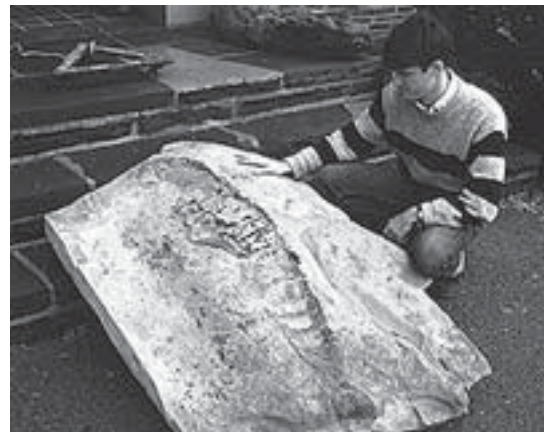
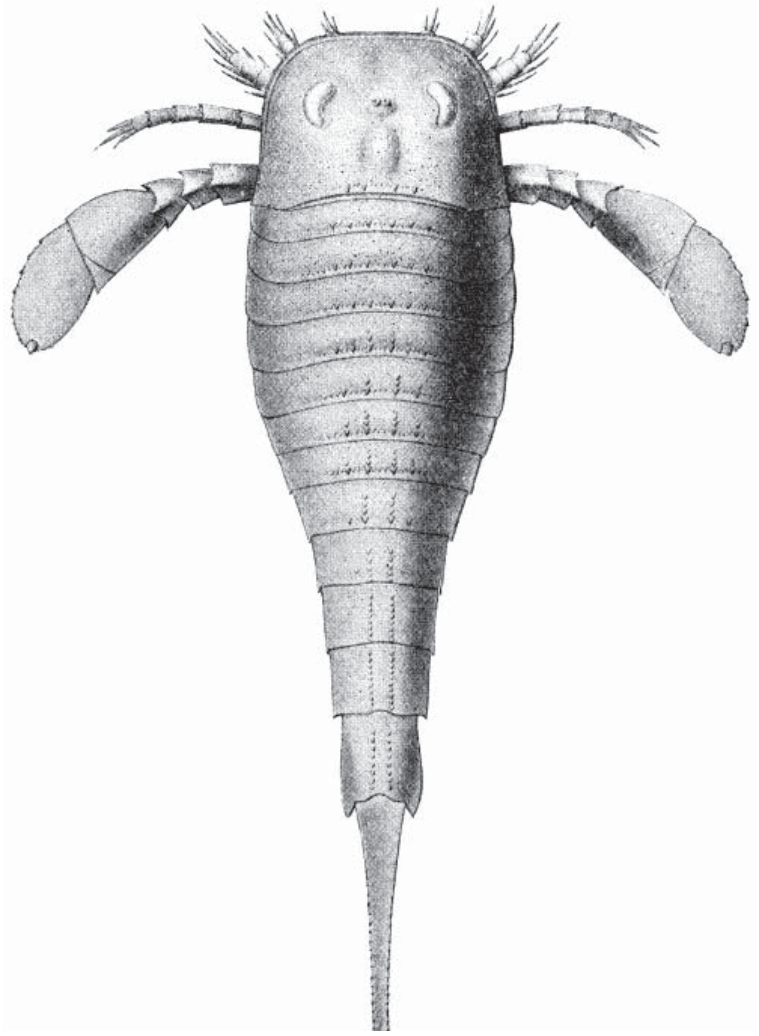
New York State Fossil – Eurypterid

Eurypterus remipes became the official state fossil of New York in 1984. Eurypterids (pronounced *yoo-rip-tuh-ridz*) or “sea scorpions” lived in New York when it was under the sea during the Silurian Period, 420 million years ago. They are called sea scorpions because each has a long spike at the end of its tail like a scorpion, but they are really more closely related to horseshoe crabs. Eurypterids are arthropods – invertebrates with an exoskeleton, segmented body, and jointed legs. Some eurypterids grew to over 8 feet (2½ meters) in length – as big as a crocodile! – making them the largest arthropods that ever lived!

During the Silurian Period, much of New York was covered by an ancient sea. Eurypterids roamed the muddy sea floor hunting for their favorite prey, such as trilobites and ammonites. They had large claws or pincers for grasping food.

The first eurypterid was discovered in New York in 1818. Some of the best eurypterid fossils in the world are found in the Bertie Dolostone that runs through central and western New York.

Museum of the Earth has some excellent eurypterids on display including one of the largest and most complete eurypterids found in New York. This slab with a specimen of *Pterygotus macrophthalmus* (seen in this photograph with Director Warren Allmon) was collected in 1965 in Herkimer County.



***Coelophysis* – New York’s Unofficial Dinosaur**

New York is full of many excellent fossils, but unfortunately not many of them are dinosaur fossils. The only New York dinosaur fossils that have been so far discovered were found in 1972 by two paleontologists, Paul Olsen and Robert Salvia. Camouflaged in the red mudstones and sandstones of Nyack, NY, were dinosaur footprints! Paleontologists dated the rocks to be Late Triassic in age (about 215 million years old) and the tracks were identified as perhaps those of the dinosaur *Coelophysis*.

Coelophysis is a Late Triassic dinosaur first discovered by the famous American paleontologist Edward Drinker Cope in 1887. The name *Coelophysis* means “hollow form” and much is known about this dinosaur because many complete skeletons were discovered at Ghost Ranch, New Mexico, in 1947.

There are several clues that led paleontologists to identify the New York tracks as *Coelophysis*. First the tracks have three clawed toes, indicating that they are the tracks of theropod (meat-eating) dinosaurs. Also the tracks were dated to be from the Late Triassic Period and are approximately 15 centimeters in length. *Coelophysis* is a Late Triassic theropod dinosaur with feet that are approximately 15 centimeters long!

When you next visit the Museum of the Earth, make sure that you take your picture with the *Coelophysis* sculpture in front of the Museum. And stop by Dino Lab in the Museum to see one of the actual *Coelophysis* tracks discovered in Nyack, NY. The footprint tracing on this page is the actual size and shape of a *Coelophysis* footprint.



New York Fossils Fill-in-the-Blank

Use the information in this issue of *Fossil Stuff* to fill in the blanks in the sentences below.

1. The state fossil of New York is _____.
2. Dinosaur footprints were first discovered in _____, NY.
3. The _____ is the New York state gem.
4. Eurypterids lived in New York during the _____ Period.
5. Garnets are mined in the _____ Mountains of New York.
6. _____ is the dinosaur that left its footprints in New York.
7. The first eurypterid specimen was discovered in New York in the year _____.
8. The Adirondack Mountains are composed of _____ rocks that are over one billion years old.
9. New York's dinosaur fossils are from the Late _____ Period.
10. The name *Coelophysis* means "_____."

BONUS: The name of Museum of the Earth's *Coelophysis* dinosaur mascot is _____.



Answers: 1. *Eurypterus remipes*; 2. Nyack; 3. garnet; 4. Silurian; 5. Adirondack; 6. *Coelophysis*; 7. 1818; 8. metamorphic; 9. Triassic; 10. hollow form; BONUS: Cecil.

FOSSILS !!

of K-bentonites. K-bentonites are volcanic ashes that have been altered into potassium-rich clay beds and represent a specific time horizon in the strata ("isochronous" in paleo-speak). There are 60+ bentonite beds in the North American Ordovician. They can be correlated regionally using chemical fingerprinting in which the percent elemental composition of target bentonites is compared (there have even been attempts to correlate several globally). In this way, a bentonite in, say, Minnesota (Deicke) can be correlated with one in Tennessee (T-3). Additionally, these volcanic ash beds can be radiometrically dated fairly precisely using uranium/lead or argon-40/argon-39 isotope ratios. These isochronous markers can also be used to define higher order stratigraphic boundaries particularly when, as with the Deicke, the bentonites are associated with a significant extinction. Given their versatility, it is no wonder why K-bentonite beds are often used as boundaries between stratigraphic units. For example, the Millbrig K-bentonite is the boundary between the Turinian and Chatfieldian stages. Because, in my opinion, the Deicke K-bentonite is easier to identify in the field, I would have preferred the Deicke to have served as this boundary.

What, then, does all of this mean to the amateur community? I'll address that in a bit but first a little background. As I stated above, the Ordovician stratigraphic terminology and designations underwent a series of changes over many years at the regional as well as the global level as the resolution of our stratigraphic assessments improved. I will briefly illustrate using the two major Ordovician rock units that are "exposed" in my collecting area – the Upper Mississippi Valley region from north-central Illinois through southwestern Wisconsin into southeastern Minnesota up to the Twin Cities. I say "exposed" because here in the Midwest, bedrock is covered by those annoying glacial deposits and viable exposed sections are almost always limited to active

quarries or, to a lesser degree, road cuts. Therefore, access to new material for collecting is often at the mercy of the vagaries of quarry owners, the economy, and government safety organizations – but that is another story.

Let me begin by going back in time to my early collecting days. In the stratigraphic system used at that time, the early and middle 1970s, the midwestern Ordovician was divided into three clearly defined Series based, of course, on the best

information available at that time, including fossils and rock correlations. The lowest (oldest) of these Series was termed the Canadian. In my earlier essay referenced above, I wrote on the attempt of several famous geologists to make the Canadian a System equal in rank to the Ordovician. The Canadian is exposed in the limestones and cherts of Minnesota, Wisconsin, and Missouri. The fossils contained in these rocks are more similar to those of the Cambrian than to those found in rocks of the rest of the Ordovician, at least for the nautiloids. This is what prompted the late Rousseau Flower, at that time the foremost authority on nautiloids, to begin using "Canadian" unofficially as a System in many of his publications. The upper (youngest) Series was termed the Cincinnati and the rocks contained in this series were, and still are, exposed in possibly the most prolific collecting area in the United States – the tri-state region of Indiana, Kentucky, and Ohio. Literally millions of fossils have been collected

ORDOVICIAN							GLOBAL	UNITED KINGDOM	NORTH AMERICA						
SYSTEM		SERIES		STAGE		SERIES		STAGE		SERIES		STAGE			
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Part of the Global Ordovician Chronostratigraphic Chart. Excerpted and reproduced with permission from Stig Bergstrom.

there and virtually every new excavation exposes these highly fossiliferous shales and limestones.

It was the Middle Ordovician, the Champlainian Series, that contained the rocks from which I obtained my nautiloids. In my collecting area, two fairly fossiliferous groups of rocks are exposed – the lower Platteville Group (a formation in Wisconsin and Minnesota) and the upper Galena Group. At that time, the Platteville was assigned to the upper part of the Blackriveran Stage whereas the Galena comprised pretty

“Each site is a small peep-hole allowing us to view a tiny segment of the total fauna...”

much the entire Trentonian Stage, and both were tentatively placed in the lower Caradoc of British usage. Both units are composed primarily of carbonates even though Galena rocks are generally more pure with less clay. Although the Platteville is generally more fossiliferous both in numbers and diversity, both units contain an abundant and diverse molluscan fauna (as well as trilobites, echinoderms, brachiopods, etc.). The taxa present in the rocks of these units are similar but not the same due to the Deicke extinction that occurred at the interface of deposition. Even in those early years, before any of the recent research, I noted obvious differences between the taxa of the two units – they can both contain nautiloids but there were very few genera in common.

Then in the mid-1980s, I became aware, by way of the academic literature and several fieldtrip guidebooks, of a subtle reassignment of several units of the Galena Group. The upper Galena, including the very fossiliferous Wise Lake Formation and the Dubuque Formation, was now being correlated with the Edenian-Maysvillian units of the type Cincinnati area. The lower Galena was still placed in the Champlainian Series. That meant that the Champlainian-Cincinnati contact occurred in the middle of the Galena Group. I had collected the fossiliferous Wise Lake Formation many times (one quarry exposing this unit was located less than a mile from my parents' house) searching for the nautiloids that represented the subsequent fauna after the deposition of Platteville rocks and, as I became aware of later, the Deicke extinction. Curiously, the trilobites that I had collected in the Wise Lake seemed very similar to those that I had found in the type Cincinnati and one of them was of a common genus – *Flexicalymene*. After much subsequent collecting, I found that several of the Wise Lake nautiloids also compared well with those in the Cincinnati, although nautiloid fossils were nowhere near as common in either unit when compared to the mighty Platteville Group. I remember wondering back then if the carbonates of the Wise Lake were somehow equivalent to the shales of the Cincinnati Series – silly thought, I concluded.

By the mid-1990s the British Ordovician had been revised from six Series designations to five and the North American Ordovician was modified, along with many name changes, into four Series – Ibexian (oldest), Whiterockian, Mohawkian (Platteville, etc.), and Cincinnati (this name

will probably never change). The Mohawkian was in turn subdivided into five or so Stages and Substages, which finally confused even an Ordovician geek like me. Fortunately, cooler heads prevailed and, with the use of the K-bentonites described above, the Mohawkian Series was re-evaluated and subdivided into only two Stages. The lower (older) Turinian Stage contains all of the Platteville rocks as well as the lower Decorah Shale whereas the upper Chatfieldian Stage contains the lower Galena (the upper Galena is still assigned to the Cincinnati Series). The Mohawkian was correlated with the lower part of the British Caradoc Series and was still considered “Middle” Ordovician.

The late 1990s and early 2000s saw both the push for Global Stages to correlate the various local and regional Ordovician units worldwide and the final (for now?) reassignments of the North American Series and Stages (see Global Ordovician Chronostratigraphic Chart). The Mohawkian is now part of an expanded Upper Ordovician and is correlated with the middle (more-or-less) of the British Caradoc Series. I mentioned in passing the new Ordovician Global Stages in a recent essay (*AP* 16(2), 2008) that described the incredible increase in taxonomic diversity that occurred during the Great Ordovician Biodiversification

Each suite of sites is a window showing us a more complete view...

Event (GOBE). As type sections and boundaries were chosen and accepted, the Global Stages were gradually approved by the ISOS. The final result was an Ordovician Correlation Chart that consisted of seven Global Stages. The Turinian (Platteville) is placed in the upper Sandbian Global Stage (fifth Stage from the bottom) whereas the Chatfieldian (lower Galena) and the type-Cincinnati are part of the Katian Global Stage (sixth Stage). Each of these Global Stages are subdivided into between two and four Stage Slices (total of 20) that are informal designations but with defined bases, again determined by graptolite or conodont fossils.

So, finally, what does the revised stratigraphy do for the average amateur and should one be apprehensive of the new stratigraphic designations? As you can see from the above discussion, the constantly changing stratigraphic nomenclature could easily confuse anyone not involved in the reassignment process itself and I can understand the apprehension felt by many amateur collectors. I always begin the calming process by reminding anyone that will listen (not many, I admit) that, no matter what regional or continental or global categories the rock units that we collect

are placed in, the names of these rock units more often than not remain the same. Rock-stratigraphic names (formations and members) are very seldom changed because this would indeed cause confusion and limit our ability to assimilate historical collections into modern databases with the resolution that we have come to expect and would also make any attempt at correlation difficult at best. I encountered such difficulties when I was researching published Ordovician nautiloid species. The stratigraphic units used in some very old publications were given vague names such as “Lower Buff Limestone” or “Upper Blue Limestone,” making correlation with the formations and members that I was using practically impossible. Additionally, higher level stratigraphic units have virtually no effect on our collections. Whether my nautiloids are Middle or Late Ordovician in age, whether the rocks belong to the Champlainian or Mohawkian Series or the Blackriveran or Turinian Stage, the animals still lived and fossilized so that an obsessed old collector millions of years later could assemble a suite of fossils that is testament to the enormous diversity of not only the nautiloids but the entire Ordovician fauna.

More important to our collections is complete documentation of both specimens and localities, as I have preached many times in these essays. And, lest we forget (and I’m here to make sure we don’t), new data is still acquired the old fashioned way – aggressive fossil collecting and committed stratigraphic investigations carried out in the field. There are many examples of the benefits of relentless field work such as the exposure of new stratigraphic horizons at old collecting sites, the discovery of new localities, and, of course, a more complete representation of the fauna. One quarry that I had been collecting regularly since early 1978, and continued to visit even when it ceased operation, exposed only the lower of the two Platteville formations that I collect. Then, in the late 1990s, a new company took over and expanded the quarry uphill and up-section. Even though I was not allowed access, I could see from the road that they had reached the upper Platteville formation – needless to say, I was intrigued. Several years later the quarry was once again abandoned and the new land owner gave permission to collect. Not only had that upper formation been exposed, but also the new section was in the rarely-exposed lower member of that upper formation. I and a friend have been hand-quarrying that site

...and combining a global set of sites lets us view the fauna through a picture window.”

ever since and have found that the rocks contain an abundant and diverse molluscan assemblage that has provided me with additional information on the Ordovician nautiloids. This past year in another quarry that has been in continuous operation since I first visited it in 1973, I found for the first time a rare conularid – one never knows what one will uncover. Finally, there is the ultimate discovery – a dream site that, because of the diversity and superb preservation, can only be referred to as a *lagerstätte* (“mother load” of fossils). I found such a deposit in late 1990 in a quarry that exposed the lower Platteville formation but in a limestone facies instead of the normal dolostone-type of rocks. Even without the soft-bodied fossils normally associated with a *lagerstätte*, the enormous taxonomic diversity along with the very uncommon preservation of outer shells, complete with ornamentation, made this site remarkable. I wrote recently on the clams and snails of this deposit (*AP* 15(3), 2007). This special window into Ordovician life has produced, so far, a total of 128 species in 102 genera representing 9 phyla with mollusks accounting for almost 70% of the species.

The new Ordovician stratigraphic chart allows systematic collections of fossils amassed by many of us serious amateurs to be placed in a global context. Now, realistically, this is not a great concern to many collectors. Some view it as merely an interesting aspect of academic paleontology that does not directly affect them. This might be so, but for serious amateurs, the ability to view their fossils in a global context adds a new dimension to their collecting activities. Remember, any fossil assemblage contained in a particular set of rocks represents just a small part of the entire fauna that was present during a particular time period such as the Ordovician. Each site is a small peep-hole allowing us to view a tiny segment of the total fauna. Each suite of sites is a window showing us a more complete view, and combining a global set of sites lets us view the fauna through a picture window. Consistent stratigraphic nomenclature is the only way that this view can be obtained, and now with a global stratigraphic scale we have the ability to correlate rock units and fossil assemblages worldwide. The result, hopefully, will be a set of enhanced databases that can facilitate population analyses, which have the ability to reveal subtle factors of a fauna such as sexual dimorphism or the possibility of hybridization. In my research, I have used 31 sites that expose Platteville Group rocks, 15 of which I consider prime collecting sites that have added significantly to my evaluation of the Platteville nautiloid fauna. Dedicated field work is a laborious but incredibly rewarding endeavor that can result in significant contributions to the picture that we have of a local or regional fauna. Now, with the finalization of the Ordovician Global Correlation Chart, these contributions can be placed in a global context that can potentially allow us to view the Ordovician radiation (GOBE) in unprecedented detail. We should not be afraid of changes in the stratigraphic units of a particular geologic period. We should embrace them as proof that our science is

not a stagnant one but a viable, always improving assessment of the evolution of life on Earth.

Further Reading

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- Walsh, Stephen L., Felix M. Gradstein, & Jim G. Ogg. 2004. History, philosophy, and application of the Global Stratotype Section and Point (GSSP). *Lethaia*, 37: 201-218.
- Webby, B. D., F. Paris, M. L. Droser, & I. G. Percival, eds. 2004. *The Great Ordovician Biodiversification Event*. Columbia University Press, New York, 484 pp.



John Catalani is retired from teaching science at South High School in Downers Grove, Illinois. His column is a regular feature of American Paleontologist. Email fossilnautiloid@aol.com.



Our Favorites on the Web

The portal **Geoscience e-Journals** after only 3 years in existence now includes more than 50 open-access publications in the several fields of the Earth Sciences (geochemistry, geophysics, paleontology, regional geology, stratigraphy, geography, etc.). This is a very convenient bundle of free online literature! See <http://paleopolis.rediris.es/geosciences>.

In these days of rapid global climate change, it's important for everyone to be as efficiently green as possible! **Energyhog.org** is hosted by the Alliance to Save Energy. It features a floorplan of a typical home upon which you can see where and what consumes the most energy. Clicking on those items then shows you how to reduce energy consumption. There's also a section designed especially for kids! See <http://energyhog.org>.

The American Museum of Natural History has a nice website called **Resources for Learning**, designed for teachers. Among the topics is Paleontology, which leads you to a series of lists of useful links and downloadable pdfs, sorted by age groups. One example is an activity called The Relative Speed of Dinosaurs, for Middle School and up. See <http://www.amnh.org/education/resources/index.php>.

Cheesy graphics aside, **NOVA's Science Now** has a cool video online from 2006 on the Permian mass extinction that not only relates it to global warming but also incorporates data from the Green Lakes just south of Syra-

cuse, New York. See <http://www.pbs.org/wgbh/nova/sciencenow/3318/01.html>.

Don Kenney's Fossil Site List has over 13,000 fossil localities in the United States and Canada, see <http://donaldkenney.110mb.com/#PALEO>. The data for New York State are at <http://donaldkenney.110mb.com/STATES/NY.HTM>.

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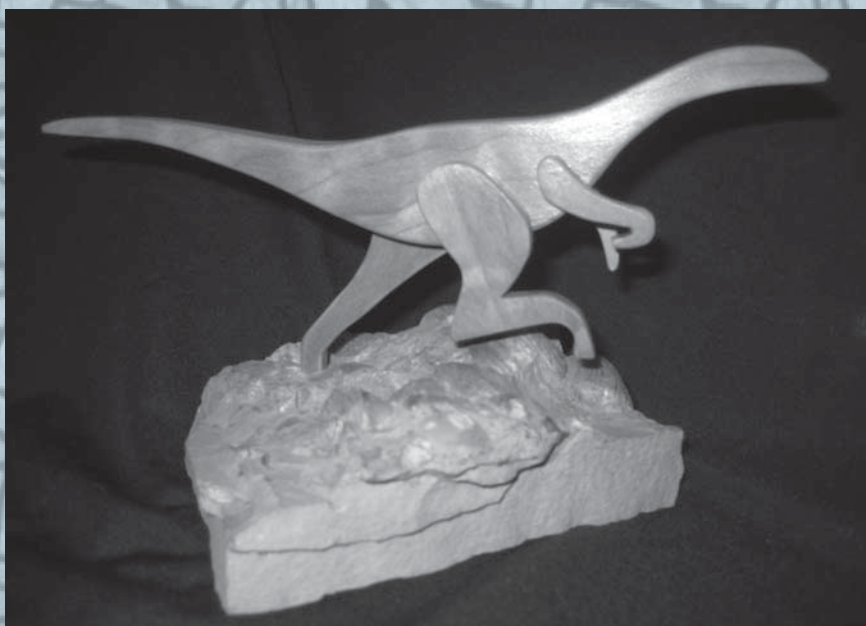
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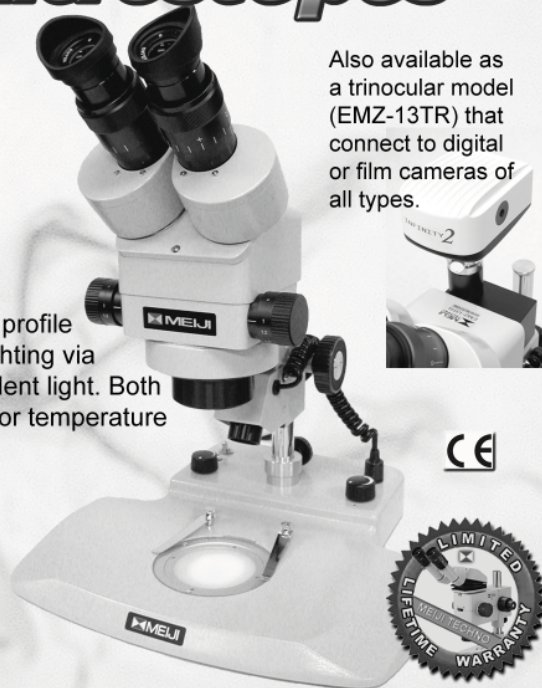
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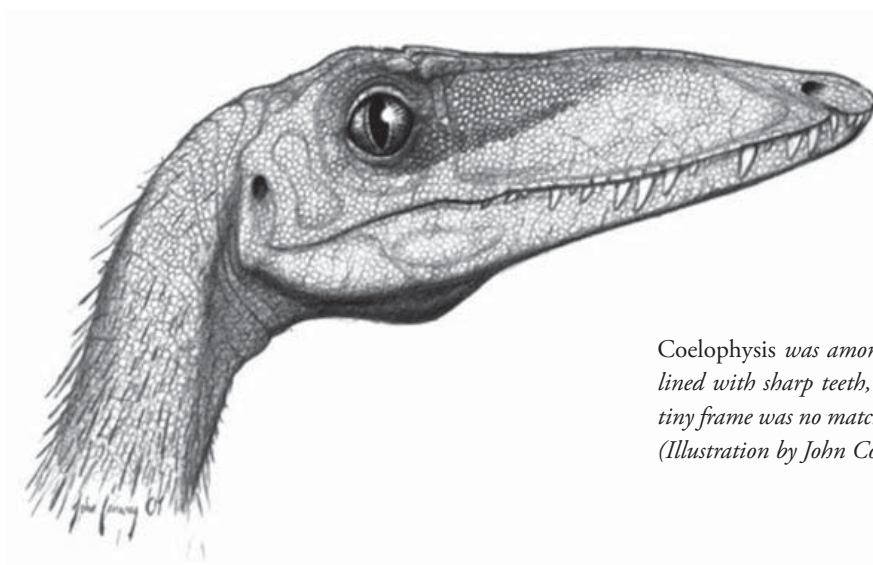
Volcanoes, Death, and the Dawn of the Dinosaurs

By Richard A. Kissel

Thunder rolls through the distant hills. A storm is approaching, and soon heavy drops will pound the far-reaching canopy of ferns and cycads. After the dark clouds pass overhead, life will again stir. Insects will awake, small mammals will scurry about, and the rulers of these lands – reptiles – will begin their hunt. But among the many beasts that inhabit this primeval landscape, there is a newcomer. The day of the dinosaur has begun.

Two hundred and fifteen million years ago, the continents had assembled to form the single landmass Pangaea. Climates were warm the world over, and vast forests blanketed much of North America. It is here that early dinosaurs thrived.

most think of today. And just as different were its inhabitants. Panning across the warm forests of ferns and horsetails, massive brutes known as pareiasaurs were the most conspicuous members of the fauna. The largest reptiles of their time, ten-foot-long pareiasaurs slowly moved about on their stocky limbs, reaching down with their knobby skulls for that next leafy bite. Another plant eater, the pig-sized dicynodont, was characterized by two front tusks that sat directly behind a sharp, turtle-like beak. Carnivorous and dog-like cynodonts – close relatives of the similarly named dicynodonts – displayed a mosaic of reptilian and mammalian features. Also closely-related were the fearsome gorgonopsians. The top predators



Coelophysis was among the first of the dinosaurs. With its long jaws lined with sharp teeth, Coelophysis was a formidable hunter, but its tiny frame was no match for rauisuchians and other predators of its day. (Illustration by John Conway via Wikimedia Commons.)

Darting between the ferns and cycads – as well as conifers and ginkgos – were forms like little *Coelophysis*. Measuring nine feet long and weighing little more than 50 pounds, delicate *Coelophysis* represents the beginning of a dynasty. Over the next 150 million years, its relatives will tower above the trees with long graceful necks, they will sprout bony plates and deadly spikes, and they will rule the lands like no other creature before. But was this a dynasty born of competition and the survival of a superior beast? Or, less dramatic but no more simple, was it a matter of circumstance and luck?

Life's Second Chance

Two hundred and fifty five million years ago, the Russian landscape was radically different than the frozen terrain that

of their day, gorgonopsians with their long, saber-like teeth were capable of taking down the prey of their choice. This eclectic parade of prehistory is the result of lineages that had survived and evolved for millions of years, perfectly adapted for the world in which they lived. But this landscape will soon change. Looming over the horizon is the greatest mass extinction to ever strike the planet, and 90% of all animals will disappear forever.

What happened? As with any question relating to life's history, scientists must look to the ground beneath their feet for answers. Entombed within the planet's rocks are the remains of ancient worlds. These remnants – whether a fossilized skeleton of a trilobite or the hardened ripple marks of a prehistoric beach – are the clues that scientists must use to

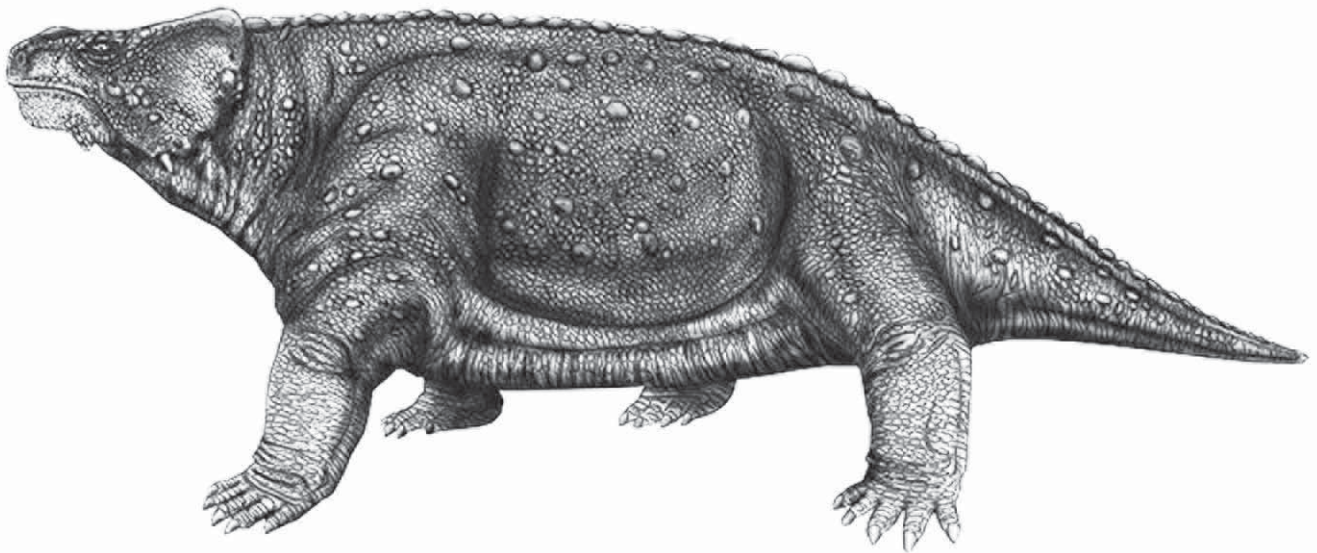
reconstruct the beasts and happenings of days long gone. For the great dying that occurred 250 million years ago, a very singular clue is found today in Siberia. There, more than two million square kilometers of terrain – an area greater than that of Europe – are composed of hardened lava. This terrain is a frozen record of one of the greatest volcanic episodes in the history of the planet.

The great eruptions of Siberia are thought to have occurred within the span of one million years, a mere instant in terms of life's four billion year history. But the effect of such a massive eruption might have been catastrophic. Beyond the immediate, local destruction, the volcanism would have poured ash and gases into the atmosphere. Initial ash clouds could have blocked sunlight, leading to cooling. But among the gases were methane, water vapor, and carbon dioxide. These greenhouse gases would have ultimately led to a more long term warming, potentially upsetting ecosystems to the point of collapse. In total, some 90% of animals in the seas and 80% of those patrolling the lands fell to extinction

500 million years ago, concludes with the mass extinction 250 million years ago. Immediately following the Paleozoic is that era known to school children the world over as the Age of Dinosaurs: the Mesozoic. The beginning of the Mesozoic Era represented life's second chance.

Reptiles Rule

As the sun rose on the Mesozoic, gone were the saber-toothed gorgonopsians, the stocky pareiasaurs, and most other forms as well. But the handful of survivors ensured life's continuation. One such group was a small, somewhat inconspicuous breed of reptiles known as diapsids. The diapsids of the late Paleozoic were not particularly special in appearance or size. Forms like the 1.5-foot-long *Youngina* are small and simple in their basic, lizard-like form, and their survival into the Mesozoic only reinforces the notion that *survival of the fittest* refers not to organisms in isolation – no Paleozoic diapsid would last but a moment in the presence of a gorgonopsian – but to the relationship of organisms and their environment.



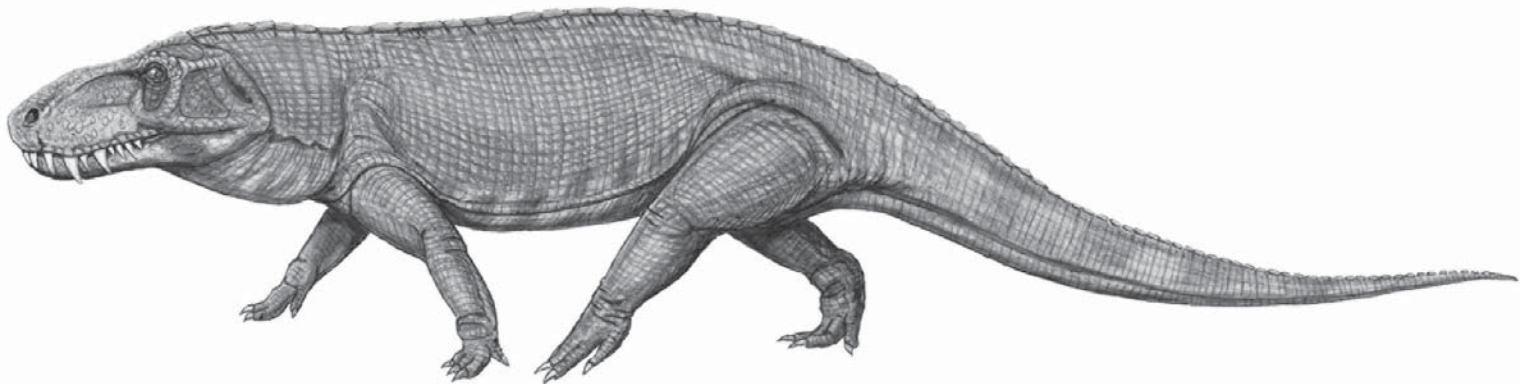
Pareiasaurs and other equally impressive beasts ruled the planet at the end of the Paleozoic, just before the mass extinction that marks that era's close. (Illustration by Karkemish via Wikimedia Commons.)

250 million years ago. Mass extinction had struck the planet twice before, but never to such a degree, and this extinction event remains the greatest in Earth's history. After more than 3.5 billion years of evolution on Earth, life nearly died.

As scientists began to first unravel the history of our planet, this great dying did not pass unnoticed. Tracking the occurrence of fossils in the rock record, the dramatic turnover of life forms served as the basis for distinguishing between two great eras of Earth history. The Paleozoic Era, which began with the trilobites and other shelled forms more than

And for reasons lost to time, diapsids survived the great extinction at the end of the Paleozoic. As they entered the early Mesozoic, these diapsids were surveying not simply an empty landscape, but an opportunity to rule.

By 215 million years ago, the unlikely diapsids had diversified into an incredible array of forms. Turtles, crocodiles, and lizards are diapsids that first evolved during the early Mesozoic Era. Soaring high above, pterosaurs took to the skies on their leathery wings, while two other diapsid lineages evolved for life in the waters: fish-like ichthyosaurs and



Armed with a massive skull and strong legs to propel it forward, 15-foot-long rauisuchians such as this species terrorized the earliest dinosaurs. Their extinction paved the way for dinosaurs to begin their reign. (Illustration by Dmitry Bogdanov via Wikimedia Commons.)

the sauropterygians – the group that includes long-necked plesiosaurs and their kin – swam early Mesozoic seas as their limbs turned to fins. And taking their first steps across the landscape were the first dinosaurs: *Coelophysis* and its kin. But the world was not yet theirs.

The first dinosaurs lived in the shadows of much larger, more powerful diapsids. With their more massive sizes and their snouts lined with sharp teeth, forms like the rauisuchians and the crocodile-like phytosaurs dominated these lands, their powerful jaws ready to grab any unsuspecting *Coelophysis*. The dinosaurs lived in a world of much bigger brutes. But once again extinction would alter life's course. Around 200 million years ago, another wave of extinction would pass, and the mighty phytosaurs and rauisuchians would fall. With their disappearance, the stage was set for the dinosaurs to begin their dynasty and rule the lands. And – for the next 135 million years – so they did.

Six and Counting

Throughout life's four billion year history, the process of survival and reproduction has driven biological evolution, with new forms arising from old to create life's expanding family tree. But that history is also significantly shaped by extinc-

tion. At least five mass extinctions have occurred since life began in primeval seas, with each one wiping out at least 50% of all species at the time, forever altering life's path. The mass extinction that closed the Paleozoic Era opened the door for diapsid reptiles to diversify during the Mesozoic. Fifty million years later, the largest and most feared of those diapsids were wiped out, allowing the likes of *Coelophysis* to reign. And with the extinction of the large dinosaurs 65 million years ago, mammals thrived and do so to this day.

The study of life's history tells us that evolution and extinction march hand in hand; as established forms pass, new ones will fill the void. And as we stand within the midst of the sixth mass extinction today, with a loss estimated at 30,000 species per year (approximately one species every fifteen minutes), it is hard to not wonder which path life will take in the coming million years or so, and it is hard to not wonder which players will survive to dominate the next era on this ever-evolving planet Earth.



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Wanna Know More about NY Paleontology??



The New York State Museum in Albany is the official museum of New York for all things biological, paleontological, historical, archaeological, etc., etc. Its website is a treasure-trove about their exhibitions, publications, collections, and educational programs, including a great deal about geology and paleontology. See <http://www.nysm.nysed.gov>.



Did you know??

A Red Wiggler earthworm (*Eisenia foetida*) produces its own weight in castings every day.

Dinosaurs in America – Joseph Leidy & the Academy of Natural Sciences

By Peter Dodson

This year of Darwin is a big one indeed, framed at one end by the 200th birthday celebration in February, and at the other end by the 150th anniversary of the publication of *On the Origin of Species* in November. In our quiet unassuming way, another important paleontological anniversary was recently observed in Philadelphia. On Dec. 14, 1858, just over 150 years ago, *Hadrosaurus foulkii* debuted, soon to become the most important dinosaur then known to science. Its story is a compelling one. Recollect that the formal scientific history of dinosaur paleontology began in England in 1824 with the description of the Middle Jurassic theropod *Megalosaurus* from Stonesfield near Oxford by Reverend William Buckland (1784-1856). The type specimen of *Megalosaurus* consists of a partial jaw with one menacing erupted tooth and



Joseph Leidy, at his desk in 1863, has been described as "the last man who knew everything."

four partially erupted teeth. The remains of several animals were included in the deposit, and Buckland presented beautiful plates illustrating some vertebrae, a partial rib, pelvic elements, a lovely femur, and a foot bone. The elements did not come from the same individual and no reconstruction was attempted. Nonetheless Buckland deserves credit (with advice from Georges Cuvier) for recognizing the reptilian nature of *Megalosaurus*. As the first such animal to be described, he naturally regarded it as "belonging to the order of Saurians or Lizards." That being the case, his fossils, preserved in the Oxford University Zoology Museum, indicated an animal with a length exceeding 40 feet and the bulk of an elephant. He believed that similar remains from Sussex collected by physi-

cian Gideon Mantell (1790-1852) indicated an animal 60 to 70 feet long, hence the name, which means "big lizard."

The following year (1825), Mantell published *Iguanodon*, based on a collection of teeth from Tilgate Forest in the Early Cretaceous Wealden Formation. Mantell sagely recognized their reptilian nature. He located the perfect reptilian model for his teeth at the Hunterian Museum of the Royal College of Surgeons in London. Here Samuel Stutchbury had skeltonized a specimen of *Iguana* from the Caribbean. Upon examining the specimen "we discovered teeth possessing the form and structure of the fossil specimens." This formed the perfect justification for Mantell's equally obvious name *Iguanodon* ("Iguana tooth"). *Iguanodon* teeth are quite large, and he felt that their size was consistent with an "oviparous quadruped" ... "upwards of sixty feet long" (Mantell, 1825, quoted from Weishampel & White 2003, page 70). A few years later in 1833, Mantell compared various body parts of *Iguanodon* with those of a five-foot *Iguana*. Various body parts yielded estimates ranging from 55 to 100 feet in length, with a mean of 70 feet, Mantell's best estimate. The proportions of his monster were striking indeed: four-and-a-half feet of head, 13 feet of body, and an astonishing 52 feet of tail. He estimated the length of the foot at six-and-a-half feet! This brings to mind O. C. Marsh's precious objection to the reconstruction of fossil skeletons: "The dinosaurs ... have suffered much both from their enemies and their friends. ... Their friends have done them further injustice in putting together their scattered remains, and restoring them to lifelike forms. ... So far as I can judge, there is nothing like unto them in the heavens, or on the earth, or in the waters under the earth" (quoted by Dodson, 1996, page 75). My intention is not to criticize, but merely to point out that in 1833, knowledge of the fundamental structure of Mesozoic "saurians" was severely constrained by the fragmentary nature of the fossils so far uncovered. Mantell described a second dinosaur from the Lower Cretaceous deposits of the Tilgate Forest. *Hylaeosaurus* is based on an articulated partial skeleton of a small dinosaur with armor. Lacking a skull, there was no clear idea of the nature of this animal, although we know today that it was one of the armored herbivorous ankylosaurs.

In 1842, dinosaurs received both a name and an identity in the hands of the great British anatomist and paleontologist Richard Owen (1804-1892). Owen's Dinosauria included at that time only the three dinosaurs named above. He did not recognize *Thecodontosaurus* (1836) and *Plateosaurus* (1837) as dinosaurs, nor did he even recognize his own *Cetiosau-*

rus (1842) as a dinosaur. A superb comparative anatomist, Owen's careful studies of the vertebral column resulted in a drastic downsizing of the size estimates of the *Megalosaurus* and *Iguanodon* to 30 feet and 28 feet respectively, essentially the size that we consider them today. Owen clearly recognized that the legs of dinosaurs were much longer compared to body size than those of lizards. Nonetheless, the life-sized reconstructions of the dinosaurs designed by Benjamin Waterhouse Hawkins under the supervision of Richard Owen and exhibited at the Crystal Palace, Sydenham, appear to us today as more like fantastic monsters than serious works of science. Gracing the gardens of the Crystal Palace since 1854 and still on view today, the sculptures of *Megalosaurus*, *Iguanodon*, and *Hylaeosaurus* represented the first public offerings on dinosaurs, and Victorian Londoners could not get enough of them. *Megalosaurus* incidentally entered British literature in 1852 in Charles Dickens' *Bleak House*. But it was viewing these sculptures in 1895 that led Marsh to make his comment, quoted above.

Joseph Leidy (1823-1891) was one of the great scientists of the 19th century, described by his biographer, Leonard Warren in 1999, as "the last man who knew everything." Leidy was a physician, anatomist, microscopist, parasitologist, protozoologist, and paleontologist, just to name a few of his fields of competence. His primary academic base was the University of Pennsylvania School of Medicine, and the Biology Department that he founded is literally across the street from my office. He also served terms as President of the Academy of Natural Sciences and the Wagner Free Institute of Science, both in Philadelphia. Dinosaur paleontology in the United States began in 1856, when Leidy received a shipment of fossils from Nebraska Territory, sent by Ferdinand Vandever Hayden from exposures along the Missouri River in what is now Montana (Montana Territory was created by an act of Congress in 1864). Leidy described the handful of teeth as *Deinodon*, *Trachodon*, *Troodon*, and *Palaeoscincus*, the first American dinosaurs. Unfortunately, teeth constitute an unsatisfactory basis for naming dinosaurs, and all of these but *Troodon* are now termed *nomina dubia*. Leidy's descriptions

of the four dinosaurs, plus a crocodile, a turtle, and two species of fish, were nothing if not brief, the whole report in the *Proceedings of the Academy of Natural Sciences of Philadelphia* consisting of but two pages without illustrations. *Palaeoscincus costatus*, based on a single tooth, merited but six lines, and was called a "lacertilian" (the name means "ribbed ancient skink"). We now know that it is the tooth of an ankylosaurian, but it is impossible to refer it to a known taxon.

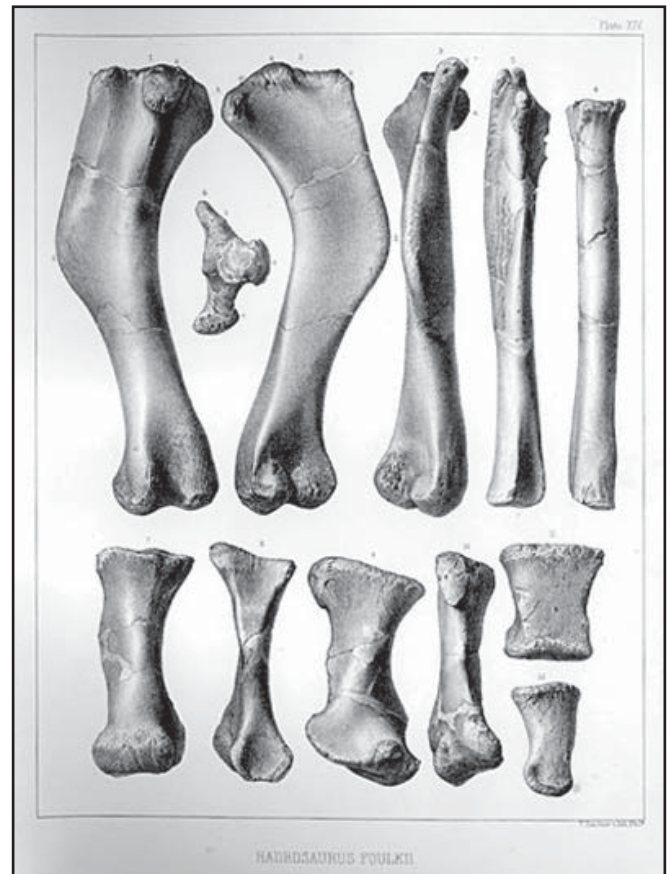
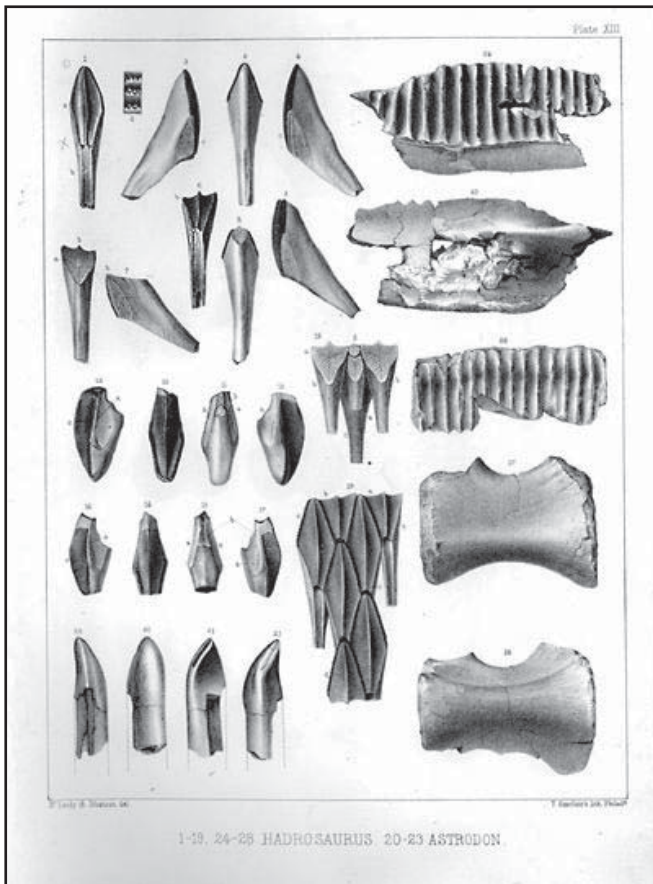
Trachodon mirabilis is the hadrosaur, and is based on a series of unworn to deeply worn teeth (number unspecified).

Leidy characterized *Trachodon* as "a herbivorous lacertian reptile allied to the *Iguanodon*." The name *Trachodon* (meaning "marvelous rough tooth") enjoyed a long run, and many species were referred to it during the late 19th century and early 20th century. It was still in common use during my childhood in the distant 1950s. For example, two of my favorite books, Edwin H. Colbert's *The Dinosaur Book* (1951) and Roy Chapman Andrews' *All About Dinosaurs* (1953) used *Trachodon*. Both Colbert and Andrews were professionals at the American Museum of Natural History. But science moves on. By 1942, Richard Swann Lull and Nelda Wright surveyed the taxonomic morass created by inadequate types and decided to drain the swamp by erecting a new genus for the now complete and abundant type of flat-headed duck-billed dinosaur from the Hell Creek Formation of Montana and its equivalents in Alberta, Saskatchewan, the

Dakotas, Wyoming, and Colorado. *Anatosaurus* (literally, "duck lizard") was an apt name, but it might never have been as popular as *Trachodon*, which is sometimes still seen in children's books today. A Google search returns 21,000 hits for *Trachodon* and only 16,500 for *Anatosaurus*! Alas, the name *Anatosaurus* did not last either. Michael Brett-Surman concluded in 1979 that *Anatosaurus* was indistinguishable from the flat-headed hadrosaur named *Edmontosaurus* by Canadian Lawrence Lambe in 1917. I am happy to report that although both of the older names persist, as much as I would like to see them disappear, Google records a whopping 55,700 hits for *Edmontosaurus*, suggesting that current scientific understanding on this question at least has penetrated



Leidy's plate 9, published in 1860, shows the dinosaur teeth that he described and that now reside at the Academy of Natural Sciences of Philadelphia.



Leidy's Hadrosaurus foulkii was, at the time of its description in 1858, the most complete and thus the most important dinosaur known.

popular culture.

The third doubtful tooth that Leidy described is *Deinodon horribilis*, “a saurian reptile.” He recognized the similarity of this tooth to that of *Megalosaurus* from Europe, hence its lurid name, which means “horrible terrible tooth.” He lavished five paragraphs on this collection of nine teeth that revealed an animal with serrated teeth up to two inches tall. Today we understand that that this animal was a smaller member of the

Tyrannosauridae, perhaps *Albertosaurus*, but we do not know for sure. Although it was once featured in popular works, it never penetrated into popular culture to the degree that *Trachodon*, for example, did, earning a paltry 3,800 Google hits. Undoubtedly it suffered eclipse by the media all-star *Tyrannosaurus* with a stupendous 1,780,000 Google hits!

Ironically, only a single one of Leidy's original four dinosaurs enjoys currency today, and that is *Troodon formosus* ("beautiful wounding tooth"), although the "lacertian" enjoys only eight lines of text. The dainty little teeth said to be "3 lines" in crown height are highly distinctive in bearing coarse denticles (the "line" is an archaic unit of measurement, also employed by Owen in 1842; evidently 12 lines make one inch). *Troodon* illustrates well the danger of using dinosaur teeth as type specimens. Three other dinosaurs described in the 20th century (*Stenonychosaurus* Sternberg, 1932; *Polyodontosaurus* Gilmore, 1932; and *Pectinodon* Carpenter, 1982) are now all regarded as junior synonyms of *Troodon*, which has given its name to a family of bird-like, slashing-clawed small raptors.

In 1860, Leidy published a somewhat expanded version of the 1856 paper in the *Transactions of the American Philosophical Society*. Plate 9 of this monograph illustrates the teeth that he described, so that the claim of the first American dinosaurs can be confirmed by one and all. The same teeth can be examined in the paleontology collections of the Academy of Natural Sciences today. The plate is an extremely valuable scientific document, and the text provides further insight into Leidy's understanding of these animals. Oddly lacking from both the 1856 and the 1860 publications is the word "dinosaur." Although he clearly recognized that *Trachodon* and *Deinodon* were relatives of *Iguanodon* and *Megalosaurus*, respectively, and despite Owen's inclusion of both of these animals in his *Dinosauria* of 1842, Leidy never identified his own animals as dinosaurs. He persisted in calling them saurians, by which he meant lizards. *Trachodon* was in Leidy's own words "a large herbivorous lizard." As to their modes of life he stated: "As anatomical and geological evidence favour the view that *Iguanodon*, *Trachodon*, and *Hadrosaurus*, were amphibious, it is not unlikely that *Megalosaurus* and *Deinodon* infested the shores, upon which the former quietly grazed or browsed, and proved them to be fierce and destructive enemies" (Leidy, 1860, page 145). *Palaeoscincus*

was deemed "a true and gigantic member of the true Iguanians" that probably fed like the marine iguana on aquatic plants. *Troodon* was a large monitor lizard "probably aquatic like many of the living Monitors, the voracious *Troodon* was most likely a troublesome enemy to the peaceful plant-eating *Palaeoscincus*." How soon arise the clichés of the good dinosaurs and the bad dinosaurs! History has not looked very kindly on Leidy's attempts to characterize the paleobiology of dinosaurs. Nonetheless, we should not judge too harshly from our vantage point 150 years later.

"...this great extinct herbivorous lizard may have been in the habit of browsing, sustaining itself, kangaroo-like, in an erect position of its back extremities and tail."

Leidy would be a mere footnote in the story of dinosaurs were it not for the discovery of *Hadrosaurus foulkii* reported by Leidy two years after the first dinosaur discoveries. The dinosaur gave its name to the family of duck-billed dinosaurs, the Hadrosauridae. The surprising thing about *Hadrosaurus* is that the skeleton came not from the great fossil beds of the American West but from Haddonfield, New Jersey, directly across the Delaware River from Philadelphia. Academy member William Parker Foulke spent the summer and fall of 1858 in the genteel and verdant suburb of Haddonfield (a town that is still verdant and genteel today). He was told by his neighbor, farmer John E. Hopkins, that 20 years previously some large bones, principally vertebrae, were discovered in a marl pit excavation. The natural curiosities were carried off by visitors and the collection dispersed. Intrigued, Foulke undertook exploration and successful excavation with Hopkins'

permission. The resulting collection of bones was brought to the Academy in October, and was described by Leidy under the name of *Hadrosaurus foulkii*, as recorded in the minutes of December 14, 1858. The fossils included 28 vertebrae, a humerus, a radius, an ulna, an ilium, a pubis, a femur, a tibia, a fibula, two metatarsals, and one pedal phalanx (toe bone). From the skull, there were nine teeth and a jaw fragment. At the time of its discovery, it was the most important (that is to say, the most complete) dinosaur known to science, and was a very exciting discovery. This was a large animal, estimated by Leidy to be 25 feet long. Its femur was 40 inches long and the tibia 36 inches. By contrast, the humerus was only 23 inches long. Leidy (1858, page 217) wrote: "The great disproportion of size between the fore and back parts of the skeleton of *Hadrosaurus* leads me to suspect that this great extinct herbivorous lizard may have been in the habit of brows-

ing, sustaining itself, kangaroo-like, in an erect position of its back extremities and tail." This was a revolutionary statement indeed, a recognition that these animals were unlike any reptile alive today. In our whiggish modern way, we tend to elevate Leidy to the status of a demigod for articulating such a bold concept. A moment later, he douses our elation by admitting that lizards show similar disparities, and that the dinosaurs probably were lizard-like in their posture after all. He concluded that *Hadrosaurus* was probably amphibious, and that the bones had been carried to the sea by the current of river on whose banks the animals lived. In 1865 in his monograph on Cretaceous vertebrates, Leidy expanded at considerable length on the anatomy of the preserved skeletal elements of *Hadrosaurus*. He then seemed a little more comfortable with his conclusion as to posture: "The enormous disproportion between the fore and hind parts of the skeleton of *Hadrosaurus* has led me to suspect that this great herbivorous Lizard sustained itself in a semi-erect position on the huge hinder extremities and tail while it browsed on plants growing on the shores of the ocean in which it lived" (Leidy, 1865, page 97).

Leidy cemented his reputation for being the author of the upright nonsaurian dinosaur when he partnered with British artist Benjamin Waterhouse Hawkins to produce the first-ever skeletal reconstruction of a dinosaur, the kangaroo-like, semi-upright *Hadrosaurus*, bearing the scaled-up head of an iguana lizard. The reconstructed skeleton went on display at the Academy of Natural Sciences in Philadelphia in November 1868, the first time that a dinosaur skeleton was ever displayed in a museum anywhere. It was another 35 years before museums in the United States began to mount skeletons of their own dinosaurs. The world has never been the same since!

A final note. I regret that I was distracted by the Darwin celebration from drawing attention to *Hadrosaurus* earlier. The Academy of Natural Sciences took down its exhibit *Hadrosaurus foulkii*, *The Dinosaur that Changed the World* on May 3rd. However, there is a superb virtual exhibit on Jo-

seph Leidy hosted by the Academy of Natural Sciences listed below.

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New York PaleoTrivia - Did You Know?

- ✿ *Coelophysis* was a very fast runner and might have clocked in at up to 25 miles per hour.
- ✿ The name *Coelophysis*, in Greek, roughly translates to "hollow form," referring to the dinosaur's hollow bone structure.
- ✿ A *Coelophysis* skull from the Carnegie Museum of Natu-



- ral History was brought into space by the space shuttle *Endeavor* on January 22, 1998. It traveled to the space station Mir. *Maisaura* beat *Coelophysis* into space by almost 3 years.
- ✿ The oldest coral reefs on Earth (approx. 460 million years old) occur in the northern Lake Champlain Valley in New York and Vermont.
- ✿ The first eurypterid fossil was discovered in New York State in 1818. It has since become the official fossil of New York State.

- Compiled by Sara Auer, PRI Education Programs Manager

Evolution (Not) for Sale

By Robert M. Ross & Richard A. Kissel

While the 2009 National Conference on Science Education was unfolding in New Orleans this past March, where 10,000 teachers were attending workshops, lectures, and courses to improve their science teaching, the Texas Board of Education was debating an addition to its education standards that would require classroom teachers to present the “strengths and weaknesses” of the theory of evolution. Any decision to teach scientific doubt regarding the existence of evolution, of which there is none in the actual scientific community, would not only lead to more poorly educated students in Texas, its implications would reach far beyond the dusty borders of the Lone Star State: with Texas representing an incredibly large market for textbooks, science textbooks for distribution across the nation would be modified to suit sales there.

The concept of textbook manufacturers not using evolution as a prominent theme was well familiar to us. But what we observed in the Exhibits hall of the NCSE conference, where institutions and companies from around the world display their teacher resources, still surprised us. PRI was giving away bookmarks advertising our Evolution Project and selling books about evolution and Darwin, but *the word “evolution” occurred almost nowhere else in obvious sight among the hundreds of exhibitor booths in the massive exhibits complex.*

In an attempt to develop a systematic approach to see if this apparent lack of “evolution” was real, one of us (RAK) talked to teachers at the PRI booth while the other (RMR) visited all of the exhibitor displays over the course of the final day. We looked for “evolution” and/or its English relatives (evolve, evolving) at each booth – on signage, on textbook covers, on flyers, etc. The goal was not to find the word “evolution” *inside* products – within a textbook or on a CD, for example – but to see if the term was easily visible to those browsing the booths. Time was limited, so it is entirely possible that a few occurrences of “evolution” were missed, especially if they were present in an inconspicuous location.

The results of the search confirmed our initial suspicion. Not one major textbook publisher (such as Pearson, McGraw/Hill, or Houghton-Mifflin) had the word “evolution” on display. One representative, when asked what they had on evolution, looked it up in a large index of company resources; the term did not appear in the index. “Evolution” also did not appear at the booths of some of the major suppliers of classroom materials, such as Carolina Biological Supply and Ward’s Natural Science. In fact, out of the 1,000 or so vendors, we found fewer than ten with the word “evolution” on display. Who *did* have the word “evolution” in sight?

1. Paleontological Research Institution: noted above.

2. Union of Concerned Scientists: a flyer about keeping creationism and Intelligent Design out of schools.
3. Howard Hughes Medical Institute: a DVD on evolution.
4. Biozone (the only firm with books specifically about evolution): workbooks on *Evolution* and *Human Evolution*. Interestingly, Biozone is a publisher from New Zealand.
5. American Association for the Advancement of Science: a booklet on evolution.
6. Public Broadcasting Corporation: NOVA DVD’s on various topics relating to evolution.
7. Macmillan: a general audience book with evolution in the title (*Evolution: The History of an Idea*).
8. National Center for Research: a curriculum on Darwin.

It is true that many of the vendors do not supply products that would logically be connected to teaching evolution, such as those vendors specializing in chemistry and physics. But at least several booths clearly selling substantial quantities of biology class resources did not use the word “evolution” on the surface of any product. Also, many of the vendors who could in principle feature evolution – science T-shirt and toy vendors, university teacher education programs, or ecotours – are not out of line for not doing so. Even the textbook publishers might defend themselves by pointing out that the titles of their books are very broad; titles such as “Biology” and “Earth Systems” tend to dominate the industry. But our surprise regarding the lack of “evolution” in the conference Exhibit hall comes from two simple observations: (1) scientists and top science educators have for decades pointed out that evolution is a central organizing principle for biological evolution and the history of Earth systems, and (2) science education is big business, and words that can be used in titles, tag lines, and advertising text to sell product (words such as environment, ecology, Earth, and global) will be used. In sum, it is quite clear that teachers attending the most important annual national conference on science education see “evolution” almost not at all as they search for books and other resources for their classrooms.

See more about the NCSE at <http://www.nsta.org/conferences/2009new/?lid=tnavhp>; also see PRI’s *Evolution Project* at <http://www.museumoftheearth.org/outreach.php?page=overview/362548>.



For an expanded version of this essay, see this issue on the American Paleontologist website (<http://www.museumoftheearth.org/publications/bookstore.php>). Both authors are staff at PRI: Rob Ross (rmr16@cornell.edu), Associate Director for Outreach; Richard Kissel (rak256@cornell.edu), Director of Teacher Programs.

Shell Games

By David C. Kendrick

The Geology of the Everglades and Adjacent Areas, by Edward J. Petuch and Charles E. Roberts, CRC Press, 212 pp., ISBN 978-1-42004-558-1, \$119.95 (hardcover), 2007.

We treasure photographs as mementos, delight in them as art, and rely on them as objective documentation of unique physical circumstances – often circumstances that no longer exist. Paleontological specimens are routinely imaged for publication as evidence of their form; crime scenes are meticulously recorded as evidence of wrongdoing. We are programmed by our visual nature and by the familiarity of the captured image, chemical or digital, to interpret these images as “truthful”: seeing is believing. Of course, they are not really objective – all captured images are manipulations of the truth, manipulations that range from subtle, unconscious choices of framing to complete and intentional fabrication. Any photographic image, digital or chemical, expresses this tension and playing with it often converts a photograph from boring to electrifying. Most people understand the tension on some level as images that show the obviously impossible can be humorous and thought-provoking; however, because captured images still “look” real in a way that drawings do not, our natural bias is to interpret them as accurate reproductions of real-life objects. That this tension should so strongly inhabit a scientific book, a venue that values the documentary aspect of the image over the interpretive, is a surprise. Petuch and Roberts’ *The Geology of the Everglades and Adjacent Areas* forces the question, “What is appropriate use of digital image manipulation in representing the past?”

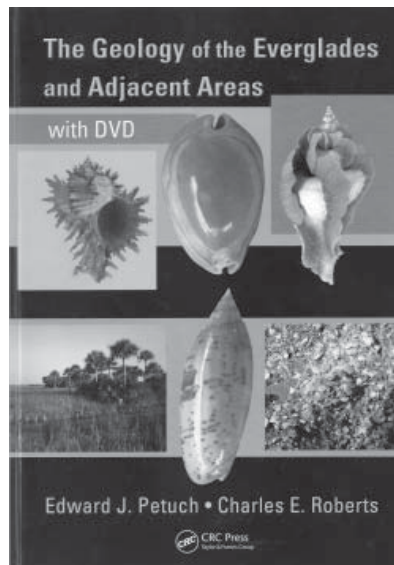
The book is both a review of older material and a presentation of much new material. It is touted as a general reference for the geology of the area, which, by the very nature of the place, is difficult to access. In a region with precious little relief and groundwater levels near or coincident with the surface, exposures are generally linked to development, which, in southern Florida, has been moving quickly. The result is a sliding geological window moving across this striking landscape. The window’s passage grants an otherwise unavailable peek into the subtle complexities below, but only briefly, as houses, streets, and the rest of our infrastructure spring up and the window slides off into fresh territory. As

a result, the book provides data from areas that are now unavailable for further study or for ground truthing.

After some introductory material and a section on geomorphology, the authors mark their territory: the upper 330 meters of strata, stretching from the Upper Eocene to the Holocene. They divide the rocks into three depositional packages representing three different paleogeographic/paleoceanographic interpretations: a carbonate platform episode, an upwelling-deltaic episode, and a pseudoatoll episode. The bulk of the book thereafter is a combination of systematic stratigraphic descriptions, figuring of index fossils, and environmental interpretations. Extensive block quoting of original lithologic and stratotype descriptions share space with original descriptions and re-descriptions of geologic units. Uniting the new and the old, the authors propose seven new geological members, resurrect and redefine eight more, and alter the status of four formations – which remain informal pending review. There is lots of detail as the authors also intend the book as a field guide and the numerous index fossil photographs are quite fine. On top of the data, there is also a lot of interpretation; sometimes it’s hard to tell the difference. To be fair, the authors do include comments like “this must remain a speculation for the time being”; however, the most interesting bit of interpretation in the book is a series of simulated photographs, taken from Earth

orbit, of the Florida peninsula, over the last 40 million years.

The authors constructed a time series of images based on a hand-held photograph of the Florida peninsula taken from the orbiting space shuttle at about 160 kilometers altitude. Paleoceanographic interpretations were superimposed on the photograph yielding a geomorphological/bathymetrical blank for each of the 14 steps in the time series. Finally, fragments of modern-day marine environments drawn from a shuttle image of Andros Island, Bahamas, were transferred to the blanks and cloned to fill in the paleoenvironmental regions, creating simulated photographs of the Florida peninsula through the last 35 million years. These images are remarkable in some ways – there is an element of the BBC’s “Walking with Dinosaurs” feeling here in that the material is presented in what we perceive as a “realistic” way. At the same



time, they also raise a very serious question: where are the lines between accuracy, honesty, and the laudable desire to make palpable the worlds of the past? In the text, the authors are clear that these are simulations and anyone familiar with the geologic timescale would recognize that they are constructs. The problem with simulated photographs is that they aren't perceived as simulated, which lends subtle, unconscious weight to these particular interpretations of the data.

A second, subtler question arises from this process, namely, "What is the nature of analogy in geology?" The simulated space-based photographs were created by capturing image slices of modern environments in the Bahamas and cloning them to fill spaces on the time-series blanks. Modern environments in the Bahamas might make excellent analogs for the paleoenvironments of the Florida peninsula; however, using actual images of these modern environments blurs the line between analogy and, to extend the metaphor, homology. Geological arguments are often framed as arguments by analogy, *i.e.*, if two things have some characteristics in common, then they likely share some additional characteristics. We use this technique all the time for generating hypotheses and making interpretations, often to great and positive effect. Similar conditions result in similar deposits, generally speaking. Likewise, in evolutionary biology, analogous characteristics represent similar solutions to similar evolutionary pressures. Understanding evolution, however, requires a second, corollary term – homology – that identifies shared characteristics resulting from shared ancestry. We don't use homology to describe sedimentary facies, because there is no ancestry of sedimentary environments. And here we come to the point – the way the images in this book were constructed invokes a kind of homology. Using pieces of Bahamian environments implies that the Florida system is not only *like* the modern Bahamas, it *is* the modern Bahamas, along with everything else that goes with it. Although this technique creates some interesting and evocative pictures, it might simultaneously be obscuring the uniqueness of the system by homologizing it with a different place, a different time.

There is an ongoing debate within the newsmedia about what kinds, if any, of image manipulations are ethical. The flood of altered images has even spawned a new field, digital forensics, in which analysts examine photographs for obvious and subtle clues that they were doctored. Petuch and Roberts are completely up front about their photographs and the method of their creation; however, their inclusion in the book still warrants a discussion about the implications of image manipulation in technical work.



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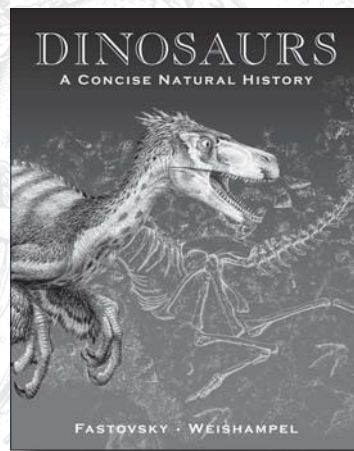
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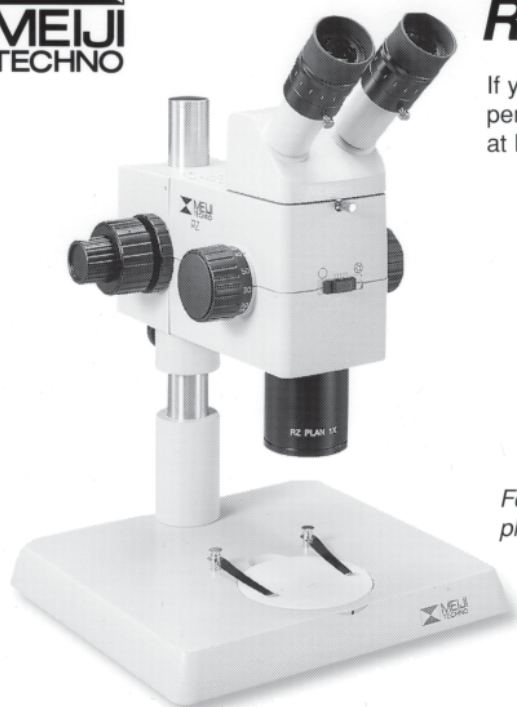


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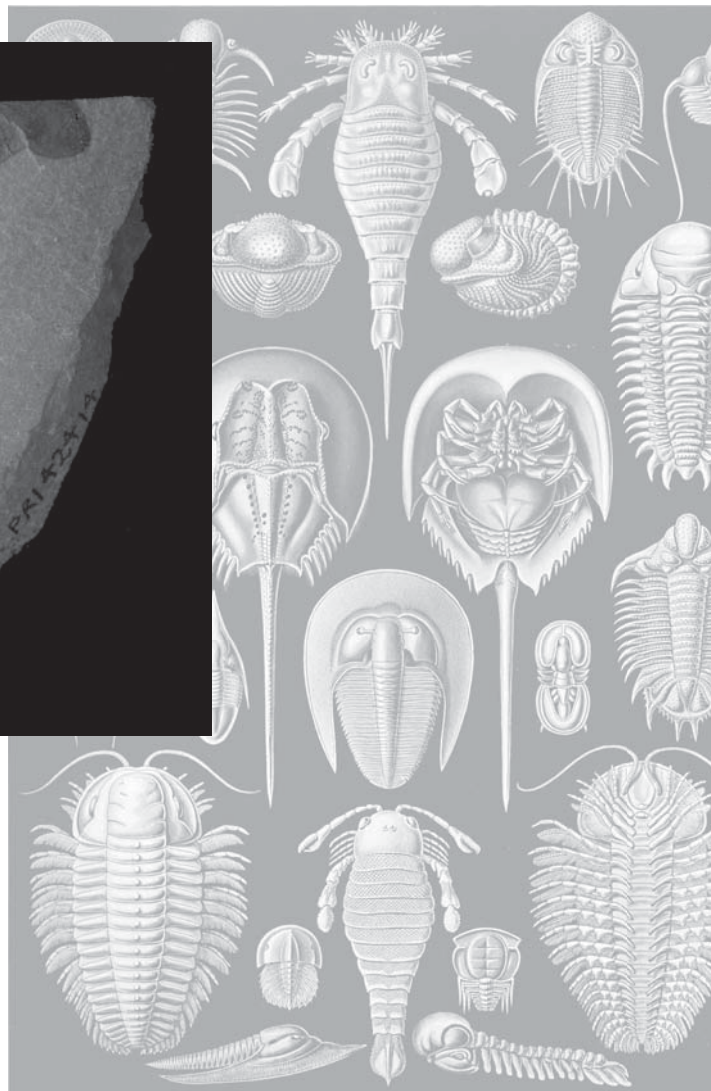
Dinosaurs could probably see colors. How do we know this? The two living groups that are most closely related to dinosaurs are birds and crocodiles. Birds are *tetrachromats* - that is, they have four kinds of visual pigments (blue, green, red, and ultraviolet) for seeing color in the specialized "cone" cells of their retinas. [That's one more than humans have - we lack the ability to see ultraviolet.] Although crocodiles haven't been studied as thoroughly, some of them probably see colors, too. All of this suggests that dinosaurs probably saw in color. So ... ideas about dinosaurs being *colorful* make sense too !!

By Ursula Smith



Above—*Eurypterus lacustris* Harlan, 1834, Bertie Dolostone, Erie County, New York, Upper Silurian Period, PRI 42414.

Right—Ernst Haeckel, in his *Kunstformen der Natur* (Art Forms in Nature, 1904), included eurypterids on a plate with trilobites and modern horseshoe crabs.



When eurypterid fossils were first found, they were described as catfish. However, shortly afterward, it was recognized that they are actually an extinct group of arthropods related to arachnids. Eurypterids are commonly known as sea scorpions because their narrow elongated body resembles those of today's terrestrial scorpions. The group appeared in the Middle Ordovician and disappeared during the end-Permian mass extinction.

Eurypterids appear to have been bottom-dwelling predators but were probably also capable swimmers. The 'sea' part of their name is not completely accurate because, although some did live in shallow marine environments, most seem to have lived in more marginal marine settings, such as brackish lagoons or in freshwater. It also seems that at least some species spent part of their time on the shore – there are known terrestrial tracks that look like those that a walking eurypterid would make.

Most individual eurypterids were less than 10 inches (4 centimeters) long but some species got much bigger. We know that the largest would have grown to approximately 10 feet (3 meters) in length, which makes these the largest known arthropods to have ever lived. We've never actually found a whole specimen of this length, but we can extrapolate from the pieces of large but incomplete specimens to work out how large an entire specimen would have been. The largest known complete specimen of a eurypterid in the world is 49.5 inches (1.25 meters) long and is in fact on display at the Museum of the Earth. The Museum's exhibits also contain a number of other eurypterid specimens.

Eurypterid fossils have been found around the world but were first discovered in New York in 1818, where they are extremely common in the state's Silurian strata. They are so abundant and are such an important part of the state's paleontological heritage that one species, *Eurypterus remipes*, has been designated as New York's official State Fossil.

Ursula Smith is a Ph.D. graduate student in the Department of Earth and Atmospheric Sciences at Cornell University.



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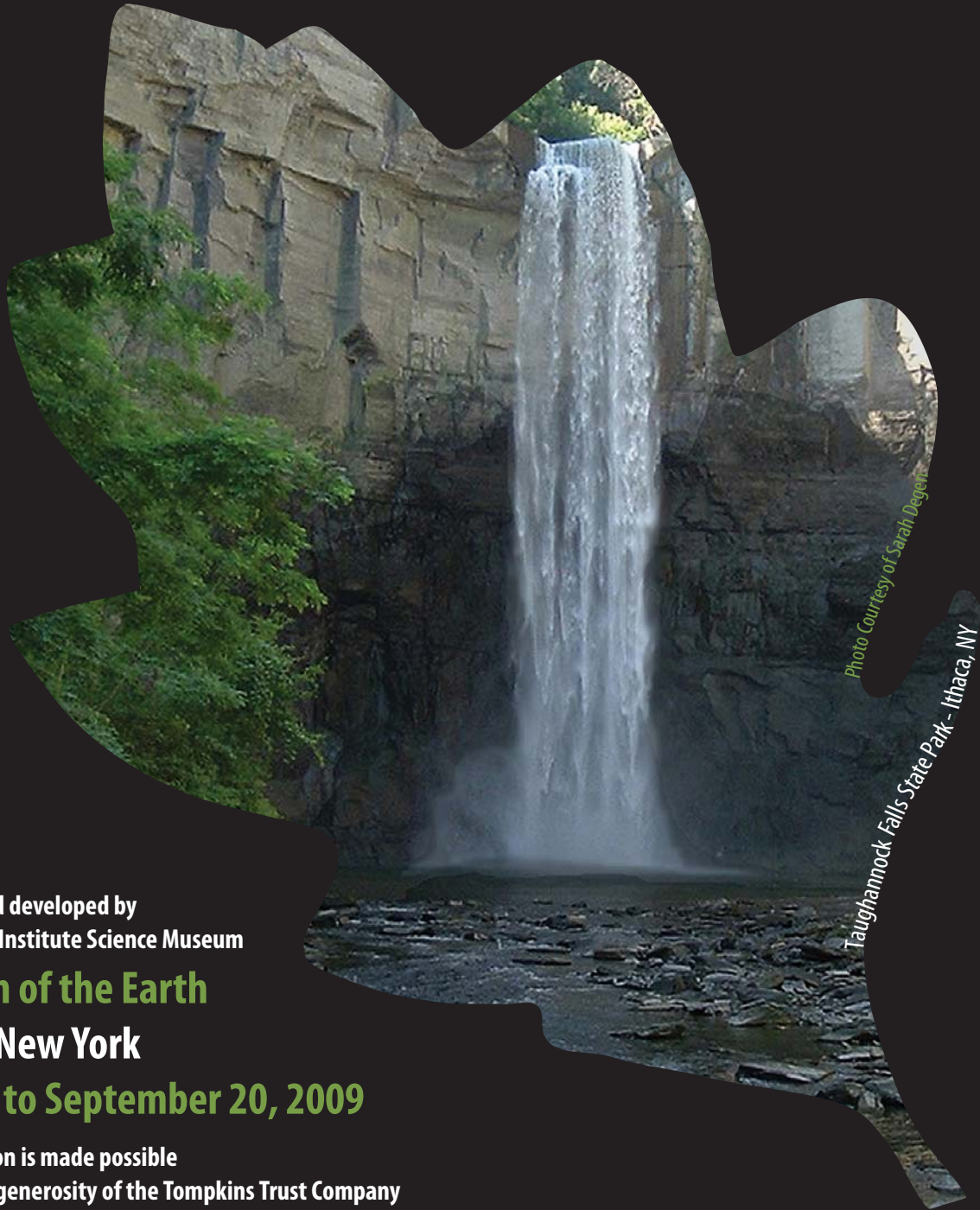


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