

150 YEARS

AMERICAN MUSEUM OF NATURAL HISTORY

ROTUNDA

Member Magazine
Spring 2019 Vol. 44 No. 2

WHAT DID
T. REX
EAT?

T. rex: The Ultimate Predator
Now Open

From the President

Ellen V. Futter



In 1869, scientists discovered DNA molecules for the first time, Charles Darwin's *Descent of Man* and the first Periodic Table of Elements were published, and the American Museum of Natural History was created.

The idea of a Museum accessible to the public and, even more, expressly created for the public good was a new idea that took root in the 19th century, first in Europe, then in the United States. And a burgeoning New York was the perfect place for a new museum of natural history.

And so, on April 6, 1869, the New York State legislature established in New York City a museum and library of natural history for "developing the study of natural science" and "furnishing popular instruction and recreation."

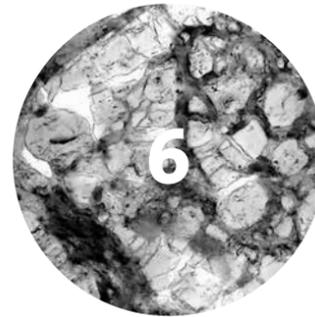
Over time, of course, the Museum would grow into one of the world's most prominent institutions

of science and education, with one of the world's most important collections and a global reach in scientific research, exhibitions, and educational programs that enhance the public understanding of science—and today welcoming some five million visitors a year.

This spring, as we launch our 150th Anniversary celebration, we reflect on that glorious history of discovery and the generations who have been inspired by our work. A lot has changed since 1869, of course, but what hasn't changed is the Museum's mission of advancing and sharing science and providing learning opportunities to people of all ages and backgrounds, ever seeking new, more effective and exciting ways to do so. I hope you will participate in the many events coming up as we celebrate not just the Museum's legacy, but also the limitless possibilities ahead.

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ROTUNDA

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D. Finnin/© AMNH

Space or Dino Questions? New Video Series Has Answers



Museum scientists Jackie Faherty and Aki Watanabe answer frequently-asked science questions in the Museum's new web video series, "Space vs. Dinos."

Have you ever wondered how astronomers find new planets? Or how paleontologists uncover fossils?

A new web video series on the Museum's website and YouTube channel featuring Museum astrophysicist Jackie Faherty, senior scientist and senior education manager, and Aki Watanabe, a resident research associate in the Division of Paleontology, tackles these and other frequently-asked questions about two persistently popular topics: space and dinosaurs.

It's no accident that space and dinosaurs have a firm hold on our collective imaginations. Both astronomers and paleontologists work to solve ancient mysteries featuring awe-inspiring scales of size and time. And both fields continue to yield new and exciting discoveries, whether it's new species like the titanosaur *Patagotitan mayorum* (see p. 16 for details about the May 1 SciCafe with Diego Pol, part of the team that identified this colossal animal), or new observations about our home galaxy (on p. 15, find out about the April 23 Hayden Planetarium program with Jackie Faherty, who will share how the latest data from the Gaia mission is helping astronomers map the Milky Way).

Whether through programs or exhibitions such as *Beyond Planet Earth: The Future of Space Exploration* (2012) or this year's *T. rex: The Ultimate Predator*, not to mention world-renown collections in each area, the Museum has a long tradition of bringing the latest from each field to the public. The new video series, named "Space vs. Dinos," serves up some of this expertise in snackable battle-style rounds on loosely-linked topics in astrophysics and paleontology.

Fittingly, the first "round" launched on YouTube with two episodes about the original cosmic connection between the two "adversaries": the massive asteroid that struck Earth 66 million years ago, shortly before non-avian dinosaurs vanished from the planet.

Over the course of the series, Faherty and Watanabe take viewers on short scientific sprints through such vital questions as whether there is life elsewhere in the universe (spoiler alert: probably!) and how long a *T. rex* lived (long enough to reach the top of the food chain, if it was lucky). Tune in to see for yourself!

Watch "Space vs. Dinos" on [YouTube.com/AMNH](https://www.youtube.com/AMNH) or amnh.org.

© AMNH

WORLD-CLASS COLLECTION

This specimen is one of an estimated 500,000 ammonites in the Museum's collection, the third largest in the world. Approximately 300 come from Madagascar, including some from the Jurassic Period. Says Curator Neil Landman, "What makes the Malagasy ammonites unique is their superb preservation with their original nacreous shell, their sheer abundance, numbering in the tens of thousands, and their diversity comprising hundreds of species."

SHELL GAME

Despite their resemblance to the extant nautilus, ammonites had a much more convoluted shell structure. (The shell's name is derived from the ram-headed Egyptian god Amun, whose horns are similarly shaped.) Its internal system of chambers and a tube or siphon allowed the animal to maintain near-neutral buoyancy in the water column.

BEAUTY TRADE

Ammonites are prized as a naturally occurring gemstone, like amber and pearl. In life, the ammonites would not have displayed the iridescence seen in some fossil specimens—that is the product of heat, pressure, and weathering over time. In commercial pieces, the shell is often cut in half and polished to a high sheen.

Puzosia saint-oursi
Collection #054209



Malagasy Ammonites

At first glance the steely gray shells of ancient Malagasy ammonites might look like nondescript stones. But look more closely—and inquire a little more deeply—and you'll find, to quote the poet Walt Whitman, these fossils "encompass worlds."

The specimen pictured below is *Puzosia saint-oursi*, a species found in the Mahajanga Province of Madagascar that dates from the Early Cretaceous, around 100.5–113 million years ago. It offers a unique window into what ocean life was like during the specific period in which it lived, as well as possible clues to how these abundant marine animals went extinct. They perished along with 75 percent of all animals on Earth, after a giant asteroid crashed into what is now Yucatán some 66 million years ago, creating ash fallout that increased the acidity of the world's oceans.

"Scientists refer to the Cretaceous Period as 'greenhouse Earth' because of parallels in climatic conditions then—higher temperatures, warming seas, carbon levels in the atmosphere—and where we are headed based on the evidence for global climate change," says Neil Landman, curator in the Division of Paleontology. And ammonites, he says, "are the organisms that can tell us about the Cretaceous world."

Using scanning electron microscopes, researchers can clearly see the inner structures of the shells and, with chemical tests of a small chip, analyze them for oxygen and carbon isotopes. The ratio of each type of isotope points to the acidity of the water in which the animals lived, as well as at which depth, and how they handled changes in the water's temperature. "They retain their whole life history in their shell," says Landman.

Landman and his team are working to understand why ammonites became extinct while their less diverse and less populous cousins, the nautilids, survived. Unlocking this puzzle may provide information about how marine life today might cope—or fail to cope—with the increasingly altered conditions of today's oceans.

Malagasy ammonites will be among the featured specimens on display in the new Gilder Center for Science, Education, and Innovation's Collections Core.

C. Chesek/© AMNH



Male Cerulean Warbler
(*Setophaga cerulea*)

Springtime Sighting

One of the more sought-after sightings during the Museum's Spring Bird Walks in Central Park is the Cerulean Warbler (*Setophaga cerulea*), a tiny songbird whose spring migration range includes New York City.

"It is a beautiful warbler," says Paul Sweet, collections manager in the Department of Ornithology, who leads walks on Tuesdays and Fridays. "They are a challenge to spot as they tend to hang out high in the canopy of deciduous trees."

True to their name, male Cerulean Warblers are blue above and have a distinctive dark blue neckband and white breast. Females are also colorful, with bluish-green or olive green coloring on their heads and backs and a yellow or white eyebrow stripe.

The birds winter in evergreen forests, woodlands, and shade coffee plantations on the eastern slopes of the northern Andes, from Venezuela and Colombia down through Ecuador and Peru. In spring, they make their way to breeding grounds that span from the southeastern and south central United States to Ontario in the northeast.

Mating pairs will choose their nesting spot together, looking for a branch where clumps of leaves conceal the nest from above, which can be anywhere from 16 to 115 feet above the ground in tall mature trees including white oaks, cucumber magnolias, and sugar maples.

Female Cerulean Warblers have a curious way of tumbling from their nests that some have compared to bungee jumping: they drop, wings tucked to their sides at first, then spread them to glide parallel to the ground when well below the nest.

Other birds "skydive," too. Writer Annie Dillard once suddenly came upon a Northern Mockingbird doing such a dive, and concluded, "The fact of his free fall was like the old philosophical conundrum about the tree that falls in the forest. The answer must be, I think, that beauty and grace are performed whether or not we will or sense them. The least we can do is try to be there."

Lunchtime Bird Walks through Central Park begin April 2. See details on p. 14.

Jim Zipp/Science Source

PAINTERLY NAME

Cerulean is a shade of blue often used in the names of pigments for paint or drawing. It means "sky blue," and its roots can be traced to the Latin word *caeruleus*, which means "dark blue," but interpretations vary widely. Pantone's Cerulean Blue, for instance, is a soft gray-blue pastel, while the Crayola crayon is bold and bright.

BREEDING GROUNDS

While Cerulean Warblers can be seen traveling through Central Park, you won't find nesting pairs there. They breed nearby in the Hudson Highlands. Local birders agree one of the best places to look for the nesting Cerulean Warblers is along Doodletown Road in Bear Mountain State Park in Rockland County, New York.

BUILDING MATERIALS

Females build a cup-shaped nest from bark fibers, grass stems, and mosses, binding it together with spider webs and adding white lichens as a final embellishment. Males have been known to help gather the spider webs, an especially valuable commodity, as females forced to rebuild a nest will gather fresh lining but recycle the spider web.

CROWDED CANOPY

Cerulean Warbler populations declined by 72 percent between 1970 and 2014, mainly due to loss of habitat, as mature forests were broken up by human activity. The fragmented canopy may be making them more vulnerable to Brown-headed Cowbirds, which lay their own eggs in the warblers' nest, forcing them to rear cowbird hatchlings, often at the expense of their own.

The Carnivore's Dilemma

How do paleontologists find out what *T. rex* ate for dinner?



Above: *The Museum's T. rex fossil skeleton.*

Right: *T. rex coprolite specimens reveal that this massive carnivore could crush and digest bone.*

With 11-inch-long teeth and a fierce bite,

Tyrannosaurus rex is the very model of a Mesozoic predator, as visitors can discover in the new exhibition *T. rex: The Ultimate Predator*. But what did the dinosaur, famous for being at the top of the food chain, actually eat? To decipher an ancient diet, scientists use some creative forensics—and search for evidence from a number of different angles.

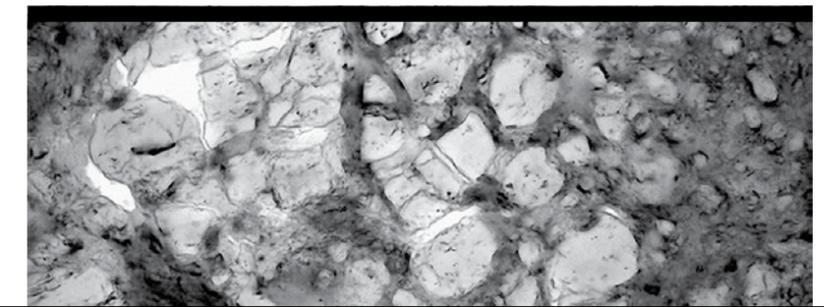
Scat Scan

One place to look for clues about what an animal like *T. rex* ate is in its stomach. Lacking that, paleontologists can also analyze the contents from a later stage in the digestive process: its waste. Fossilized remains of the latter, known as coprolites, can reveal not only what an animal has eaten but how it consumed its prey.

In the *T. rex* case, the big break came in 1998, in Saskatchewan, Canada. Paleontologists discovered a rare, 1.5-foot-long coprolite that only could have been produced by a very large carnivorous dinosaur like *T. rex*.

Analyzing the fossil, researchers found that it contained high levels of phosphorus and that 30 to 50 percent of the specimen was composed of bone fragments—some as small as grains of sand—from a young animal. The contents helped scientists confirm what its impressive anatomy had long indicated: *T. rex* could crush and digest large amounts of solid bone.

“Certainly, from a biomechanical perspective, that’s what you’d expect,” says Mark Norell, Macaulay Curator of Paleontology and curator of *T. rex: The Ultimate Predator*. “Its entire skull and entire neck are just built for massive, crushing bite force.”



Dilong paradoxus evolved around 40 million years after the first tyrannosaur, and it was the first to be found with fossilized feathers.

Check Scars and Wounds

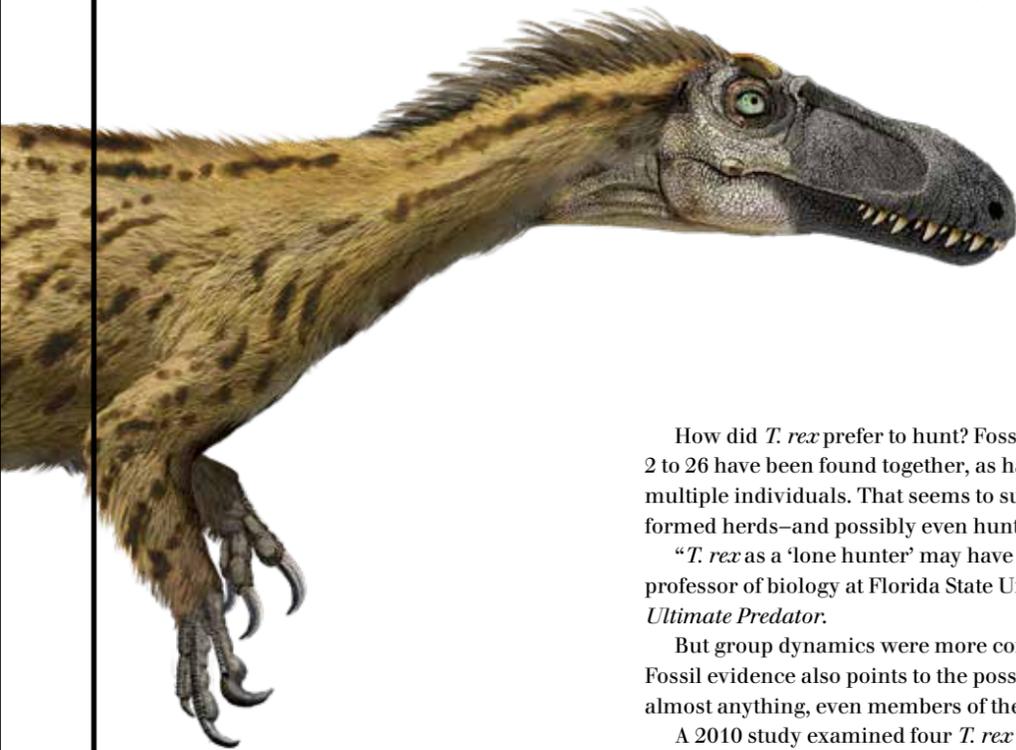
Bones don't have to be found inside a *T. rex* stomach, or in its feces, to tell part of this apex predator's story.

Just as forensic investigators might examine a victim's injuries at a crime scene, paleontologists look for bite and scratch marks on fossilized skeletons of other animals for evidence of attempted attacks.

For instance, researchers have uncovered a *T. rex* tooth embedded deep in the tail bone of a duck-bill dinosaur. The duck-bill dinosaur managed to escape—and, in fact, lived long enough for new bone to grow around the puncture wound.

Still, the scar on its skeleton offers paleontologists some valuable insight. It's evidence that *T. rex* wasn't simply a scavenger: it actively hunted live prey, including sizable vertebrates like *Edmontosaurus annectens*, which could grow to be almost 10 feet tall and up to 7,700 pounds.

Apex predators like *T. rex* can't count on every hunt resulting in a meal, since the catch hinges on a number of factors, including type of prey or time of day. Lions, for example, succeed less than 20 percent of the time when they hunt on their own, but more than 30 percent when they hunt as part of a group.



T. rex as a 'lone hunter' may have been a myth.

Gregory Erickson

Professor of Biology at Florida State University

How did *T. rex* prefer to hunt? Fossils from tyrannosaurs ranging from ages 2 to 26 have been found together, as have *T. rex* trackways with footprints from multiple individuals. That seems to support the idea that this species may have formed herds—and possibly even hunted together.

"*T. rex* as a 'lone hunter' may have been a myth," says Gregory Erickson, professor of biology at Florida State University and consultant on *T. rex: The Ultimate Predator*.

But group dynamics were more complicated than collaborative hunting. Fossil evidence also points to the possibility that some tyrannosaurs would eat almost anything, even members of their own species.

A 2010 study examined four *T. rex* specimens that bore tooth marks that could only have been made by another tyrannosaur. The "puncture and pull" direction of the marks were a close match to previous bites attributed to *T. rex*, and the location and types of wounds—repeated, to feet and arms—suggested feeding, not fighting.

And unlike the lucky *Edmontosaurus* that got away, these *T. rex* specimens showed no signs of healing, suggesting that the bites were inflicted after the animals had already died.

NOW OPEN

T. REX: THE ULTIMATE PREDATOR

Look at Life Cycle and Family

Evidence of a scavenging *T. rex* is a reminder that, like all animals, *T. rex* didn't hatch as a 40-foot, nearly 15,000-pound giant. It had to survive a childhood and adolescence without its fully formed, bone-crushing skull and jaws—and find its food where it could.

With different bodies and teeth, hatchlings and juveniles would have occupied different niches in their ecosystem along the way, with their diets changing as they grew, much like animals do today.

Juvenile *T. rex* teeth would have been much more like a lot of other carnivorous dinosaurs—little miniature steak knives on the side of the skull, as opposed to big bone-crushers.

Mark Norell

Macaulay Curator of Paleontology

Norell points to the world's biggest lizard, the Komodo dragon, as an example of the various ways a single species functions in its environment over its lifetime.

"Juvenile Komodo dragons live in trees, and when they get to about one-third of their adult size, they start living on the ground. Each of those different zones have different diets," he says. "After they hatch, they feed primarily on insects and small reptiles, and when they're teenagers, they become active predators, eating small mammals. When they're adults, they feed on giant pigs."

The body, behavior, and diet of a juvenile *T. rex* likely had a lot in common with its smaller ancestors, such as *Dilong paradoxus*, which evolved about 40 million years after the first known tyrannosaur, *Proceratosaurus*.

Like many early tyrannosaurs, the arms of *Dilong* were relatively long and capable of seizing small prey. It also had thin, bladelike side teeth, unlike the thick teeth of an adult *T. rex*—indicating a very different diet.

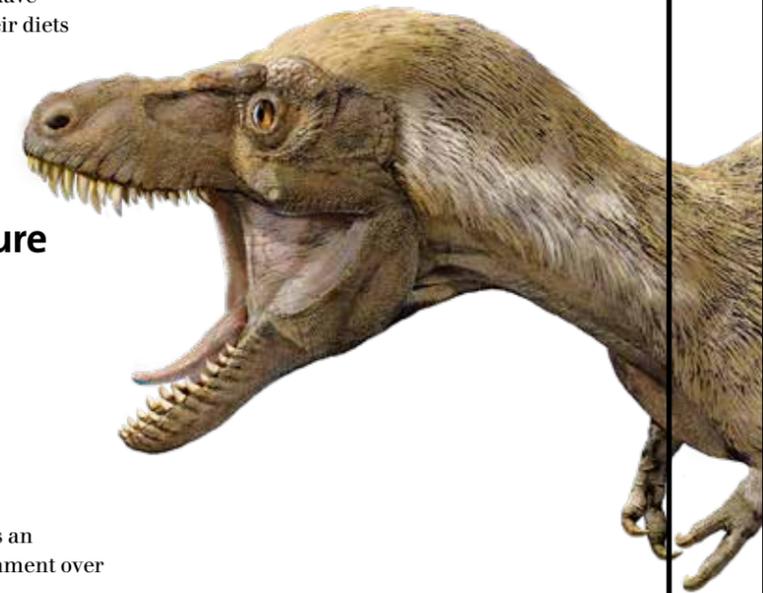
"Juvenile *T. rex* teeth would have been much more like a lot of other carnivorous dinosaurs, little miniature steak knives on the side of the skull, as opposed to big bone-crushers," says Norell. Insects and small lizards would have been likely prey.

As *T. rex* grew into its apex predator body form, its teeth and diet changed, too—a trajectory biologists see today when they look at alligators. As small hatchlings, their bladelike teeth are good for snacking on insects and small fishes. Then they'd mature into turtle-shell-crunching machines with acorn-shaped back teeth.

So, to get back to the original question: what did the full-grown, apex-predator, top-of-the-food-chain *T. rex* actually eat with its bone-crushing molars? That, as it happens, is still to be determined.

"The study of *T. rex* is still a very active scientific endeavor," says Norell.

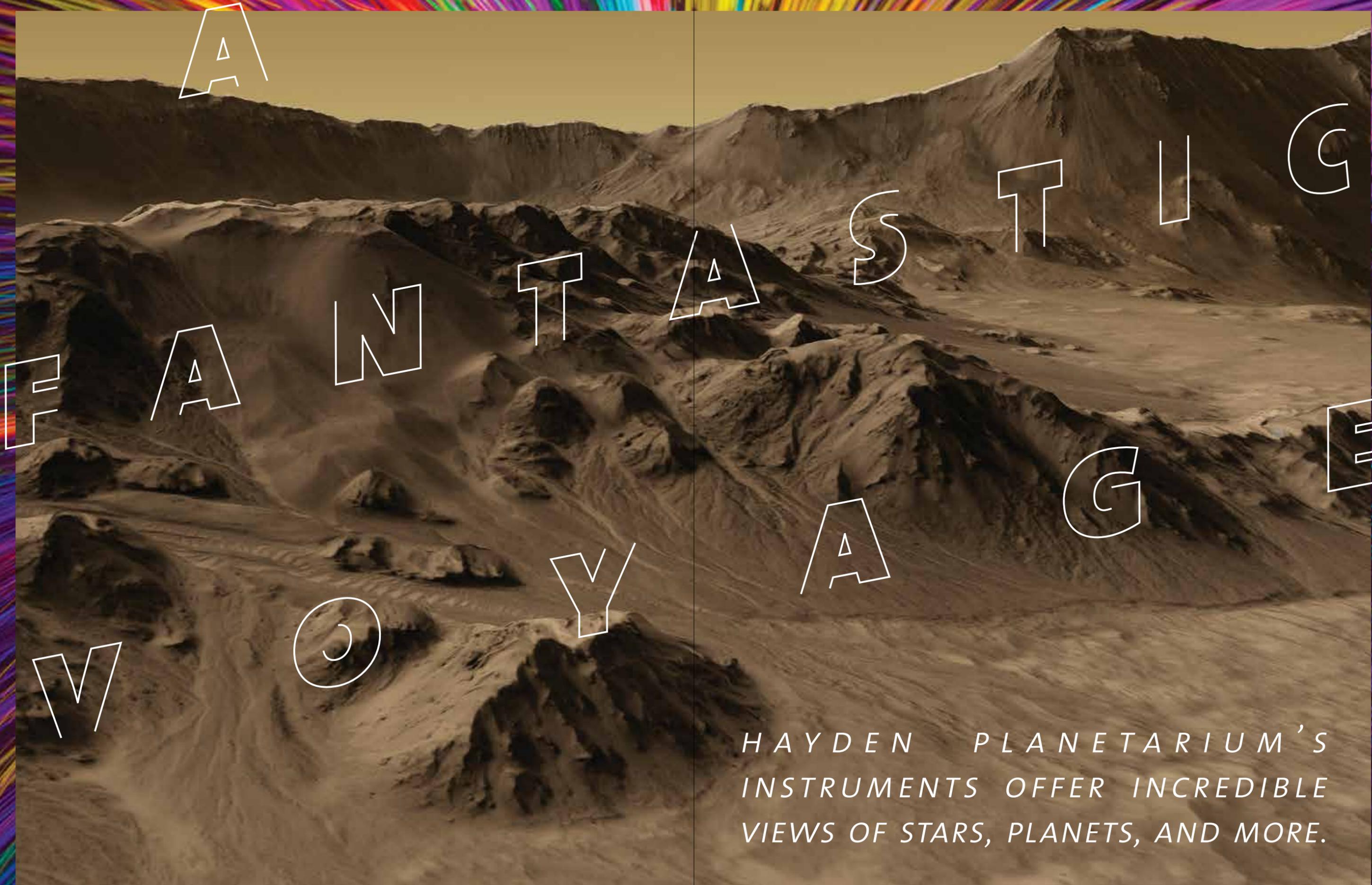
"We're currently looking at a couple of different things—and one is that we're going to need more high-resolution CT scans of *Tyrannosaurus* feces, to actually see if we can figure out what kinds of animals it was eating." 🦖



Juvenile *T. rex* shared distinctive features, like longer arms and thin side teeth, with smaller tyrannosaur ancestors like *Dilong paradoxus*.

Page 6-7: C. Chesek/AMNH; Karen Chim/specimen belongs to the Royal Saskatchewan Museum (Saskatchewan, Canada)
Page 8-9: Illustrations by Zhao Chuang; Courtesy of PNSO

Members see *T. rex: The Ultimate Predator* for free.



*HAYDEN PLANETARIUM'S
INSTRUMENTS OFFER INCREDIBLE
VIEWS OF STARS, PLANETS, AND MORE.*

YOU'RE LOOKING OUT OVER A ROCKY, dusty valley, at a series of jagged peaks on the horizon. If you've ever visited the American Southwest, the terrain may seem vaguely familiar. But this landscape isn't on our continent. It isn't even on our planet.

You're looking at the latest visualizations of Mars' surface from the perspective of the Curiosity rover. And the best part: you don't even have to leave New York City to get this close.

This scene is what visitors saw during a recent program in the Hayden Planetarium's Astronomy Live series, as Director of Astrovisualization Carter Emmart fed the rover's data through an open source software platform called OpenSpace, rendering it in three spectacular high-resolution dimensions onto the dome's 68-foot-diameter convex screen—which appear even more brilliant now that the Planetarium has been outfitted with new state-of-the-art projectors. “OpenSpace hopes to take a sense of discovery that is usually reserved for those in mission control and make it a shared one,” says Emmart.

BEST WAY TO SEE THE STARS

OpenSpace is just one of the cutting-edge tools that scientists at the Museum are using to visualize space for visitors, students, and other researchers.

Want to spend an hour under the glowing light of the night sky in the Chilean desert? Or see the Milky Way unobscured by light pollution? The Zeiss star projector can make it happen.

Specially designed for the Hayden when it was installed in 1999, this instrument creates hyper-realistic views of the sky from Earth, allowing viewers to trace constellations and track the motion of planets and stars. It was used in 11 Museum programs last year and will be featured in “Under the Southern Cross,” an Astronomy Live program coming up on May 28 that will show visitors the skies over the Southern Hemisphere.

Of the various platforms used to visualize space in the dome, “it wins out for the sheer beauty of the stars—they twinkle! Nothing else comes close,” says astrophysicist Jackie Faherty, a senior scientist and senior education manager at the Museum.

PICTURE-PERFECT SPACE SCENES

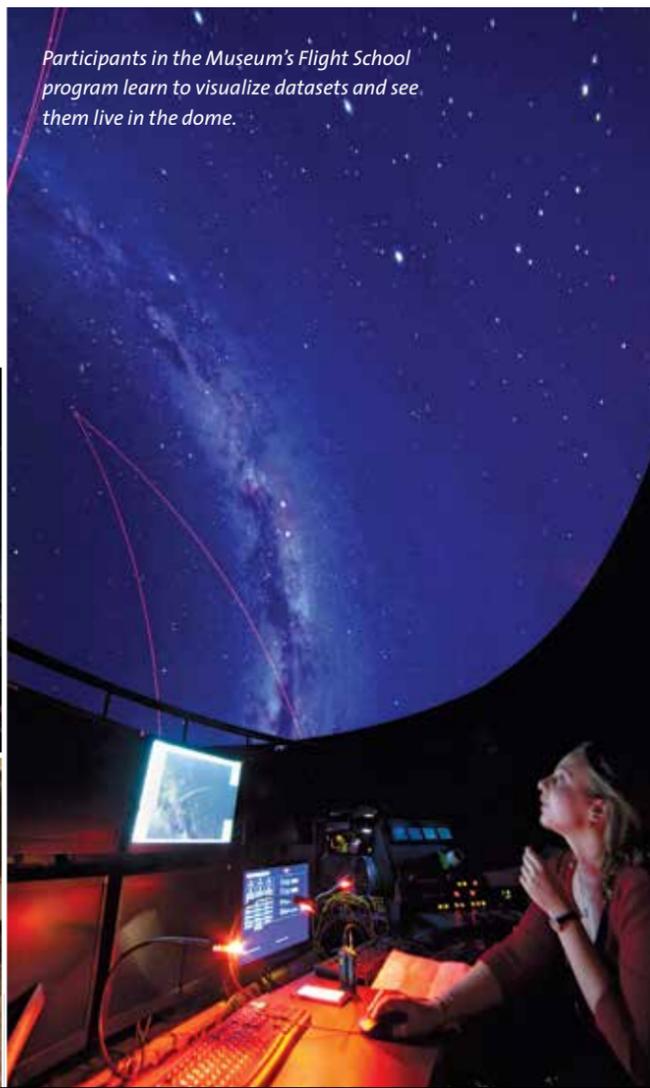
Want to go farther? How about a tour of the solar system?

The Museum's Space Shows and many of the Hayden Planetarium programs offer visitors a roundtrip ticket to explore our galactic neighborhood through the Digital Universe, an atlas of the cosmos developed by the Hayden Planetarium in 1998.

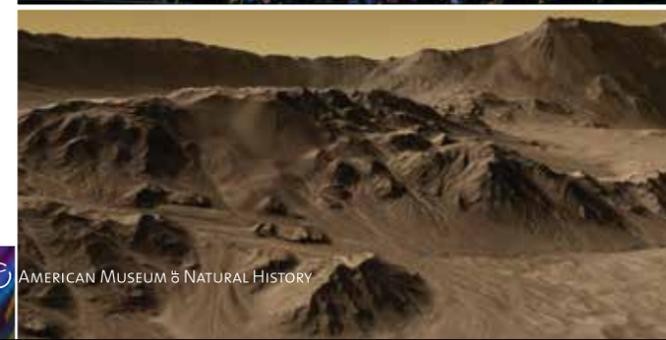
The primary advantage of Uniview—the software that renders the Digital Universe atlas accurately in three dimensions—is that it doesn't confine viewers to gazing at the stars from the ground. Instead, the interactive nature of the software lets viewers fly beyond our solar system to the edges of space.

Digital Universe uses raw data from images and measurements taken from space-based observatories and Uniview converts it into a colorful, textured, three-dimensional environment where the only limits are the edges of the known universe. And with more than 20 years to compile a curated catalog of rendered scenes, there is a beautiful set of space imagery that's regularly featured in live programs, including another Astronomy Live program, “Black Holes and the Force of Gravity,” coming up on June 25.

“Our visitors have a real hunger for knowing where they are in the universe,” says Hayden Planetarium Assistant Director Brian Abbott. “With Digital Universe's visual interpretation of astrophysical data, we can show them.”



Participants in the Museum's Flight School program learn to visualize datasets and see them live in the dome.



TOP WAY TO TIME TRAVEL

And then there's OpenSpace. Developed by a team that includes the Museum, Sweden's Linköping University, Visualization and Data Analysis (ViDA) lab at New York University's Polytechnic School of Engineering, and the Scientific Computing and Imaging Institute (SCI Institute) at the University of Utah, this next-generation visualization software is supported by NASA and available for anyone to download and use—though it's hard to beat seeing it on the Hayden Planetarium's dome.

Unlike Uniview, the code can be tinkered with to accommodate larger data sets and to create sophisticated maps to explore data through time—such as fast-forwarding one million years to see if other planetary systems will make a close flyby past our own.

Like the other instruments, OpenSpace isn't just for show—it's also a powerful research and teaching tool. “Scientists, artists, and educators are all working in the same digital medium, using many of the same softwares tools, so the line from researchers to the public is much shorter,” says Vivian Trakinski, the Museum's director of science visualization and project manager on the OpenSpace team.

Last spring, following the release of the European Space Agency's Gaia observatory's second catalog, which includes distances to 1.4 billion stars, Faherty worked with Abbott to render the Gaia data in OpenSpace. (Faherty will discuss the Gaia catalog and her work with Abbott during the the Astronomy Live program, “Gaia and the Milky Way,” on April 25.)

In June, Faherty and David Spergel, director of the Center for Computational Astrophysics (CCA), gathered 90 scientists in the Hayden Planetarium dome to fly through the data in three dimensions. “Our little computer screens on our desks are useful, but they don't do justice to this volume of data,” says Spergel.

Natalie Hinkel, a senior research scientist at the Southwest Research Institute who studies elements in stars nearest our Sun, had never visited the Hayden Planetarium before she answered Faherty's call to submit data for the June gathering. “It was unlike anything I've ever even dreamed of,” says Hinkel of seeing the data visualized in the dome. “Flying through eight years of work I'd done, it was very powerful.”

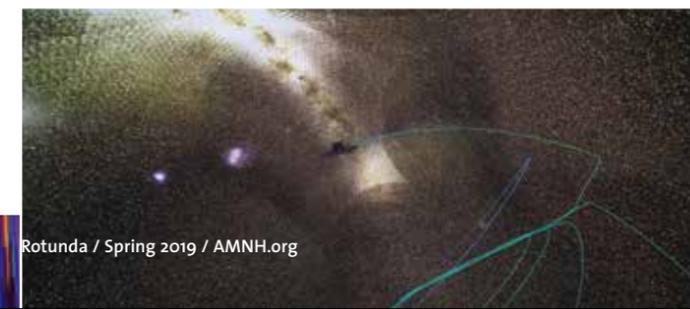
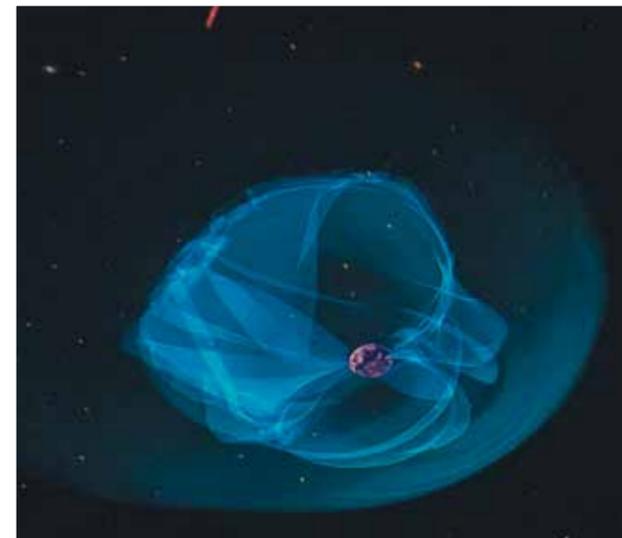
Most recently, Faherty worked with five students in the Museum's Master of Arts in Teaching program to use OpenSpace to render and analyze Gaia data. She's currently working with Helen Fellow Colleen Cleary and six of the Museum's high school student Brown Scholars to use OpenSpace to visualize brown dwarfs.

“I'm excited for my students to try it,” says Cleary. “For them to be able to see what they've been working with up on the dome adds a different aspect to working with code, and it also teaches them a new skill.”

“Plus, where else do you get to drive around the universe but here?” she says. ☺

Space: Now Darker Than Ever

The next time you're in the Hayden Planetarium, sit back and enjoy the widest color gamut of any planetarium in the world. With a first-of-its-kind planetarium projector system installed in February, the Hayden Planetarium now boasts not only a world-class way to show the universe's bright spots, but a world-leading ability to reveal its darkest depths. That's because the projectors' contrast ratio—the difference between the brightest and darkest image—in the dome has jumped from 7,000-to-1 to an astronomical 1,000,000-to-1. And with higher resolution and speed, even a hard-to-improve-on shooting star now looks... well, starrier. “You'll see a star streak, not a star smear,” says Benjy Bernhardt, the Museum's senior director of electronic media engineering.



Programs and Exhibits

For more programs and to purchase tickets, visit amnh.org/calendar.

For updates and reminders, sign up for monthly Calendar Highlights for Members by sending your membership number and request to subscribe to members@amnh.org. The Museum does not trade, rent, or sell this information.

Tickets

Tickets are available by phone at 212-769-5200, Monday–Friday, 9 am–5 pm, or by visiting amnh.org. Please have your membership number ready.

Availability may be limited. Please purchase tickets in advance.

Please be aware that ticket sales are final for all Member programs. All programs go ahead rain or shine. There are no refunds unless the program is canceled by the Museum.

Please check amnh.org for Member ticket prices for live animal exhibits and giant-screen 2D and 3D films.

Information about programs is current as of February 21, 2019. Please check amnh.org/calendar for updates.



APRIL

Lunchtime Bird Walks begin Wednesday, April 2

\$50

Join us for walks through Central Park to observe birds migrating north this spring. Learn how to identify bird species using field marks, behavior, and song.

SciCafe: The Microbial Worlds of the Deep Sea

Wednesday, April 3
Doors open at 6:30 pm,
program begins at 7 pm
Free

For adults 21+

In an attempt to understand the limits of life on Earth and beyond, geobiologist **Jeffrey Marlow** studies the unusual ways microbes can obtain energy and nutrients. Hear how he has followed extreme microorganisms to deep-sea vents, active volcanoes, and acidic rivers. Why is it important to consider microbes in marine conservation efforts? Marlow explains how deep-sea microbial communities control the distribution of the potent greenhouse gas methane, how these organisms might mitigate climate change, and how they can be used for biofuel production.

Hall Tour: North American Mammals

Saturday, April 6
10:30 am or 1:30 pm
Free

Registration required;
call 212-769-5200

Join an expert guide on a tour of the spectacular Bernard Family Hall of North American Mammals. Learn about the diversity of North American flora and fauna by exploring some of the continent's most stunning landscapes, depicted in vivid detail within the hall's 43 dramatic dioramas. Visit beloved National Park sites like the Grand Canyon, Great Smoky Mountains, and Yosemite National Park, and learn about many of the 46 featured mammal species, from the Alaska Brown Bear to the Wapiti.



Illustration by Zhao Chuang; Courtesy of PISO, D. Finnin/©AMNH, ©AMNH, D. Finnin/©AMNH, M. Shanley/©AMNH, ESO/S. Brunier R. Mickens/©AMNH, ALMA (ESO/NAOJ/NRAO), M. Shanley/©AMNH, ESO/S. Brunier

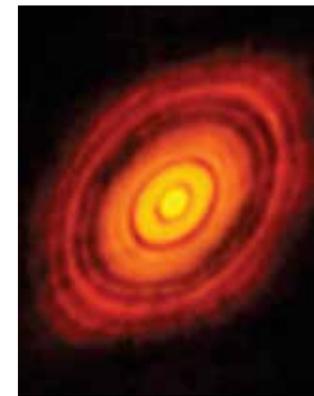
T. rex: The Ultimate Predator Free

Everyone knows *Tyrannosaurus rex*. But do you know how this mega-predator evolved to become the most fearsome carnivore of the Mesozoic? Meet the entire tyrannosaur family through fossil casts and life-sized models of hatchlings, juveniles, and full-grown, towering *T. rex*, with engaging interactives that will reveal the amazing story of this iconic dinosaur.



Unseen Oceans Free

Meet the elusive giants of the sea, including whales, sharks, and giant squid; sink beneath the waves in a virtual submersible theater; and marvel at the vivid fluorescence displayed by marine creatures but invisible to us—until now.



The Golden Age of Star Formation

Monday, April 8

7:30 pm

\$12

Join Astrophysics Curator **Mordecai-Mark Mac Low** on a journey from the birth of the very first stars to the formation of our own Sun and solar system in the Milky Way galaxy. Explore the golden age of star formation 10 billion years ago, when stars were forming at ten times the rate today. See the planet-forming disks revealed by the high-resolution radio telescope ALMA, and learn where to look for newly forming stars in the night sky.



EarthFest

Saturday, April 13

Beginning at 7 am

Free

From early-morning yoga to special performances, visitors will be immersed in art, science, and culture at this festival honoring Earth Day. Participate in hands-on activities, join surprise guest stars on our main stage, and celebrate the beautiful planet we call home.

Gaia and the Milky Way

Tuesday, April 23

7 pm

\$12

The Gaia space telescope recently released its second catalog of over 1.4 billion stellar distances, which is helping astronomers visualize the universe and map the Milky Way like never before. Join Museum astrophysicist **Jackie Faherty** to explore the data in this immersive full-dome experience.



Accessibility Programs

To learn more, email accessibility@amnh.org or call 212-313-7565.

Visitors who are blind or partially sighted are invited to attend tours highlighting exhibits through verbal descriptions and touchable objects. The Museum also offers tours for both deaf and hearing audiences that are simultaneously signed and spoken. And our Discovery Squad Tours were developed specifically for families affected by autism spectrum disorders.

Discovery Room

Free

Monday–Thursday, 1:30–5:30 pm
Saturday, Sunday, and public
school holidays, 10:30 am–1:25 pm
and 2:15–5:10 pm

The Discovery Room offers families, and especially children ages 5–12, an interactive gateway to the wonders of the Museum and a hands-on, behind-the-scenes look at its science.

Gateway Storytime

Free

On Friday mornings during the school year, children ages 2–5 are invited to the Discovery Room for storytime. Space is limited and tickets are distributed on a first-come, first-served basis.

The Butterfly Conservatory Free

This popular live-animal exhibition features up to 500 free-flying tropical butterflies from the Americas, Africa, Asia, and Australia. Housed in a tropical vivarium with flowering plants, see iridescent blue morphos, striking scarlet swallowtails, and more.



Oceans: Our Blue Planet

Embark on a global odyssey to discover the largest and least explored habitat on Earth. New ocean science and technology has allowed us to go further into the unknown than we ever thought possible. From the coastal shallows to deeper, more mysterious worlds, we reveal the untold stories of the oceans' most astonishing animals. Captioning and audio devices are available.





Animal Encounter: Wild Babies
Saturday, April 27
 11 am (recommended for families with younger children), 1 pm, 3 pm
\$15
 Spring is the season for new discovery and the beginning of new life for creatures around the world. Meet some of nature's cutest youngsters and learn how they adapt to their unique habitats. **Grant Kemmerer**, wildlife expert and animal caretaker from the Wild World of Animals, will introduce you to a diverse group of babies, large and small, from across the animal kingdom.

MAY
SciCafe: Why Dinosaurs Matter
Wednesday, May 1
 Doors open at 6:30 pm, program begins at 7 pm
Free
For adults 21+
 Are penguins related to dinosaurs? Are the tiny arms of *T. rex* the key to its power and ferocity? What can long-dead dinosaurs teach us about our future? Plenty, according to paleontologist **Diego Pol**, who has discovered some of the largest dinosaurs ever to walk the Earth, including *Patagotitan mayorum*, the species exhibited at the Museum as The Titanosaur. Pol weaves together stories of our planet's geological history, exploring the meaning of fossils and our own place on the vast and bountiful Tree of Life.



A Night at the Museum Sleepover
Friday, May 3, 10, and 17
 6 pm–9 am (recommended for families with children 6–13 years old)
\$140
Registration required; call 212-769-5200
 As the doors close and the lights dim, you and your group will head out with flashlights in search of a variety of adventures. Meet your relatives in the Hall of Human Origins. Climb the stairs and enter the age of dinosaurs, standing beneath a fearsome *T. rex*. Settle down beneath the 94-foot-long blue whale, next to African elephants, or at the base of a striking volcanic formation, and fall asleep in the darkened halls of one of the world's most beloved museums.



Hall Tour: Ocean Life
Saturday, May 11
 10:30am and 1:30 pm
Free
Registration required; call 212-769-5200
 Explore the Museum's Irma and Paul Milstein Family Hall of Ocean Life with an expert guide to learn more about the making of the Museum's iconic cantilevered 94-foot-long, 21,000-pound blue whale model. Dive below the surface and travel from vibrant coral reefs to the oceans' remote depths, and behold more than 750 spectacular marine animals along the way.

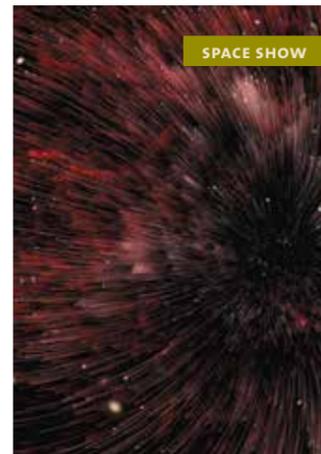
Courtesy Arise Media/Archipelago Films, R. Mickens/©AMNH, © NASA/Cassini, ©AMNH, © NASA/JPL, © NASA/JPL-Caltech, C. Chesek/©AMNH, D. Finnin/©AMNH

Backyard Wilderness
 Discover the unexpected wonders of nature that are in our own neighborhoods and communities. See animal inhabitants in rare and breathtaking detail, moving along forest floors and pond bottoms, captured by cameras mounted inside dens and nests. Captioning and audio description devices are available.



2D AND 3D
 CLOSING APRIL 30

Dark Universe
 Narrated by Neil deGrasse Tyson, Frederick P. Rose Director of the Hayden Planetarium, this Space Show celebrates pivotal discoveries and the cosmic mysteries that remain. Gaze up at the Milky Way from Mt. Wilson Observatory in California, plunge into Jupiter's atmosphere with a NASA probe, and find out what scientists are learning about dark matter and dark energy. Captioning devices are available.

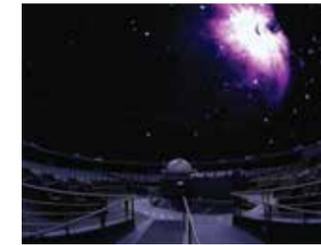


SPACE SHOW



Cassini, Explorer of the Outer Solar System
Monday, May 13
 7:30 pm
\$12
 The extraordinary Cassini spacecraft ended its 13-year mission in 2017 with a fiery plunge into Saturn. Its reach extended across our solar system's distant sixth planet and the objects in its orbit. Planetary scientist **Jani Radebaugh** discusses the storms and structures Cassini revealed in Saturn's colorful atmosphere, the movement and order of its complex rings, and the surfaces of its moons.

Milstein Science Series: Ocean Babies
Sunday, May 19
 11 am–4 pm
Free
 Seahorses pop from their fathers' pouches, Emperor Penguins carry eggs on their feet, catfish guard their young in their mouth, and killer whales stay with their pods for life. For many animals, the relationship between parent and child is one of the most vital and important factors for survival. Learn all about the youngest animals that live beneath the sea and the parenting strategies used to keep them safe.



Under the Southern Cross
Tuesday, May 28
 7 pm
\$12
 Journey to the skies of the Southern Hemisphere with presenters **Joe Rao** and **Irene Pease** without leaving the Hayden Planetarium. See how the stars over New York shift gradually northward and view constellations like the Crux, also known as the Southern Cross, which twinkles in the dome with the Museum's Zeiss Mark IX star projector.

Field Trip to the Moon
Wednesday, May 29
 6–6:30 pm, 6:45–7:15 pm
\$8 for children; \$12.50 for adults
 Join us for a virtual trip to the Moon in the immersive Hayden Planetarium. Feel the ground shake beneath you as you experience a thrilling NASA rocket launch. Take a guided tour of the cosmos and orbit the Earth to get an astronaut's view of a sunrise in space!



Exhibition Credits
 Major funding for *T. rex: The Ultimate Predator* provided by the **Lila Wallace-Reader's Digest Endowment Fund**.
 Generous support also provided by: **Dana and Virginia Randt Chase Private Client**
 Virtual reality experience created in collaboration with **HTC VIVE**.

Lead funding for *Unseen Oceans* and its educational resources is provided by **OceanX**, an initiative of the **Dalio Foundation**.
 The **American Museum of Natural History** gratefully acknowledges the **Richard and Karen LeFrak Exhibition and Education Fund**.
Unseen Oceans is generously supported by **Chase Private Client**.

Generous support for The **Butterfly Conservatory** has been provided by the **Eileen P. Bernard Exhibition Fund**.
Dark Universe was created by the **American Museum of Natural History**, the **Frederick Phineas and Sandra Priest Rose Center for Earth and Space**, and the **Hayden Planetarium**.

The **Museum** also gratefully acknowledges major funding from the **Charles Hayden Foundation**.
 Presented with special thanks to **NASA** and the **National Science Foundation**.
Dark Universe was developed by the **American Museum of Natural History**, **New York (www.amnh.org)** in collaboration with the **California Academy of Sciences**, **San Francisco**, and **GOTO INC**, **Tokyo, Japan**.



JUNE
Degenerates of the Universe
Monday, June 3
7:30 pm
\$12

What is a degenerate object in space? From white dwarfs to neutron stars and brown dwarfs, the universe is full of degenerate celestial objects, a classification used in physics. Museum Curator **Rebecca Oppenheimer** discusses her 25 years of research on these small but fascinating denizens of the universe.

SciCafe: The Dire Reality of Coral Mortality
Wednesday, June 5
Doors open at 6:30 pm, program begins at 7 pm
Free
For adults 21+

Why are corals dying? Marine ecologist **Jeremy Jackson** says seaweed overgrowth, pollution, disease, and climate change are all to blame. Jackson studies the effects of climate change and other factors as they are currently transforming our oceans. And while studies show a dire reality, he hopes we may find a collective solution to save the world's largest ecosystem.



A Night at the Museum Sleepover

Friday, June 7, 14, and 21
6 pm–9 am (recommended for families with children 6–13 years old)
\$140
 Registration required; call 212-769-5200

As the doors close and the lights dim, you and your group will head out with flashlights in search of a variety of adventures. Meet your relatives in the Hall of Human Origins. Climb the stairs and enter the age of dinosaurs, standing beneath a fearsome *T. rex*. Settle down beneath the 94-foot-long blue whale, next to African elephants, or at the base of a striking volcanic formation, and fall asleep in the darkened halls of one of the world's most beloved museums.



Hall Tour: Vertebrate Origins

Saturday, June 8
10:30 am or 1:30 pm
Free
 Registration required; call 212-769-5200

Join an expert guide in the Hall of Vertebrate Origins to examine some of the Museum's oldest and most remarkable fossil specimens. Travel 500 million years back in time to gain a better understanding of the origins, evolution, and diversity of life on Earth.

Dinos After Dark
Thursday, June 13
\$35
For adults 21+

Go back in time for a prehistoric party in the Museum's celebrated dinosaur halls. Toast *The Titanosaur* and enjoy an exciting evening of expert talks, hands-on activities, and after-hours access to the fossil halls. Wander freely, drink in hand, and come face-to-face with the dinos after dark.



Black Holes and the Force of Gravity

Tuesday, June 25
7 pm
\$12

Why do celestial objects orbit one another? Why do black holes have such strong gravitational pulls? Join **Jana Grcevich** and **Irene Pease** for an introduction to astronomical gravity, through the orbits in our solar system and beyond.

Program Credits:

Support for Hayden Planetarium Programs is provided by the Horace W. Goldsmith Endowment Fund.

Selected Hayden Planetarium Programs are sponsored by JetBlue.

The Milstein Science Series is proudly sponsored by the Irma and Paul Milstein Family.

Support for accessibility initiatives at the American Museum of Natural History has been provided by the Filomen M. D'Agostino Foundation.

The Discovery Room was made possible by a grant from the Edward John Noble Foundation.

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APRIL

2 TUESDAY
 Lunchtime Bird Walks begin
Special Program

3 WEDNESDAY
 The Microbial Worlds of the Deep Sea
SciCafe

6 SATURDAY
 Hall Tour: North American Mammals
Member Program

8 MONDAY
 The Golden Age of Star Formation
Hayden Program

13 SATURDAY
 Earthfest
Family Festival

23 TUESDAY
 Gaia and the Milky Way
Hayden Program

27 SATURDAY
 Animal Encounter: Wild Babies
Member Program

30 TUESDAY
Backyard Wilderness closes

MAY

1 WEDNESDAY
 Why Dinosaurs Matter
SciCafe

Oceans: Our Blue Planet opens Giant-screen film

3 FRIDAY
 A Night at the Museum Sleepover
Family Program

10 FRIDAY
 A Night at the Museum Sleepover
Family Program

11 SATURDAY
 Hall Tour: Ocean Life
Member Program

13 MONDAY
 Cassini, Explorer of the Outer Solar System
Hayden Program

17 FRIDAY
 A Night at the Museum Sleepover
Family Program

19 SUNDAY
 Milstein Science Series: Ocean Babies
Family Program

27 MONDAY
The Butterfly Conservatory closes

28 TUESDAY
 Under the Southern Cross
Hayden Program

29 WEDNESDAY
 Field Trip to the Moon
Member Program

JUNE

3 MONDAY
 Degenerates of the Universe
Hayden Program

5 WEDNESDAY
 The Dire Reality of Coral Mortality
SciCafe

7 FRIDAY
 A Night at the Museum Sleepover
Family Program

8 SATURDAY
 Hall Tour: Vertebrate Origins
Member Program

13 THURSDAY
 Dinos After Dark
Special Program

14 FRIDAY
 A Night at the Museum Sleepover
Family Program

21 FRIDAY
 A Night at the Museum Sleepover
Family Program

25 TUESDAY
 Black Holes and the Force of Gravity
Hayden Program

The Amateur's Hour

Star specimens from a hobby collection picked for exhibit



Select beetle specimens from Craig Zammiello's insect collections will be featured in the new Susan and Peter Solomon Family Insectarium.

When Craig Zammiello was growing up on Long Island, he visited a local butterfly farm and befriended the amateur lepidopterist who ran it. He started learning about insects, and about pinning specimens in a collection. Soon, he was avidly collecting insects and spiders himself.

"There's something about the structure, the design, the colors," says Zammiello, who became an artist and master printer. "Mimicry, camouflage fascinate me. There's beetles mimicking wasps, moths mimicking bees, grasshoppers mimicking walking sticks—these things fascinate me."

Over the years, as Zammiello's collection grew, he focused on learning the proper way to pin and display insects and arachnids. He also found a home away from home at a popular natural history emporium, Maxilla and Mandible, located on Columbus Avenue near the Museum until 2011. Through the owners, he met Museum staff and exhibition artists—and became known for his wide-ranging, exquisitely kept beetle and spider collection, as well as for his skill with specimen preparation. He even worked on some of the spiders now on view in the Hall of Biodiversity, using what were, at the time, new techniques for specimen display.

Now, as the Museum finalizes plans for exhibits in the new Susan and Peter Solomon Family Insectarium scheduled to open as part of the new Richard Gilder Center for Science, Education, and Innovation, some of the specimens from Zammiello's own decades-in-the-making collection are finding their way to the Museum. After Vice President of Exhibition Lauri Halderman met Zammiello at the annual Insect Day at the New York Hall of Science, she and Curator David Grimaldi realized that his pinned specimens would be a perfect way to encourage visitors to look closely at these small, fascinating animals.

"Craig's specimens are of particularly beautiful beetles and some other insects, with the appendages expertly arranged for display," says David Grimaldi, curator in the Division of Invertebrate Zoology. "His collection will be terrific for exhibition."

The new Insectarium, which will include more than a dozen species of live insects and physical and digital models in addition to pinned specimens, will focus on the vital role insects play in the world's ecosystem—and remind us humans that, despite their diminutive size, insects affect our planet on a grand scale.

"The fact that my collection is going to be in the halls of the place of which I grew up in awe—and which I think is the keystone of New York City—is probably the cherry on top of my life," says Zammiello.

M. Shanley ©AMNH



T. rex Revealed

As the Museum celebrates its 150th anniversary, each issue of *Rotunda* will bring you some little-known facts about the Museum's best-known exhibits. Here we peel back the layers on the discovery and display of *Tyrannosaurus rex*, the "tyrant lizard king" that has thrilled visitors for more than a century.

FRANCHISE FOSSIL

Chip Kidd, a graphic designer, was inspired by the Museum's *T. rex* and a book he bought featuring a Museum rendering to create the iconic image for Michael Crichton's mega-hit *Jurassic Park*. Using a transparency and a rapidograph pen, Kidd reworked the rendering into the terrifying silhouette now widely recognized around the world.

NOW OPEN

T. REX: THE ULTIMATE PREDATOR



WALKING WOUNDED

Many fossilized remains of *T. rex* feature evidence of wounds sustained in life, and the Museum's *T. rex* is no exception. It has two fused vertebrae where the neck joins the rib cage. It also has two rib-bearing vertebrae that are fused farther down the spine, and there is evidence several ribs were broken and healed over.

BONE BY BONE

The free-standing *T. rex* mount in the Hall of Saurischian Dinosaurs is about 45 percent real fossils, all of them—including the vertebrae, hips, and ribs—from a specimen found by legendary dinosaur hunter Barnum Brown at Big Dry Creek, Montana, in 1908.

HISTORIC HUNCH

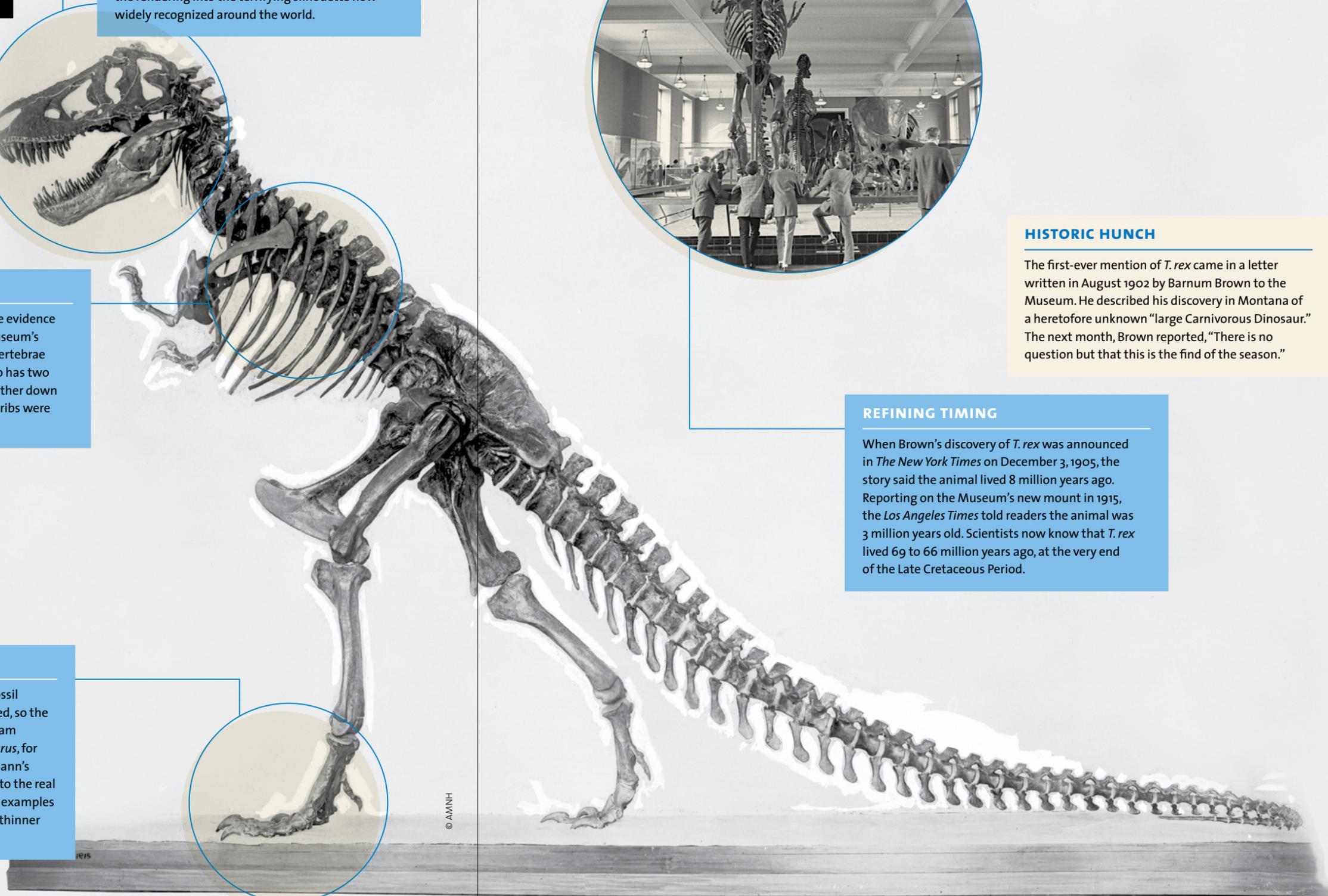
The first-ever mention of *T. rex* came in a letter written in August 1902 by Barnum Brown to the Museum. He described his discovery in Montana of a heretofore unknown "large Carnivorous Dinosaur." The next month, Brown reported, "There is no question but that this is the find of the season."

REFINING TIMING

When Brown's discovery of *T. rex* was announced in *The New York Times* on December 3, 1905, the story said the animal lived 8 million years ago. Reporting on the Museum's new mount in 1915, the *Los Angeles Times* told readers the animal was 3 million years old. Scientists now know that *T. rex* lived 69 to 66 million years ago, at the very end of the Late Cretaceous Period.

FANCY FOOTWORK

When the 1915 display was mounted, no fossil fragments of *T. rex* feet had been discovered, so the feet were hand-sculpted by preparator Adam Hermann using another carnivore, *Allosaurus*, for reference. The shape and position of Hermann's three-toed feet ended up being very close to the real thing. When researchers eventually found examples of *T. rex* fossil toes, they were only slightly thinner than Hermann's handiwork.



Membership

Central Park West at 79th Street
New York, New York 10024-5192
amnh.org



D. Finnin/AMNH



The teeth of an adult *T. rex* were capable of crushing the bones of its prey. Visit the special exhibition *T. rex: The Ultimate Predator*—free for Members—and flip to p. 6 to find out more about how, and what, this animal ate.

General Information**HOURS**

Museum: Open daily, 10 am–5:45 pm;
closed on Thanksgiving and Christmas.

ENTRANCES

During Museum hours, Members may enter at Central Park West at 79th Street, the Rose Center/81st Street, and through the subway (lower level).

RESTAURANTS

Museum Food Court, Café on One, and Café on 4 offer Members a 15-percent discount. Hours are subject to change.

MUSEUM SHOPS

The Museum Shop, Dino Store, Planetarium Shop, Cosmic Shop, *T. rex* Shop, *Unseen Oceans* Shop, and Online Shop (shop.amnh.org) offer Members a 10-percent discount.

PHONE NUMBERS

Central Reservations 212-769-5200
Membership Office 212-769-5606
Museum Information 212-769-5100
Development 212-769-5151

TRANSPORTATION AND PARKING

Subway: **B** (weekdays) or **C** to 81st Street; **1** to 79th Street, walk east to Museum
Bus: M7, M10, M11, or M104 to 79th Street; M79 to Central Park West
Parking Garage: Open daily, 8 am–11 pm; enter from West 81st Street. Members can park for a flat fee of \$10 if entering after 4 pm. To receive this rate, show your membership card or event ticket when exiting the garage.

ACCESSIBILITY

For information on accessibility, email accessibility@amnh.org or call 212-313-7565.