



**mini museum**

# mini museum:

a companion guide to 4.6 billion years of history  
as seen from the planet Earth

HANS-FILIP J. FEX

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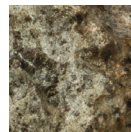
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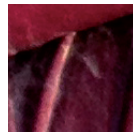
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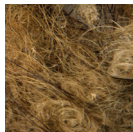
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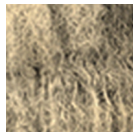
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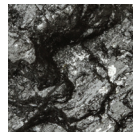
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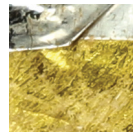
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# hello, everyone!

**My name is Hans Fex,  
and I am the creator  
of the mini museum.**

The mini museum is a portable collection of curiosities where every specimen is authentic, iconic, and labeled. I carefully designed the mini museum to take you on a journey of learning and exploration.

#### ABOUT THE MINI MUSEUM

Many things inspired me to create the mini museum, but it really started with my father.



*Dr. Jörgen Fex (1924-2006)*

When I think back to my childhood, I can't imagine a more welcoming environment for developing a keen interest in science and history. My father kept an amazing collection of artifacts, and we had a subscription to every great science magazine of the time. Living near Washington DC, we visited the Smithsonian museums almost every weekend, or at least it seemed that way to me. I saw dinosaur bones, meteorites, and rockets,

of course, but mostly I recall how excited my father was by all of the exhibits and how he tried to get me to think about the world in a different way.

My father was born in Stockholm, Sweden. When he grew up, he studied to become a neurologist. He practiced medicine for a few years, but the limitations of medical therapy in the 1950's frustrated him, so he decided to turn his mind to research.



Over the following decades, my father travelled to Australia as a Senior Research Fellow, worked for the National Institutes of Health (NIH) in the United States, and taught at Indiana University. Eventually, he returned to the NIH as the Chief of the Laboratory of Otolaryngology at the National Institute of Neurological Disease and Stroke and was the Scientific Director of National Institutes on Deafness and Other Commu-

nication Disorders (NIDCD).

In 1977, my father went to Malta for a scientific conference. I was only seven, but I remember the date clearly because it was the same historic year as the premiere of *Star Wars* and the Atari 2600.

When he returned, my father brought back some artifacts. He embedded the artifacts into epoxy resin. I had never seen this done before, and it was beautiful.

Then, all at once, I saw it – my first product idea. The mini museum. A grand collection within a manageable space.

Several times during the next year I discussed the project with my father and with his friends. I should clarify that my father's friends were also scientists and colleagues, researchers who had won Nobel Prizes or been knighted for their scientific accomplishments. They were all so kind,

but they were also excited. They helped me refine the candidates for inclusion, things we all agreed we'd like to have on our desks or in our pockets. They also recommended ways of acquiring each specimen and some even got on the phone and started calling museum curators to find sources.

Those first efforts resulted in prototypes I still have today.

(In order, left to right) Dr. Edgar Mitchell (Apollo 14 Lunar Module Pilot, moonwalker), Charles Duke Jr. (Apollo 16 Lunar Module Pilot, moonwalker), Richard Gordon (Gemini 11 Pilot, Apollo 12 Command Module Pilot), Jack Lousma (Skylab 3 Pilot, STS-3 Commander), Reena Morris, Hans Fex, Dr. Joseph Kerwin (Skylab 2 Science Pilot), Captain Eugene Cernan (Gemini 9A co-pilot, Apollo 10 Lunar Module Pilot, Apollo 17 Commander, moonwalker), Walter Cunningham (Apollo 7 Lunar Module Pilot).



Over the decades, I've collected many specimens from across the world. I've had the privilege of meeting some incredible people: astronauts, museum curators, fossil hunters, research scientists, university historians, and meteorite enthusiasts. I've also met fellow travelers like myself out in the world and seeking adventure. It's been such an amazing journey.

#### ABOUT THE COMPANION GUIDE

This companion guide includes scientific and historical details about each specimen as well as some of my own personal reflections. The size of this guide and the white cover material provides excellent backing when displaying the mini museum to friends or other small groups.

I should point out that the guide is not meant to be an exhaustive account of each specimen. Rather, I've done my best to present both relevant

and obscure facts about each specimen to inspire readers to begin their own investigation of the universe. Where possible, I've included specifics about the source of each specimen, along with references to additional reading material the reader may find interesting.

I've tried to be very careful in framing certain subjects, but a mini museum encased in acrylic is likely to survive for a few hundred years. So it is inevitable that a future reader will find science has advanced in one way or another so as to render some of the information in this guide obsolete. This is the nature of making something that lasts a really long time. However, if you find something amiss or if you want to ask a question, I look forward to hearing from you!

Now - back to work!





SPECIMEN TYPE:  
METEORITE

ESTIMATED AGE:  
4,568,200,000 YEARS OLD



## oldest matter ever collected

"The size and age of the Cosmos are beyond ordinary human understanding. Lost somewhere between immensity and eternity is our tiny planetary home."

– Carl Sagan, *Cosmos*, 1980



The Allende meteorite (pictured above) is rich in calcium-aluminum inclusions, also known as CAIs. CAIs are artifacts from the nebula phase of our solar system. They formed in a swirling and violent environment and provide clues to understanding the formation of the Sun.

### SOURCES:

The specimens in the mini museum were obtained from professional meteorite hunters and dealers, including Adam Hupé, Robert Haag, Gary Fujiwara, and John and Dawn Birdsell. Raab, H. Raab. Allende Image. Wikimedia Commons. Bouvier, Audrey, and Meenakshi Wadhwa. "The age of the Solar System redefined by the oldest Pb–Pb age of a meteoritic inclusion." *Nature Geoscience* 3.9 (2010): 637–641.



The area representing a single meteorite fall is referred to as a strewnfield. Strewnfields form when a meteorite breaks into pieces in mid-air or upon collision with the Earth. Professional meteorite hunters carefully chart the size of recovered fragments. This information provides clues to the size of the strewnfield as well as the location of the largest fragments which tend to be found at the terminal end.

The Allende meteorite fell to Earth on February 8th, 1969. Allende was very large (about the size of a car). Allende broke apart in the atmosphere like most meteorites and scattered across Chihuahua, Mexico.

We might call this item the stuff that universes are made of. After all, carbonaceous chondrites are the oldest matter humans have touched so far.

Carbonaceous chondrites are rare and primitive. Less than 5% of all meteorites recovered are carbonaceous chondrites, which is not too surprising when you consider that they formed billions of years ago before our sun was even a twinkle in its nebular cloud.

There are many types of carbonaceous chondrites. The specimen in the mini museum is a mixed sample of several carbonaceous chondrites, including the Murchinson and Tagish Lake meteorites, NWA 2364, and the famous Allende meteorite.



SPECIMEN TYPE:  
METEORITE

ESTIMATED AGE OF THE MOON:  
4,450,000 YEARS OLD



## lunar rock (meteorite from the moon)

"I think we're going to the moon because it's in the nature of the human being to face challenges."

– Neil Armstrong

While we've spent millennia gazing at our nearest neighbor, it is only within the last few decades that we've come to learn many of the Moon's deepest secrets.

The most widely-accepted scientific theory about the creation of the Moon involves a massive impact during the early days of our planet. Scientists believe that the core of the Moon is made from this colliding body while the outer crust is primarily composed of material from Earth. As evidence for this theory, we can look to the isotopic signature of lunar rocks returned by the Apollo program, which happen to match rocks here on Earth.

Of course, hitching a ride with an astronaut is not the only way rocks from the Moon end up back on Earth. When asteroids or meteoroids impact the Moon, bits of material are ejected into space.

These fragments often spend millions of years orbiting our planet until finally landing on Earth.

The deserts in the Middle East and Africa are excellent places to look for meteorites. Meteorite hunters use customized, four-wheel drive vehicles with benches attached to the outside. From this high vantage point, the meteorite hunters look for anything that is darker than the sand. Their finds usually turn out to be camel dung or bits of tire tread, but every once in a while they find a meteorite!

### SOURCES:

The specimens in the mini museum come from a pair of meteorites retrieved by professional meteorite hunters: Dar Al Gani 400 from Moritz Karl and NWA 5000 from Adam Hupé. Both meteorites were found in Africa.

Canup, Robin M., and Erik Asphaug. "Origin of the Moon in a giant impact near the end of the Earth's formation." *Nature* 412.6848 (2001): 708-712.

Pahlevan, Kaveh, and David J. Stevenson. "Equilibration in the aftermath of the lunar-forming giant impact." *Earth and Planetary Science Letters* 262.3 (2007): 438-449.

Herwartz, Daniel, et al. "Identification of the giant impactor Theia in lunar rocks." *Science* 344.6188 (2014): 1146-1150.

Astronauts visiting the moon were the first people to smell the moon, too. The first time they got a whiff was when Neil Armstrong and Buzz Aldrin returned to the Lunar Lander from their first moonwalk and removed their space suits. Apollo 17 astronaut Jack Schmitt had an allergic reaction to moon dust, similar to hay fever. Apollo 16 pilot Charlie Duke said it had a really strong smell, and his fellow mission John Young reported that it didn't taste half bad.

But perhaps the most telling statement came from Apollo 17 astronaut Gene Cernan who said, "It smells like someone just fired a carbine in here."





SPECIMEN TYPE:  
METEORITE

TOTAL WEIGHT OF MARTIAN METEORITES  
DISCOVERED ON EARTH (SO FAR):  
240 LB / 108 KG



## martian rock (meteorite from mars)

"I'd like to die on Mars..."

– **Elon Musk, founder of PayPal,  
Tesla Motors, and SpaceX**

We think of Mars as the red planet, primarily due to the oxidation of iron-rich minerals on the surface. However, in some places the rocks on the surface are butterscotch yellow, black, and even green.

As a result, Martian meteorites come in a variety of colors which can make identification difficult. Scientists use mass spectrometers to look for certain isotopic signatures. They compare this data to information sent to Earth by various unmanned Mars missions.

Like lunar meteorites, Martian rocks arrive on Earth as a result of ancient asteroid and comet strikes. To determine the age of a specimen, scientists measure the effect of cosmic radiation on the meteorites to determine their transit time. From this information, meteorite clusters are sorted into families that appear to correspond to distinct impact events.

There are three main groups of Martian meteorites: shergottites, nakhlites, and chassignites (named after the location of the first fall). Each corresponds to a specific composition of the material. Shergottites are the most common Martian meteorite, comprising more than 75% of all Martian meteorites discovered to date. Of course, common is a relative term given the scarcity of Martian meteorites.

Scientists recently traced the source of shergottites to a single impact event on Mars, the Mojave crater in the Oxia Palus quadrangle. The Mojave crater is roughly 3 million years old. It is 2,600 meters deep (1.6 miles) and 55 km in diameter (34 miles). The rocks ejected from the event are thought to be over 4 billion years old.

### SOURCES:

The specimen in the mini museum comes from shergottite NWA 7397, which was recovered in Morocco. It was purchased from Gary Fujihara, Officer of Public Outreach for the University of Hawaii Institute for Astronomy.

Mahaffy, Paul R., et al. "Abundance and isotopic composition of gases in the martian atmosphere from the Curiosity rover." *Science* 341.6143 (2013): 263-266.

Werner, Stephanie C., Anouck Ody, and Francois Poulet. "The Source Crater of Martian Shergottite Meteorites." *Science* 343.6177 (2014): 1343-1346.

When scientists examine meteorites, they look for the presence of certain elements. One element in particular is the noble gas argon. Argon is chemically inert, which is to say that it does not interact with other elements. This makes it ideal for detailed study.

In 2013, scientists examining data from NASA's Curiosity Rover determined the precise ratio of two forms of argon (argon-36 and argon-38) in the Martian atmosphere. Scientists have used this precise figure to confirm certain meteorites are undoubtedly from Mars.





SPECIMEN TYPE:  
METEORITE

COMBINED WEIGHT OF THREE FRAGMENTS:  
110LB/50KG



## alleged cow killer (meteorite)

"It was past midnight... there was a strange noise... due to the dark of the night we saw nothing... the next morning a worker came to say that there was a cow killed under strange circumstances."

— Juan Delgado, 1972

One of my favorite questions to answer is, "Has anyone or anything ever been killed by a meteorite?" The short answer is that we don't have enough scientific evidence to convict any single meteorite of murder. We don't have chemical or other forensic analysis, and we don't have video footage of a meteorite killing anything.

However, there is one meteorite that has become something of a legend: Valera.

On October 15th, 1972 in Trujillo, Venezuela, a meteor entered our atmosphere and allegedly killed a cow. We say "allegedly" because no human witnessed this event as it happened, but according to sworn statements a cow was found the next day, cut in half at the shoulder with part of the meteorite close by.

The owner of the farm, a physician by the name of Argimiro Gonzalez, wasn't particularly concerned or surprised. He rationalized that this sort of thing must happen from time to time and he ended up using a fragment of the meteor as a doorstop while the largest piece (weighing over 38 kilograms or 84 pounds) was left outside for decades.

Many years later an astronomer, Dr. Ignacio Ferrin, heard about the story and approached the heirs of Dr. Gonzalez. After verifying the story with several witnesses, Dr. Ferrin purchased the Valera meteorite which has the distinction of being one of the few documented fatal meteorite impacts.

### SOURCES:

The Valera specimen in the mini museum was purchased from Bonham's British Auction House in 2007.

Hutchison, Robert. *Meteorites: A petrologic, chemical and isotopic synthesis*. No. 2. Cambridge University Press, 2004.

McCall, Gerald Joseph Home, Alan John Bowden, and Richard John Howarth, eds. *The History of Meteoritics and Key Meteorite Collections: Fireballs, Falls and Finds*. Geological Society of London, 2006.

Valera is what meteorite collectors call a "hammer stone." Hammer stones are meteorites that strike specific objects (people, animals, buildings, even artifacts). Collectors who specialize in these particular falls are often interested in both the meteorites and the objects they came in contact with.

Another famous hammer stone is the Peekskill meteorite of 1992. This meteor crushed the rear end of a 1980 Chevy Malibu in Peekskill, NY. The car has toured the world and is currently owned by The Macovich Collection. The taillight and title for the car sold at auction for \$5,000 in 2012.





SPECIMEN TYPE:  
METEORITE

EXPLOSIVE FORCE:  
1.8 PETA JOULES, OR 500 KILOTONS OF TNT



## chelyabinsk meteorite

"Asteroids are nature's way of asking: 'How's that space program coming along?'"

– Neil De Grasse Tyson

On February 15th, 2013, an asteroid traveling approximately sixty times the speed of sound punched into Earth's atmosphere. The asteroid decelerated quickly due to friction and became a superbolide meteor. The asteroid exploded several times at a height of about 19 miles, creating a massive strewnfield in Chelyabinsk, Russia.

The shock waves from the explosion damaged over 7000 regional buildings and sent over 1000 people to the hospital mostly suffering with lacerations from flying glass. The event was so powerful it created a dust belt in the stratosphere that circled the entire planet and lingered for months.

This event occurred at 9:20 a.m. local time and was captured by dozens of dashboard cameras. Videos quickly appeared on the Internet where millions around the world viewed the event soon after it occurred.

Many satellites also recorded the event, and a significant body of research is developing based on this data. One piece of evidence is not well known. It turns out that just hours after Chelyabinsk, a much larger body passed within 27,000 kilometers of Earth. Scientists estimate a collision with this second object might have equaled the destructive force of the 1908 Tunguska event.

### SOURCES:

The Chelyabinsk meteorite fragments in the mini museum were acquired from professional meteorite dealers. Like many specimens, they were gathered by local Chelyabinsk residents who were at home when the event took place and simply went out to their snow-covered yards and started looking for holes in the snow.

Miller, Steven D., et al. "Earth-viewing satellite perspectives on the Chelyabinsk meteor event." *Proceedings of the National Academy of Sciences* 110.45 (2013): 18092-18097.

Ozawa, Shin, et al. "Jadeite in Chelyabinsk meteorite and the nature of an impact event on its parent body." *Scientific reports* 4 (2014).

"Bolide" is a term used to describe certain features of meteors, meteorites, and other large bodies entering our atmosphere. While there are no official standards, it is generally accepted that a bolide is a fireball that reaches an apparent magnitude of -14. A "superbolide" is considered -17 or greater.

Apparent magnitude is an ancient measurement of brightness that originated in the Hellenistic practice of measuring the brightness of stars. You can think of it as a number line where the faintest stars have a higher value and the brighter stars have a lower value. The star Vega in the constellation of Lyra was selected as the "zero" value for the scale (though it is really +0.03 by modern measurements). Our Sun is -27, though from Alpha Centauri it would be roughly +0.5.







SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
3,430,000,000 YEARS OLD



## earliest life

"All life is an experiment.  
The more experiments  
you make the better."

– Ralph Waldo Emerson

Stromatolites (sometimes called stromatoliths) are the result of a natural process that laminates sediments and mats of microorganisms into a layered structure. They are one of the most well-studied microbial phenomena.

The fossilized specimen in the mini museum comes from the Pilbara Strelley Pool stromatolites in Australia. Current research indicates that this source contains the earliest cellular life discovered so far. As the final remains of something that lived over three billion years ago, this little fossil is hugely inspirational.

It's always interesting to consider how we got here. Imagine your ancestry as a single line of beings. First, you'd see your parents, and then behind them would be their parents, and so forth. Now imagine walking along that line and stopping at each person. When you'd walked 20 generations, that person probably

wouldn't look much like you. When you walked back 100,000 generations, that being is going to look very different in many ways.

And you keep walking further and further back? Eventually when you've walked back 4 billion years, you're going to have to pull out your microscope to greet a cell, perhaps one very much like the fossilized specimen in the mini museum.

### SOURCES:

Pelbara Strelley Pool Stromatolite acquired from Crystal World in Melbourne, Australia in accordance with the Australian Heritage Commission Act and the Australian Environment Protection and Biodiversity Conservation Act. (This important legislation is used by Australia to manage access to important cultural and environmental relics such as the Pilbara Strelley Pool stromatolites.)

Kalkowsky, Ernst. "Oolith und Stromatolith im norddeutschen Buntsandstein." *Zeitschrift der deutschen geologischen Gesellschaft* (1908): 68-125.

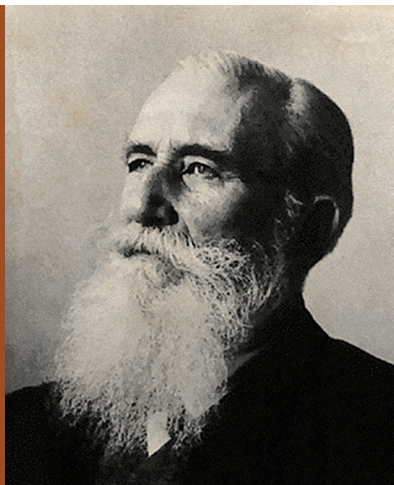
Sugitani, Kenichiro, et al. "Microfossil assemblage from the 3400Ma Strelley Pool Formation in the Pilbara Craton, Western Australia: Results form a new locality." *Precambrian Research* 226 (2013): 59-74.

### Ernest Louis Kalkowsky (1851-1938)

Dr. Kalkowsky is generally credited with introducing the term "stromatolith" to science in his 1908 paper "Oolith und Stromatolith im norddeutschen Buntsandstein."

In this paper, Dr. Kalkowsky studied the Early Triassic stone of northern Germany's salt lakes. He hypothesized that the structures were microbial in origin, a theory that was immediately challenged by others in the scientific community.

As it turns out, not only was Kalkowsky correct but stromatolites are still being formed today. They can be found at the edges of hypersaline lakes and marshes in many areas of the world as well as shallow, warm seas like those around the Bahamas.





SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
55,000,000 YEARS



## palm tree from antarctica

“The land looks like a fairytale.”

– Roald Amundsen (1872 to 1928) about Antarctica

During the early Eocene epoch, a land bridge existed between Antarctica and Australia in much the same way the Bering Strait connected Asia and North America. By the mid-point of the epoch, shifting continental plates opened a gap between Australia and Antarctica, allowing water to rush in. This deep water channel created a boundary current around Antarctica, which we now call the Antarctic Circumpolar Current.

Ocean currents have a powerful effect on the flow of kinetic and thermal energy, which has a direct impact on the global climate. The development of the Antarctic Circumpolar Current dramatically changed the pattern of oceanic circulation, which in turn altered the global heat transport.

Scientists believe this change contributed to a global cooling of environment and the rapid expansion of the ice sheet in Antarctica.

Prior to the development of the Antarctic Circumpolar Current, Antarctica had a subtropical climate. Carbon dioxide levels were roughly two and a half times higher than they are today, and instead of ice, thick forests of beech trees and conifers dominated the interior of the continent while coastal areas were lined with palm trees.

### SOURCES:

The mini museum includes a sample gathered from the coal-bearing band in Mac. Robertson Land by one of the last Soviet research expeditions in 1986. While heading back to the mainland on a boat, the research team threw overboard several redundant and unnecessary specimens. These specimens were salvaged from that purge.

Becquey, Sabine, and Rainer Gersonde. “A 0.55-Ma paleotemperature record from the Subantarctic zone: Implications for Antarctic Circumpolar Current development.” *Paleoceanography* 18.1 (2003).

Holbourn, Ann, et al. “Impacts of orbital forcing and atmospheric carbon dioxide on Miocene ice-sheet expansion.” *Nature* 438.7067 (2005): 483-487.



Today, the Antarctic Circumpolar Current is responsible for keeping Antarctica in a permanent deep freeze. It is also one of the most important ocean currents, connecting the Indian, Pacific, and Atlantic Oceans and allowing for these waters to exchange nutrients and energy.

In 2014, a study from NASA's Jet Propulsion Laboratory found that warming of the Antarctic Circumpolar Current had created a major instability in the Western Antarctic Ice Sheet. Loss of the ice sheet is thought to be unstoppable at this point, though it may take several centuries before it slips into the ocean.

SPECIMEN TYPE:  
FOSSIL

ORIGINAL EGG SIZE:  
JUST 11-12 CM (4-5 IN) IN DIAMETER



## dinosaur egg (shell)

"I would go to museums and say can I open your dinosaur egg? Can I just drop them on the floor and look inside? And they'd say no."

- Jack Horner, Paleontologist

Where paleontologists find dinosaurs they also find dinosaur eggs! Just like dinosaurs, dinosaur eggs come in many shapes and sizes. Some are smooth while others display what scientists call "ornamentation," which is a way of saying they have ridges.

Scientists can discern many things about a species by the structure of their eggs. For example, if the shell is particularly porous, it is likely that the species buried their eggs as modern crocodiles do.

Many kinds of naturally occurring objects can resemble fossilized egg fragments so it's important to know the three basic traits that separate the eggs from the rocks. First, the thickness of the shell should be roughly uniform, the same all the way around. Second,

like most eggs, the egg fragment should be slightly curved. Finally, the surface of the egg should be pitted with tiny pores.



### SOURCES:

The eggs in the mini museum were recovered in Patagonia and are believed to come from a *Saltausaurus* (pictured above). They were acquired from Trevor George of British Jurassic Fossils. The *Saltausaurus* was a sauropod from the Late Cretaceous Period, roughly 39 ft. or 12 m in length and weighing 8 tons. *Saltausaurus* was one of the first sauropods to sport body armor, and yet, like every dinosaur, the *Saltausaurus* began its life inside an egg.

Chiappe, Luis M., and Lowell Dingus. *Walking on eggs: the astonishing discovery of thousands of dinosaur eggs in the badlands of Patagonia*. (2001).

Paul, Gregory, ed. *The Scientific American book of dinosaurs*. Macmillan, 2003.



Many classic dinosaur books credit American George Olson with the first discovery of dinosaur eggs back in 1923 during an expedition in Mongolia. While Olson's find was the first recognized egg find, the real honor goes to 19th century French Catholic Priest Father Jean-Jacques Poehc. In 1859, Father Poehc came across the shell fragments of what he believed to be a giant bird. As it turns out, those eggs were really from *Hypselosaurus*, a sauropod of the Late Cretaceous.

In 1975, Chinese paleontologist Zhao Zi-Kui began developing the first classification system for dinosaur eggs. Based on this work, dinosaur eggs are now classified into three main groups: spherulitic, prismatic, and ornithoid. The classifications are based on the morphology of the egg (the size and shape) as well as the crystal structure of the shell.



SPECIMEN TYPE:  
FOSSIL

LARGEST SIZE:  
OVER 50 METRIC TONS  
(CONSERVATIVE ESTIMATE)



## sauropod (vertebrae)

“Conclusions based on such work will naturally be received with distrust by anatomists.”

– O.C. Marsh on the work of his rival, Edward Drinker Cope

Of all dinosaurs, the sauropods were the largest. In fact, they are generally considered the largest creatures to have ever walked the earth. Sauropods were herbivores with long necks, small heads, and massive bodies. Most had very long tails to balance their enormous bodies, and some even had body armor for added protection.

It's interesting to note that new dinosaur species are discovered quite regularly all over the world. The modern process for species identification is rigorous and time consuming, but it wasn't always this way.

In the late 19th century, paleontologists Othniel Charles “O.C.” Marsh and Edward Drinker Cope described over one hundred and thirty different dinosaur species. However, the two men were anything but friendly. These bitter

rivals worked hard to one-up each other during a period known as The Great Dinosaur Rush.

During these so-called “Bone Wars,” Marsh received the partial remains of an Apatosaurus. Several years later, he received a more complete skeleton of the same dinosaur but mistakenly paired it with the head of a Camarasaurus and dubbed the new dinosaur Brontosaurus. The mistake was spotted in 1903, but the name “Thunder Lizard” lived on for decades.

### SOURCES:

The sauropod vertebrae specimen in the mini museum comes from an incomplete set of bones discovered in the Dana Quarry in the village of Ten Sleep at the western edge of the Bighorn Mountains in Wyoming. It was found together with a Diplodocus, Apatosaurus, and a yet to be identified sauropod which paleontologists are hoping might be accepted as *Amphicoelias Brontodiplodocus*.

Gould, Stephen Jay. *Bully for brontosaurus: reflections in natural history*. WW Norton & Company, 2010.

Switek, Brian. *My Beloved Brontosaurus: On the Road with Old Bones, New Science, and Our Favorite Dinosaurs*. Scientific American/Farrar, Straus and Giroux, 2013.

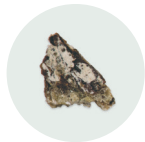


It was thought that agents of Othniel Charles Marsh (back-row, center) dynamited valuable fossil beds. As it turns out, this appears to be a false rumor sown to discourage rival teams from digging in the same area. In 2002, researchers located the original quarry. With help from paleontologist Robert T. Bakker, new discoveries have been made on the site of the very first Apatosaurus find including a “running trackway” giving the first evidence of how fast these massive sauropods could move.



SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
100–66,000,000 YEARS OLD



## triceratops (brow horn)

“We all have a dinosaur deep  
within us just trying to get out.”

– Colin Mochrie

Triceratops belongs to a large family of dinosaurs known as the Ceratopsids. Ceratopsids lived during the Late Cretaceous period between sixty-six and seventy-nine million years ago, or just before the Cretaceous–Paleogene (K–Pg) mass extinction event that wiped out the dinosaurs.

All Ceratopsids are quadrupeds with bony frills, horns, and beak-like mouths. In particular, the head of Triceratops was nearly one-third the length of its entire body. A structure that large leads scientists to wonder about its evolutionary purpose.

As you might expect, there is evidence that the frill and horns were used as defensive weapons against predators such as Tyrannosaurus Rex, including partially-healed frills and brow horns with Tyrannosaurid tooth marks.

Recent studies noting the presence of blood vessels in the frill suggest that these features

could be used in identification, courtship, and dominance displays, much like the antlers and horns of modern reindeer, mountain goats, or rhinoceros beetles. The blood vessels also point to the possibility that the frill served to help regular body temperature.

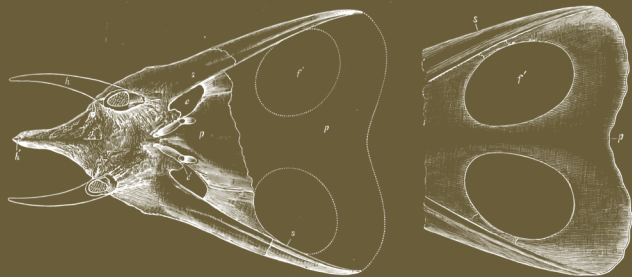
### SOURCES:

The specimen in the mini museum comes from Lance Creek, Wyoming. It was acquired by Hans directly from the person who dug it from the earth. The specimen was found together with parts of the skull including the short horn (snout horn), at least 30% of the frill, a few teeth, rib bones, and assorted other bones.

Hatcher, John Bell, Henry Fairfield Osborn, and Othniel Charles Marsh. *The Ceratopsia*. Vol. 49. US Government Printing Office, 1907.

Scannella, John B., and John R. Horner. “Toro-saurus Marsh, 1891, is Triceratops Marsh, 1889 (Ceratopsidae: Chasmosaurinae): synonymy through ontogeny.” *Journal of Vertebrate Paleontology* 30.4 (2010): 1157–1168.

Brusatte, Stephen L. *Dinosaur Paleobiology*. Vol. 2. John Wiley & Sons, 2012.



There's a growing body of evidence that suggests that the dinosaur we refer to as “Triceratops” may in fact be a juvenile *Torosaurus*. The question revolves around the ontology of the species, which is to say the way that the animal grew and changed over its lifespan. The evidence presented by Jack Horner, Mark Godwin, and John Scannella is compelling, but not accepted by all paleontologists just yet.



SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
67-66,000,000 YEARS OLD



## t-rex (tooth)

“Must go faster.”

– Dr. Ian Malcolm, *Jurassic Park*

Though *Tyrannosaurus Rex* is no longer thought of as the biggest predator that ever lived, this theropod remains the largest of the tyrannosaurid family and one of the most popular dinosaurs of all time.

Tyrannosaurids lived during the Late Cretaceous period between sixty-six and eighty million years ago. It is believed that *Tyrannosaurus Rex* grew slowly until its early teens and then rapidly gained mass over the second half of its life. *Tyrannosaurus Rex* only lived a short while after reaching maturity, perhaps living to a maximum age of thirty-five.

Due to its large size, some scientists believe that a full grown T. rex could not possibly run faster than 11 miles per hour (5 meters per second). Others estimate that T. rex could run as fast as 45 mph (20 m/s). The variation in speed estimates also leads to speculation about feeding habits.

So, was T. rex a hunter or a scavenger? There is evidence for both, as well as the possibility

for pack hunting behavior. Though scientists are still unsure of T. rex's social dynamics, there is conclusive evidence that T. rex fought among each other, biting one another's faces, sometimes with deadly results.

Various scientific studies of the T. rex's bite force place the “Tyrant Lizard” firmly at the top of the terrestrial charts, with anywhere between 35,000-75,000 newtons of force. This is about 15 times greater than the bite force of an African lion. The T. rex also had some of the largest teeth of any carnivorous dinosaur, with the largest yet found coming in at 30 cm long (1 ft.).

### SOURCES:

Several *Tyrannosaurus Rex* teeth were used in the mini museum, including teeth collected on private ranch land by paleontologist Jared Hudson.

Erickson, Gregory M., et al. “Bite-force estimation for *Tyrannosaurus rex* from tooth-marked bones.” *Nature* 382.6593 (1996): 706-708.

Fiffer, Steve. *Tyrannosaurus Sue: The Extraordinary Saga of Largest, Most Fought Over T. Rex Ever Found*. Macmillan, 2001.

DePalma, Robert A., et al. “Physical evidence of predatory behavior in *Tyrannosaurus rex*.” *Proceedings of the National Academy of Sciences* 110.31 (2013): 12560-12564.

“Sue” (FMNH PR 2081) is the largest *Tyrannosaurus Rex* discovered so far. Her estimated weight is about 11,500 pounds. She died from an apparent head bite inflicted by another tyrannosaur.

Discovered in 1990, Sue sold at auction for an unprecedented \$8.3M. The price stunned the field of paleontology, igniting fears of another Great Dinosaur Rush similar to that of the 19th century.

Today, Sue's remains can be viewed at the Field Museum in Chicago, Illinois, and a cast replica of her is on continuous tour.

But Sue may not hold her title forever...

In 2013, Dr. Jared Hudson discovered a nearly complete T. rex in South Dakota which has been named Darwin. Independent experts indicate Darwin may rival Sue in size and completeness.





SPECIMEN TYPE:  
FOSSIL

DENTAL DYNAMO:  
UP TO 1400 TEETH



## duckbilled dinosaur (misc. bone)

"Leonard Webb loves Geneva Jordan, 1916."

— **scrawled into the rock near the location of Leonardo, the most well-preserved Brachylophosaurus (Hadrosaurid) ever found**

The hadrosaur is one of the most easily recognizable species of dinosaur due to its iconic duck-billed head, but without any protective plates or other obvious defenses, hadrosaurs had to get big quickly or be eaten.

Recent research on *Hypacrosaurus*, a member of the hadrosaur family which was about the size of *T. rex*, indicates that the species reached maturity in less than ten years. Compare this with *T. rex*, which took three times that long to grow to full size.

*While I've been unable to locate any specific studies relating to bone density, I have to say that hadrosaur bones are unlike any other dinosaur bones I've come across.*

*They are extraordinarily light, and feel like cattle bones left to dry in the desert for a few*

*years. Of course, there are many factors in permineralization, but I believe this is due to the numerous vascular channels in the bone.*

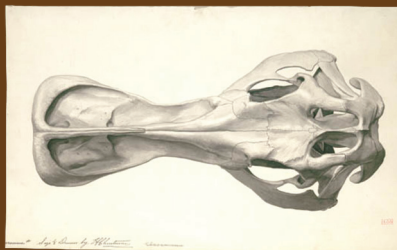
*I was tempted to place this specimen after the K-Pg Boundary material when researchers at the University of Alberta, Canada announced they recovered hadrosaurid remains that appear to date more than 700,000 years after the event. An active discussion of the techniques used in dating this material is ongoing in the geological community, so at least for the moment, our hadrosaur will remain in the Late Cretaceous.*

### SOURCES:

The hadrosaur in the mini museum was acquired from paleontologist Jared Hudson at the Tucson Gem and Mineral Show. The Tucson show is the largest gathering of its kind in the United States.

Cooper, Lisa Noelle, et al. "Relative growth rates of predator and prey dinosaurs reflect effects of predation." *Proceedings of the Royal Society B: Biological Sciences* 275.1651 (2008): 2609-2615.

Fassett, James E., Larry M. Heaman, and Antonio Simonetti. "Direct U-Pb dating of Cretaceous and Paleocene dinosaur bones, San Juan Basin, New Mexico." *Geology* 39.2 (2011): 159-162.



The Hadrosaurids' unique jaw worked like no other before or since, allowing these giant herbivores to grind through all manner of plant material, including rotting wood. You might wonder how they did that with a beak, but the hadrosaur "beak" housed hundreds of teeth. In fact, some species had up to 1400!

SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
228–66,000,000 YEARS OLD



## pterosaur (wing bone)

“If birds can glide for long periods of time, then why can’t I?”

– Orville Wright

When we think about flying dinosaurs, we often call them “pterodactyls.” However, pterodactyls are really a sub family of pterosaurs, which are not even dinosaurs at all but reptiles!

Spanning 160 million years of evolution, pterosaurs were quite diverse. Some were as small as a bat or a bird, and others, such as *Quetzalcoatlus*, were the size of a giraffe with a wingspan of 10 meters.

Given their size, scientists assume that pterosaurs must have had very firm, if somewhat delicate, skeletons. Recent studies suggest that the wings in larger species contained air sacs that functioned as part of the animal’s respiratory system.

So, did pterosaurs soar, glide, or were they active flyers?

Many scientists and engineers have tried to recreate their flight dynamics. No one knows for

sure, but one study by aerospace engineer Colin Palmer turned up some interesting ideas about the shape of the pterosaurs’ wings. Palmer’s wind tunnel tests suggest that pterosaurs could glide for hours using minimal effort. The tests also suggest that pterosaurs landed using a slow glide to protect their complex wings.

### SOURCES:

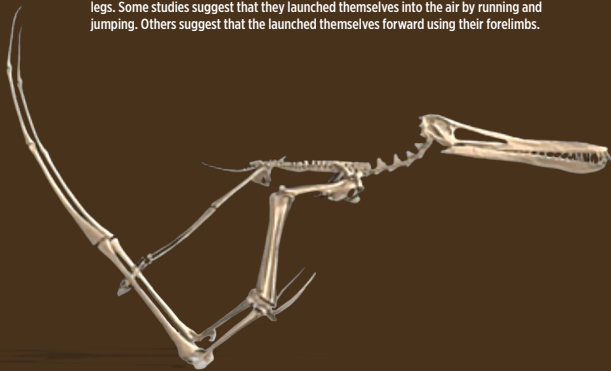
The mini museum specimen comes from a pterosaur wing bone. As some pterosaur bones are as thin as a millimeter, several specimens from different species were used. All of the pterosaur specimens were purchased from paleontologists working in the field.

Unwin, David. *Pterosaurs: from deep time*. Dutton Adult, 2006.

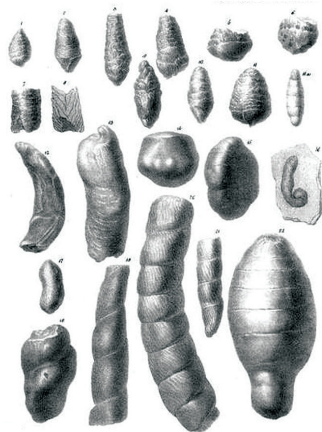
Palmer, Colin. “Flight in slow motion: aerodynamics of the pterosaur wing.” *Proceedings of the Royal Society B: Biological Sciences* 278.1713 (2011): 1881-1885.

Veldmeijer, Andre J., Ilja Nieuwland, and Mark Witton. *Pterosaurs: Flying Contemporaries of the Dinosaurs*. Sidestone Press, 2012.

Pterosaurs are believed to have been quadrupedal, meaning that they walked on four legs. Some studies suggest that they launched themselves into the air by running and jumping. Others suggest that they launched themselves forward using their forelimbs.







With a wide variety of shapes, sizes, and colors, it's very difficult, if not impossible, to match coprolites to a particular species. However, modern research methods including biogeochemical analysis and x-ray diffraction are creating a growing body of knowledge.

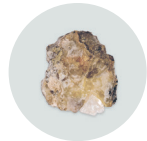
In particular, Karen Chin is noted for her identification of a possible *T. rex* coprolite in 1998:

"This specimen is more than twice as large as any previously reported carnivore coprolite, and its great size and temporal and geographic context indicate that it was produced by a tyrannosaur. The specimen contains a high proportion of bone fragments."

Dr. Chin's research has also uncovered fossilized muscle tissue in tyrannosaur coprolites, providing new insight into the Cretaceous food chain.

SPECIMEN TYPE:  
FOSSIL

MAXIMUM BRITISH COPROLITE YIELD :  
35,000 TONS (1872)



## dinosaur dung

"Everyone poops."

– Tarō Gomi

Fossilized feces are called coprolites.

Coprolites can come from reptiles, dinosaurs, and even ancient mammals.

Depending on their origin, coprolites may contain a variety of minerals such as phosphorus and calcium. Scientists use this information to help identify the species responsible for the droppings and to learn more about their diet.

Yet, while modern interest in coprolites is mainly focused on their value to science, coprolites were once worth their weight in gold.

In 1842, English agricultural entrepreneur John Lawes successfully used vitriol, also known as sulphuric acid, to reduce coprolites to calcium phosphate from which Lawes created a super-phosphate that could be applied directly to fields. The results were impressive, and when this process became widely known, it created a massive demand for phosphates around the world.

For several decades, Cambridgeshire county, which is adjacent to Hertfordshire, became a hotbed of coprolite mining in Britain. This area was a particularly rich source of coprolites from a variety of mega fauna. Near the end of the 19th century, the coprolite mining industry came to an abrupt halt as new sources of rock phosphate around the world led to greater price competition.

### SOURCES:

The coprolite in the mini museum comes from a specimen retrieved in Utah. It comes from an unspecified dinosaur.

Grove, Richard. *The Cambridgeshire coprolite mining rush*. Vol. 1. Oleander Press, 1976.

Reinhard, Karl J., and Vaughn M. Bryant Jr. "Coprolite analysis: A biological perspective on archaeology." *Papers in Natural Resources*. (1992).

Chin, Karen, et al. "A king-sized theropod coprolite." *Nature* 393.6686 (1998): 680-682.

Chin, Karen, et al. "Remarkable preservation of undigested muscle tissue within a Late Cretaceous tyrannosaurid coprolite from Alberta, Canada." *Palaio* 18.3 (2003): 286-294.



SPECIMEN TYPE: EXTINCTION EVENT ESTIMATED AGE: 65,500,000 YEARS OLD



## k-pg boundary (mass extinction event)

"The public image of dinosaurs is tainted by extinction. It's hard to accept dinosaurs as a success when they are all dead. But the fact of ultimate extinction should not make us overlook the absolutely unsurpassed role dinosaurs played in the history of life."

— Robert T. Bakker

There is a very special layer of sediment separating our Cenozoic Era from its predecessor, the Mesozoic. This layer is called the K-Pg Boundary Layer because it separates the Cretaceous Period (part of the Mesozoic Era) from the Paleogene Period (part of our Cenozoic Era). This layer also marks a mass extinction event in the fossil record known as the Cretaceous-Paleogene Extinction Event or the end of the age of the dinosaurs.

The K-Pg Boundary Layer contains a high concentration of the element iridium which is rare on earth but is often found in abundance in meteorites. For this reason, most scientists

believe that a massive asteroid strike might have been involved. New evidence also suggests several strikes may have occurred during a single event, similar to the impact of comet Shoemaker-Levy 9 which broke apart and collided with Jupiter in 1994.

While the Cretaceous-Paleogene Extinction Event is perhaps the best known mass extinction event, it is hardly the only such occurrence. It's not even the most destructive! There is evidence to suggest that such events happen perhaps every one hundred million years or so.

### SOURCES:

The specimen in the mini museum is a mixture of K-Pg Boundary Layer samples taken from France, Spain, Canada, and the United States. Acquired directly from geological professionals, the mixture illustrates the scale of this particular event and serves as a reminder that we are all connected across space and time.

Bakker, Robert T. *The dinosaur heresies: new theories unlocking the mystery of the dinosaurs and their extinction*. New York: Morrow, 1986.

Schulte, Peter, et al. "The Chicxulub asteroid impact and mass extinction at the Cretaceous-Paleogene boundary." *Science* 327.5970 (2010): 1214-1218.



Evidence of the K-Pg Boundary Layer can be found all over the world, but the official reference point for the K-Pg Boundary Layer is in El Kef, Tunisia. This point is called a "golden spike" or Global Boundary Stratotype Section and Point. Golden spikes are defined by scientists who work in the field of stratigraphy. This branch of geology focuses on both the rocks within each layer and the process of layering itself.

SPECIMEN TYPE:  
FOSSIL

ESTIMATED AGE:  
40-60,000,000 YEARS OLD



## insect in amber

“Amber is a liquid produced by the rays of the sun.”

– Nicias, Ancient Greece

Resin is a sticky substance produced by plants, primarily from conifers. Its primary purpose is to protect the plant from invasive pests, such as insects. Resin accomplishes this by being both sticky and smelly (some might say fragrant).

The tackiness of resin comes from carboxylic acids which make up the bulk of its mass. Hydrocarbon compounds known as terpenes provide the fragrance. Over time, humans have learned to refine these compounds to create a wide array of products industrial solvents to adhesives and protective coatings. We’ve even used terpenes to flavor our food. For example, beer gets its bitter flavor from a terpene that comes from the hops plant, which happens to be a conifer.

When compressed and heated beneath layers of sediment for millions of years, resin undergoes a process of molecular polymerization. The result is a low-density, amorphous solid known as amber.

When recovered, amber is often dull, reddish brown, or even gray. After polishing, amber practically glows. This glow has been prized by humans for millennia. Scientists often find objects trapped in fossilized amber. These objects are called inclusions, and they range from dust and pollen to insects and even fossilized lizards!

The largest amber deposits in the world are located around the Baltic Sea. Amber from this region, referred to as Baltic amber, is considered the highest amber quality in the world. Baltic amber deposits date from the Eocene period, some 40-60 million years ago. Scientists consider Baltic amber the greatest repository of fossilized insects from any age.

### SOURCES:

The Baltic Amber in the mini museum comes from Marius Vesta of Lithuania.

Bohme, W., M. Borsuk-Bialynicka, and M. Lubka. “A lizard from Baltic amber (Eocene) and the ancestry of the crown group lacertids.” *Acta Palaeontologica Polonica* 44 (1999): 349-382.

Wolfe, Alexander P., et al. “A new proposal concerning the botanical origin of Baltic amber.” *Proceedings of the Royal Society B: Biological Sciences* 276.1672 (2009): 3403-3412.



In the early 18th century, King Ferdinand I of Prussia commissioned the creation of an Amber Room as a gift for the Russian Tsar, Peter the Great. The Amber Room was installed in the Catherine Palace outside St. Petersburg in 1717. When lit with candles, the Amber Room glowed with a deep golden light that so impressed visitors that it was called the Eighth Wonder of the World. During World War II, Nazi Germany invaded Russia and captured the Catherine Palace. During their retreat, the Nazis looted many treasures, including dismantling the entire Amber Room. The Amber Room was lost after the war. Treasure hunters have searched for decades for this priceless relic, but only a single panel has been recovered.





SPECIMEN TYPE:  
HAIR

ESTIMATED AGE:  
10-12,000 YEARS OLD



## mammoth hair

"It may be asked, why I insert the Mammoth as if it still existed? It may be asked in return, why I should omit it, as if it did not exist? Such is the economy of nature, that no instance can be produced of her having permitted any one race of her animals to become extinct; of her having formed any link in her great work so weak as to be broken."

– Thomas Jefferson

In the popular imagination, the "Ice Age" happened in the distant past, but in fact an ice age is still ongoing today. We just live in a warm pocket known as an interglacial period, also known as the Holocene. Our ice age began 2.6 million years ago at the start of the Pleistocene epoch. Repeated periods of glacial incursions during the Pleistocene created the permanent ice sheets that cover Antarctica, Greenland, and parts of the Arctic. This massive environmental change allowed for

the development of megafauna adapted to the colder climate, including the woolly mammoth.

A full-grown woolly mammoth, just one species of the genus *Mammuthus*, stood 10-12 feet at the shoulder with shaggy hair. The woolly mammoth's hair provided a substantial advantage in the struggle to stay warm.

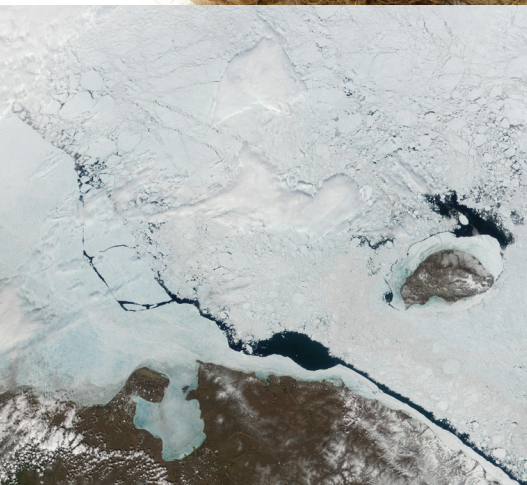
Like all megafauna species, the woolly mammoth population dwindled during the Quaternary Extinction Event. This event separates the Pleistocene epoch from the Holocene. There are many theories about the cause of this event, including climate change and the rise of *Homo sapiens* as the dominant global predator.

### SOURCES:

The specimen in the mini museum comes from several woolly mammoth sources.

Tikhonov, Alexei, Larry Agenbroad, and Sergey Vartanyan. "Comparative analysis of the mammoth populations on Wrangel Island and the Channel Islands." *Advances in Mammoth Research* 9 (2003): 415-420.

Barrow, Mark V. *Nature's Ghosts: Confronting Extinction from the Age of Jefferson to the Age of Ecology*. University of Chicago Press, 2009.



Caught between Arctic and Northern Pacific air masses, Wrangel Island is a land characterized by harsh winds and cold temperatures where the average summer high only reaches 40°F/5°C.

A population of Woolly Mammoth survived here until 2000 BC. Their long isolation resulted in some morphological changes for certain individuals, such as reduction in size, but they were not dwarf mammoths. Recent studies have shown that certain individuals were likely 230 cm (7 ft.) or taller at the shoulder.



SPECIMEN TYPE:  
BURIAL RELIC

TIME TO MAKE A MUMMY:  
70 DAYS



# egyptian mummy wrap (c. 350 BC)

"The Egyptians are the first that laid down the principle of the immortality of the human soul."

– Herodotus

While most ancient cultures preserve their dead, few went to the lengths of the ancient Egyptians.

Extensive funerary works in Egypt date back to the Early Dynastic Period around 3000 BC. Over millennia, the Egyptians made steady progress in both scale and sophistication of the processes surrounding corpses. Low, flat-topped mastabas became step pyramids, while preparation of the dead shifted from air-drying techniques to careful chemical preparation using natron (a natural form of sodium carbonate), oils, plant resins, and a form of petroleum known as bitumen.

Bitumen is a tar-like substance that can be found at the bottom of ancient lakes, in natural pools, or seeping from cracks in sandstone. In the ancient world, bitumen was referred to as pitch, which was used as both a waterproof sealant and glue. Nebuchadnezzar II, the last great King of Babylon, used

bitumen in many civic works from lining sewers to setting paving stones. We still use bitumen today as a component of asphalt.

## SOURCES:

The specimen in the mini museum comes from an Egyptian mummy and dates to roughly 350 BC. This falls between the fall of Ancient Egypt and the rise of the Ptolemaic Kingdom. It was a time of successive conquests of Egypt, first by Persians and then by the Greeks.

Pettigrew, Thomas Joseph. *A History of Egyptian Mummies: And an Account of the Worship and Embalming of the Sacred Animals by the Egyptians: with Remarks on the Funeral Ceremonies of Different Nations, and Observations on the Mummies of the Canary Islands, of the Ancient Peruvians, Burman Priests, Etc.* Longman, Rees, Orme, Brown, Green, and Longman, 1834.

Rullkötter, J., and A. Nissenbaum. "Dead Sea asphalt in Egyptian mummies: molecular evidence." *Naturwissenschaften* 75.12 (1988): 618–621.

Peck, William H. "Mummies of ancient Egypt." *Mummies, Disease and Ancient Cultures*, 2nd edition, Cambridge University Press: Cambridge (1998): 15–37.

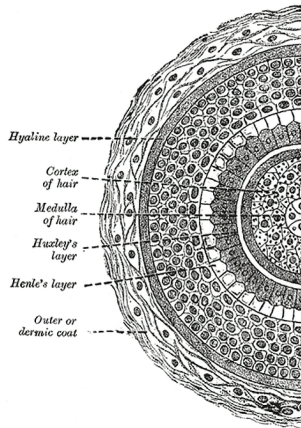
Wilkinson, Toby AH. *Early Dynastic Egypt*. Routledge, 2002.

Aufderheide, Arthur C. *The scientific study of mummies*. Cambridge University Press, 2003.



Bitumen was once held in high esteem as a medical cure-all used to treat digestive illnesses, to seal cuts, and even to set broken bones. As natural supplies ran short, people turned to mummies as a new source of bitumen. Brewed into a broth, powder from mummies found its way into medical practices in Europe and was used well into the 17th century. Mummies were also sold as sources of paper and pigment until the early 20th century.





The longest beard on record belonged to Hans Langseth (1846-1927). At its peak, his mighty beard measured 17 1/2 feet or 5.3 meters. A Norwegian by birth, Langseth moved to the United States in 1867. His family bequeathed his beard to the Smithsonian in 1967 where it can be viewed by special appointment.

Hair grows just about everywhere on the outside of the human body. Certain areas, such as the palms of the hands and lips, are "glabrous skin" which means they do not have hair follicles.

For most mammals, the primary function of hair is thermal regulation, but hair also provides sensory input. Body hair helps us sense the motion of air around us. Cochlear hair, particularly that of the inner ear, is integral to hearing. In some mammals, like porcupines, hair thickens into sharp quills which are used for protection.

SPECIMEN TYPE:  
BIOLOGICAL

AVERAGE BEARD HAIRS:  
7,000 - 15,000



## gratitude

"Yviga skägg kan aldrig ersätta kloka hjärnor."

"A bushy beard can't replace a clever brain."

— Swedish Proverb

The origin of the human beard is rooted in the production of dihydrotestosterone. Dihydrotestosterone is synthesized by the body from testosterone. Both forms are considered androgenic hormones, which is to say that they are involved in the expression of male characteristics in vertebrate species. In humans, this expression takes the form of body and facial hair growth along with increased muscle mass. Dihydrotestosterone in particular is key to the linear growth of facial hair, and recent scientific studies indicate that dihydrotestosterone plays a significant role in spatial memory.

The cultural impact of a beard depends on the context in which the beard is worn. Some cultures mandate the wearing of a beard for religious reasons or as a symbol of virility and honor. Others mandate shaving for the same reasons.

In ancient Greece, beards were common until the time of Alexander the Great when shaving became mandatory for his troops. A similar cycle of beardedness and barefacedness swept through Europe during and after the Crusades.

Charles Darwin theorized that beard growth was a sexual trait defined by natural selection, though his own beard was grown to help ease the irritation of eczema.

### SOURCES:

The specimen in the mini museum was cultivated and gathered personally by an American man of Swedish descent. It represents extreme dedication and focus. Shaving of a beard grown in such a fashion is often seen as a display of ritualistic gratitude for all those who helped bring about the successful conclusion of an odyssey.

Peterkin, Allan. One thousand beards: a cultural history of facial hair. Arsenal Pulp Press, 2001.

Cherrier, Monique M., Suzanne Craft, and Alvin H. Matsumoto. "Cognitive changes associated with supplementation of testosterone or dihydrotestosterone in mildly hypogonadal men: a preliminary report." *Journal of Andrology* 24.4 (2003): 568-576.

Sherrow, Victoria, ed. *Encyclopedia of hair: A cultural history*. Greenwood Publishing Group, 2006.

SPECIMEN TYPE: "NEW" LONDON BRIDGE WEIGHT:  
HUMAN ARTIFACT 120,000 TONS



# london bridge

"That's the craziest idea  
I have ever heard."

— Robert P. McCulloch

The earliest history of London Bridge dates back to the Roman invasion of Britain and the settlement of Londinium in AD 50. Over the centuries the bridge was razed by war and fire, abandoned to ruin, rebuilt by Saxons, and seized by the Danish during the Viking invasions.

The London Bridge of the 19th century was designed by John Rennie and opened in 1831. This version was called "New" London Bridge as it replaced the "Old" London Bridge of medieval times.

In the late 1960's, the City of London moved forward with plans to replace the bridge with a modern structure capable of handling even more traffic. To help raise necessary funds for a new bridge, the City of London decided to sell the old bridge. It was unclear who might buy such a thing, but one crazy idea found another in the form of Lake Havasu, Arizona.

Lake Havasu is a 19,300 acre reservoir sitting behind the Parker Dam on the Colorado River. Robert P. McCulloch, an American entrepreneur, received a large parcel of land along the shore in exchange for a promise to develop the area. McCulloch's real estate agent came up with the idea of buying London Bridge as an attraction to bring prospective buyers to the region.

The bridge was dismantled and shipped to Arizona via the Panama Canal, then reassembled on land over a steel super-structure. Once complete, McCulloch had a channel cut beneath the bridge to create an artificial island in what is technically an artificial lake. Not only did the plan work, but McCulloch went on to buy another 11,000 acres of land to develop Lake Havasu City.

## SOURCES:

The specimen in the mini museum comes from remnants of reassembled New London Bridge in Lake Havasu, sold as novelties to tourists.

Salmon, M. A professional survey of the old and new London Bridges, and their approaches, including historical memoirs of both structures. Salmon, M. 1831

Elborough, Travis. London Bridge in America: The Tall Story of a Transatlantic Crossing. Random House, 2013.



The longest-lived version of London Bridge is "Old" London Bridge. Built in 1209, "Old" London Bridge served the city for over 600 years. This medieval bridge was an inhabited structure with homes stretching half a dozen feet out over the Thames and reaching up to seven stories high. The original plots on the bridge were sold by King John to help pay for the bridge.



SPECIMEN TYPE: HUMAN ARTIFACT TOTAL LENGTH: 66 MILES/107 KILOMETERS



## berlin wall

"We praise the strength, the patience and the longing of the people who did not stop thinking of freedom and democracy in these dark times"

– Joachim Gauck

mass at the checkpoints to the west. Hundreds became thousands. The East German troops guarding the checkpoints eventually gave way and allowed people stream through.

In the weeks after the fall of the Wall, the remnants of the East German leadership tried and failed to reassert their leadership. Ultimately, it was the state of the economy that ended the debate about reunification. The East Germans were bankrupt, just days from default on heavy debts from western banks. The costs for reunification would be high, far higher than anyone expected, but the result would mean freedom for millions.

### SOURCES:

The specimen in the mini museum was personally collected by Hans during a trip to the former East Germany. It represents not only oppression, but the strength of the human spirit to endure against all odds and emerge triumphant.

Funder, Anna. Stasiland: Stories from Behind the Berlin Wall. (2003).

Taylor, Fred. The Berlin Wall: a world divided, 1961-1989. HarperCollins, 2006.

On the night of August 13th, 1961, the German Democratic Republic (GDR) began the construction of a massive wall to enclose West Berlin and seal it off from the rest of East Germany, though the real purpose of the structure was to keep East German citizens from defecting to the West.

The Wall stood until November 9th, 1989.

Radical political changes had been underway in Eastern Europe, and civil unrest had wrecked the East German government for weeks. Thousands of East Germans had passed to the west through Czechoslovakia and then into Austria. There were peaceful, yet defiant, demonstrations in many East German cities.

To ease the pressure, the government decided to loosen travel restrictions to the west. As the news spread, East German citizens began to

The grand style of the Brandenburg Gate has made it an attractive centerpiece for many important political events. Napoleon passed through the gate in 1806 after his conquest of Prussia. Hitler came to power beneath its arches in 1933. U.S. President John F. Kennedy gave his famous "Ich bin ein Berliner" speech in front of the gate in 1963. Then in 1987, U.S. President Ronald Reagan visited Berlin and in a speech before the Brandenburg Gate called on Soviet leader Mikhail Gorbachev to "tear down this wall." Two years later, the Brandenburg Gate served as a backdrop to the end of the division between East and West Germany.





SPECIMEN TYPE: TOTAL GOLD MINED:  
PRECIOUS METAL 174,100 TONNES



## raw gold nugget

"If more of us valued food  
and cheer and song above  
hoarded gold, it would be  
a merrier world."

– J.R.R. Tolkien

substance to industry, including a high resistance to corrosion and exceptional conductivity.

### SOURCES:

The gold in the mini museum comes from California, primarily from the Sierra Nevada and was mined by modern prospectors. The alluvial gold in the Sierra Nevada is the result of intense volcanic activity during the Cretaceous Period. This mother lode of ore was then overlaid by thick, granite intrusions. After millions of years of erosion and continued upheaval, these intrusions were worn away and streams carried gold across the region where it would be found by the famous "49er" prospectors of the mid-19th century.

Cutter, Donald C., and Sacramento Club of Printing House Craftsmen. The discovery of gold in California. Sacramento Club of Printing House Craftsmen, 1949.

Garside, Larry J., et al. "The upper reaches of the Sierra Nevada auriferous gold channels, California and Nevada." Geological Society of Nevada Symposium. 2005.

Hart, Matthew. Gold: The Race for the World's Most Seductive Metal. Simon and Schuster, 2013.

When our solar system began to form, Earth was a collection of spinning rocks, known as an "accretion disk." Being more dense than other matter, metals like iron, nickel, and gold were drawn into the molten core of the planet by the force of gravity, while the outer layer, comprised mostly of silicates, cooled and formed what we call the mantle.

Gold discovered on the surface comes primarily from a massive meteor bombardment 3.9 billion years ago which seeded the mantle with more rare metals. Volcanic eruptions, along with general plate tectonics, also bring gold to the surface.

Due to its relative scarcity, gold has played an important role in commerce in the form of coins and backing for paper currencies. Gold also has special properties which make it a valuable

There have been many famous gold "rushes", but few as well-known as the California Gold Rush of 1848-1855. In January of 1848, James Marshall discovered gold at Sutter's Mill near Coloma, California in the Sierra Nevada mountains. Today, there are still gold prospectors up and down the Pacific coast. These modern 49ers ply their trade using both traditional sluices and panning alongside new geophysical methods in seismic, gravitational, and magnetic analysis.



SPECIMEN TYPE:  
HUMAN ARTIFACT

16TH PRESIDENT OF THE UNITED STATES OF AMERICA:  
B. FEBRUARY 12TH, 1809  
D. (ASSASSINATION) APRIL 15, 1865

# abraham lincoln's house (foundation brick)

"O Captain! My Captain!"

- Walt Whitman

Four months after the end of the Civil War, President Lincoln delivered remarks at the dedication of the Solider's National Cemetery in Gettysburg, Pennsylvania. It is said that Lincoln was rather quiet as he delivered the speech. Most researchers believe he may have been suffering from a case of smallpox. Regardless, this short speech summarizes one of the most tumultuous events in American history:

"Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the proposition that all men are created equal.

Now we are engaged in a great civil war, testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field, as a final resting place for those who here gave their lives so that nation might live. It is altogether fitting and proper that we should do this.

In a larger sense, we can not dedicate, we can not consecrate, we can not hallow this ground. The brave men, living and dead, who struggled here, have consecrated it, far above our poor power to add or detract. The world will little note, nor long remember what we say here, but it can never forget what they did here. It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us—that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion—that we here highly resolve that these dead shall not have died in vain—that this nation, under God, shall have a new birth of freedom—and that government of the people, by the people, for the people, shall not perish from the earth."

- Abraham Lincoln, November 19, 1863

## SOURCES:

The specimen in the mini museum comes from a collection of foundation bricks taken from Abraham Lincoln's house and sold to benefit the rehabilitation of the property and the museum on the site.

Goodwin, Doris Kearns. Team of rivals: The political genius of Abraham Lincoln. Penguin UK, 2009.



During his time in office, President Lincoln masterfully guided significant legislation through a very complicated Congress. In addition to winning the Civil War and ending slavery through the passage of the Thirteenth Amendment to the United States Constitution, Abraham Lincoln signed the Homestead Act of 1862, making millions of acres of Western lands available for purchase, and the Pacific Railway Acts of 1862 and 1864 which made the first Transcontinental Railroad possible and opened the West for dramatic expansion.

President Lincoln was assassinated in office while attending a play at Ford's Theater in Washington, DC. His assassin was John Wilkes Booth, a well-known actor of the time and Confederate spy. The President's death sealed his memory as a national martyr and in the years since his legend has grown. He is often considered the greatest of all American Presidents.

SPECIMEN TYPE: HUMAN ARTIFACT  
PEAK SALES: 1976 165,000



## corinthian leather

"Advertising is based on one thing: happiness. Do you know what happiness is? Happiness is the smell of a new car. It's freedom from fear. It's a billboard on the side of a road that screams with reassurance that whatever you're doing is OK."

— Don Draper, *Mad Men*

When the Chrysler Corporation introduced Corinthian Leather, no one paid much attention. Every automotive manufacturer had their own "special" fabric, and like the others "Corinthian Leather" was just standard upholstery leather manufactured in an ordinary warehouse outside Newark, New Jersey. What made Corinthian Leather exceptional was its role in the execution of an advertising campaign for the Chrysler Cordoba.

By the early 1970's, Chrysler had a long reputation producing big luxury cars, but the oil embargo of 1973 changed the economics. Big was out and small was in. However, consumers still

wanted the illusion of luxury, and the Cordoba was designed to fit this niche. Corinthian Leather was included in the Cordoba and a marketing campaign was designed around a charismatic spokesperson named Ricardo Montalban.

Ricardo Montalban was a Mexican actor who had been in Hollywood since the mid-forties. Montalban's role was to evoke a sense of European style by using his rich, Castilian accent to emphasize the soft Corinthian Leather of the Cordoba's interior as well as the implied sophistication and performance of the vehicle overall.

Sales of the Cordoba shocked the industry. Montalban's character and the phrase "Soft Corinthian Leather" became cultural icons in their own right, outlasting both the Cordoba and its heir the Chrysler Le Baron.

### SOURCES:

The specimen in the mini museum comes from the front seat of a 1976 Chrysler Cordoba. It was personally recovered by Hans from a junkyard.

Underhill, Paco. *Why we buy: The science of shopping—updated and revised for the Internet, the global consumer, and beyond.* Simon and Schuster, 2009.

Many forces influence our beliefs. Yet, there is one particular force which bombards us with hundreds if not thousands of messages each day... advertising.

A good advertising campaign has the power to warp common sense and shape opinions. It can induce hunger or amnesia. It can make us buy products

that are harmful, like cigarettes, while making us feel good about doing it. Advertising transforms the ordinary into the exceptional and rare.





SPECIMEN TYPE:  
SAND

ANNUAL TRAVELERS TO HAWAII:  
8,235,510



## sand from waikiki

“Ua Mau ke Ea o ka `Āina  
i ka Pono.”

“The life of the land is per-  
petuated in righteousness.”

– King Kamehameha III, 1843

To many, the name Waikiki evokes an idyllic image of a tropical paradise. They picture the gentle curve of a pristine beach backed by lush palms. They may even recall the volcanic crest of Diamond Head. Yet, while Waikiki boasts some of the best surfing on the planet, it also has a tremendous historical and cultural significance for the Hawaiian people.

In the Hawaiian language, Waikiki means ‘spouting fresh water’. This fertile region is the central meeting point for a number of mountain streams and underground springs, and human habitation here dates back at least 1,400 years

During the 15th century, the ruling King of O’ahu, Ma’ilikūkahi, established his seat of power in Waikiki. The people of O’ahu developed an extensive agricultural system covering the 2,000 acres of wetland that separated the mountains

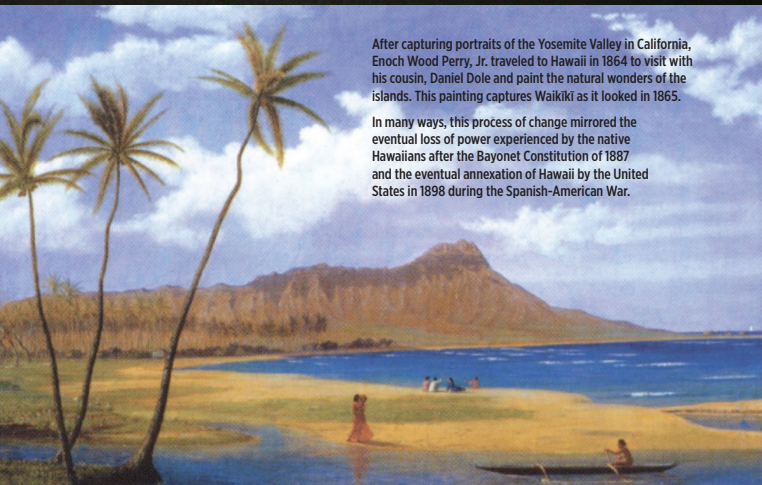
from the beach. Their works included irrigation canals, taro fields, and pools for fish farming.

In 1795, King Kamehameha I of the island of Hawai’i stormed the beaches of Waikiki with a large, modern army of 12,000 men equipped with cannons and muskets. This battle closed a string of victories for King Kamehameha, allowing him to proclaim the formation of the Kingdom of Hawai’i.

By 1810, the remaining islands succumbed to King Kamehameha and the Royal Court formally relocated to Honolulu. The beach of Waikiki remained a semi-private retreat for the royals, but near the end of the 19th century, hotels and resorts began to appear.

### SOURCES:

The specimen in the mini museum includes samples taken from Waikiki beach throughout the 20th century, including an heirloom from a 1950’s honeymoon trip. The inclusion of this specimen is a symbol of paradise, but also as a reminder that every paradise has a hidden past. White, Kai, and Jim Kraus. Waikiki. Arcadia Publishing, 2007.



After capturing portraits of the Yosemite Valley in California, Enoch Wood Perry, Jr. traveled to Hawaii in 1864 to visit with his cousin, Daniel Dole and paint the natural wonders of the islands. This painting captures Waikiki as it looked in 1865.

In many ways, this process of change mirrored the eventual loss of power experienced by the native Hawaiians after the Bayonet Constitution of 1887 and the eventual annexation of Hawaii by the United States in 1898 during the Spanish-American War.

SPECIMEN TYPE:  
SOIL

VOIVODE (WARLORD) OF WALLACHIA:  
1448, 1456-1462, AND 1476



## dracula soil (vlad III's castle)

"He was deathly pale, just like a waxen image, and the red eyes glared with the horrible vindictive look which I knew so well."

– Bram Stoker, *Dracula*

Built on top of a high rock, Cetatea (Castle) Poenari, the citadel of Prince Vlad's ancestors, is not an easy place to reach, something Hans learned first-hand when he went to Romania to collect this specimen.

*I flew into Bucharest, but I didn't manage to reach Poenari until after sundown. By then it was so dark I couldn't even make out a silhouette of the castle ruins. I was nervous, but I knew there was a staircase. Sure it had some 1480 steps, but how hard could it be?*

*When I checked into the hotel, I met a few Romanian tourists. I told them of my plan, and they warned me not to walk the stairs to the fortress at night. I thought they were joking, but they went on to tell me that wolves, bears and packs of wild dogs were a real problem.*

*After eating supper, I opened my guide book and learned that sure enough this region has the highest concentration of wolves, bears and feral dogs in all of Europe. Still, I only had a few days and I was determined to get my soil samples. So, rather than go up the stairs I decided to climb the sheer cliff below the castle where nothing could reach me.*

*In retrospect, this really sounds horrible and I suppose I am lucky to be alive. However, I did learn that while very difficult the castle is not impossible to reach in this manner. Even when one forgets their headlamp and a rainstorm pops up in the middle of the climb.*

*The next day I used the stairs, but of course it was a beautiful day.*

### SOURCES:

Stoker, Bram. *Dracula*: 1897. Intervisual Books, 1897.

Florescu, Radu R., and Raymond T. McNally. *Dracula, Prince of Many Faces: His Life and His Times*. Hachette Digital, Inc., 2009.

Pettersen, L. and Baker, M.. *Lonely Planet Romania*. Lonely Planet Publications, 2010

Vlad Tepeș III, Prince of Wallachia and member of the house of Drăculești was famous even before Bram Stoker used him as his model for the vampiric Count Dracula.

During the 13th century, Prince Vlad III was known for his heroic exploits in battle and cunning guerrilla warfare tactics against the vast forces of the Ottoman Empire. He is also known for his exceptional cruelty, including impaling tens of thousands of captured Turks.



SPECIMEN TYPE:  
PLANT

EXPLOSIVE FORCE:  
15,000 KILOTONS OF TNT



## tunguska event (surviving tree)

"During 60 years of night observations, I cannot re-collect seeing the firmament so light as at this period."

– W.F. Denning,  
British Amateur Astronomer

of their research has focused on Lake Cheko. Some studies suggest the lake formed nearly 6,000 years ago, but core samples taken by the Bologna team indicate the lake may be just a century old. The shape, or morphology, of the lake is quite similar to the Odessa Meteor Crater in West Texas. Furthermore, seismic readings indicate the lake has a deep, conical shape masked by sedimentary fill.

### SOURCES:

The specimen in the mini museum comes from scientists at the University of Bologna who recovered it from a surviving tree near the center of the event. Analysis of tree resin and growth rings provides evidence of the catastrophic event.

Serra, R., et al. "Experimental hints on the fragmentation of the Tunguska Cosmic Body." *Planetary and Space Science* 42 (1994): 777-783.

Gasperini, L., et al. "A possible impact crater for the 1908 Tunguska Event." *Terra Nova* 19.4 (2007): 245-251.

Napier, Bill, and David Asher. "The Tunguska impact event and beyond." *Astronomy & Geophysics* 50.1 (2009): 1-18.

Gasperini, Luca, et al. "Sediments from Lake Cheko (Siberia), a possible impact crater for the 1908 Tunguska Event." *Terra Nova* 21.6 (2009): 489-494.

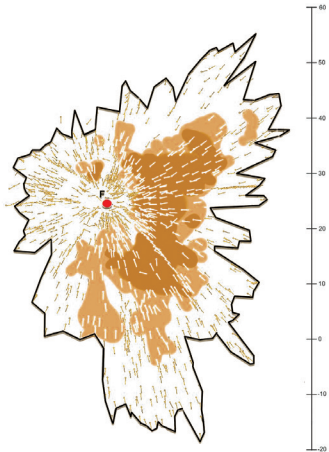
On June 30th, 1908, a massive explosion in the skies over the Podkamennaya Tunguska River lit up the midnight sky as far away as London. It is believed that the event was caused by an asteroid or comet which entered the atmosphere and exploded 5-10 kilometers above the surface of the planet. The blast decimated an area of 830 square miles (2,150 km<sup>2</sup>), flattening over 80 million trees.

The Podkamennaya Tunguska River runs for a thousand miles deep within the Russian Taiga. This region is difficult to reach, but for over a century scientists have trekked to study and retrieve physical evidence of the event.

In the last decade, researchers from the University of Bologna, Italy have studied the Tunguska event from several scientific perspectives. Much

Damage from an event like Tunguska would easily cover the area of a major metropolitan area such as New York City. The illustration on the left demonstrates the damage caused by the Tunguska event. The small radial lines indicate the direction of fallen trees, also known as an "azimuth study." The scale is in miles.

In 2014, the Nuclear Test Ban Treaty Organization released new data about the frequency of large asteroid strikes. The organization operates a network of sensors across the planet that listen for the infrasound signature of a nuclear detonation. From 2000 to 2013, the network detected 26 explosions all of which came from asteroids exploding in the atmosphere. The events ranged from 1 to 20+ kilotons, yet with the exception of Chelyabinsk none are thought to have caused significant damage as the explosions occurred so high up in the atmosphere.







## titanic (coal from the wreck)

"I cannot imagine any condition which would cause a ship to founder. I cannot conceive of any vital disaster happening to this vessel. Modern shipbuilding has gone beyond that."

— Captain Edward Smith  
of the R.M.S. Titanic

Unfortunately, disaster struck on April 15th, 1912 when the ship struck an iceberg, sinking the "unsinkable," and causing the death of more than 1,500 people. Eyewitness reports indicate that the engineers on board did their best to keep the dynamos and the boilers running as long as possible.

The wreck of the Titanic was thought lost forever, but a joint French-American expedition discovered the ship in 1985 using a deep-sea camera sled named the Argo. Recovered artifacts have gone on display around the world, and a small selection, including the coal in the mini museum, has been made available to collectors.

### SOURCES:

Obtained from RMS Titanic, Inc, the exclusive steward of RMS Titanic. The Company is dedicated to preserving the legacy of the ship, wreck site and all her passengers and crew through educational, historical, scientific, and conservation-based programs.

Timpany, Mary S. "Ownership Rights in the Titanic." Case W. Res. L. Rev. 37 (1986): 72.

Lord, Walter. *The Night Lives On: The Untold Stories and Secrets Behind the Sinking of the "Unsinkable" Ship-Titanic*. Open Road Media, 2012.

Butler, Daniel Allen. *Unsinkable: the full story of the RMS Titanic*. Da Capo Press, 2012.

The R.M.S. Titanic was a legendary ship of epic proportions: 883 feet long, carrying nearly 2,200 passengers and crew, with a total displacement of 52,310 tons. The ship required enormous amounts of power. Her twin, triple-screw propulsion systems delivered 46,000 horsepower enabling the Titanic to achieve a top speed of 24 knots. By comparison, the fastest ocean liner today is the Queen Mary 2, which is capable of reaching just above 30 knots.

On a normal crossing, the Titanic's boilers consumed 600 tons of coal per day. Her coal bunkers could hold 6,600 long-tons, which was more than enough to get the fast ship from Southampton to New York in seven days.



The Titanic was equipped with every modern luxury and technological convenience of the time. An article published in the trade journal *The Electrician* in 1911 described the range of devices:

"Electricity is used in all departments of these mammoth ships, and before describing the large electrical installation in detail it will be of interest to the reader to enumerate the purposes to which electricity has been applied for power, quite apart from lighting. They are as follows:—Electric deck cranes, from 30 to 50 cwt.; cargo, boat and engine room winches; passenger elevators; stores, mail and pantry lifts; ventilating and stokehold fans; cabin fans; motors for cylinder lifting gear, turbine turning and lifting gear, and condenser sluice valves; pneumatic conveyor for Marconiograms; gymnastic apparatus; domestic machinery (such as ice rocker, dough mixers, potato peelers, roasters, knife cleaners, soup and sorbet machines, mincers); electric heaters and fires, hot plates, electric baths and irons; main steam whistles; sounding machines; stoking indicators; boiler room telegraphs; clocks; watertight doors; helm indicator; illuminated pictures and signs; chimes; bells; loud-speaking telephones and service telephones; submarine signaling; wireless telegraphy."

To meet such tremendous power requirements, the ship was equipped with four massive, steam-driven dynamos. Each dynamo produced 400 kilowatts of power supplying 16,000 amps at 100 volts to all areas of the ship.

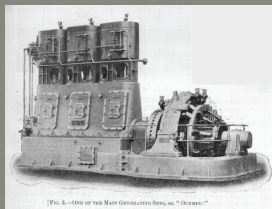


Photo. 3.—One of four steam dynamos from the "Titanic."

SPECIMEN TYPE: HUMAN ARTIFACT  
ESTIMATED FORMATION TEMPERATURE: 8430 K, 14714 F, 8156 C



## trinitite (first nuclear bomb test)

"Now I am become Death,  
the Destroyer of Worlds."

— Robert Oppenheimer

On July 16, 1945 near Alamogordo, New Mexico, the United States Army detonated the first nuclear device in history. Robert Oppenheimer and Major General Leslie Groves authorized this full-scale nuclear test, codenamed "Trinity," as part of the Manhattan Project. The "Gadget," as the device was referred to, exploded with an energy equivalent of around 20 kilotons of TNT, leaving a crater in the desert 2500 feet (76 m) wide. The explosion produced a mushroom cloud, which reached 7.5 miles (12.1 km) in height. People felt the shock wave over 100 miles (160 km) away.

The blast swept desert sand into the mushroom cloud where it liquefied and rained down on the crater. The cooling liquid formed a layer of glass 1-2 centimeters thick. The glass is referred to as "trinitite" or "Alamogordo Glass."

The sand at the Trinity Site is arkosic, which means it is composed primarily of feldspar and quartz. While these two minerals generally

produce clear glass, most trinitite is either pale green or oxblood red. The most common color is pale green, which indicates the presence of ferromagnesian silicates, such as olivine. Red trinitite indicates the presence of copper, which scientists believe came from melting overhead wires at the test site. Bits of the support structure and even the lead from the bomb casing itself have also been discovered in trinitite.

### SOURCES:

The specimen in the mini museum comes from mineral collections gathered in the early 1950's and sold to the public as novelties.

Ross, Clarence S. "Optical properties of glass from Alamogordo, New Mexico." *American Mineralogist* 33 (1948).

Hersey, John. *Hiroshima*. Random House LLC, 1985.

Bellucci, Jeremy J., et al. "A detailed geochemical investigation of post-nuclear detonation trinitite glass at high spatial resolution: Delineating anthropogenic vs. natural components." *Chemical Geology* 365 (2014): 69-86.

Kelly, Cynthia C. *The Manhattan Project: The birth of the atomic bomb in the words of its creators, eyewitnesses, and historians*. Black Dog & Leventhal, 2009.

This image of a "classic" mushroom cloud was taken during the Trinity test by the U.S. Department of Defense just 9 seconds after detonation.

We tend to associate mushroom clouds with nuclear blasts, but they can form as a result of any large explosion. Upon detonation, the fireball of the explosion rises into the air, drawing cooler air from below. The difference between the lower density cool air and hot gasses of the explosion creates a rotational effect that draws dirt and dust up from the ground along with the cooler air.







SPECIMEN TYPE:  
HUMAN ARTIFACT  
OR ROCK

TOTAL SUMMITS RECORDED:  
6,871 BY 4,042 CLIMBERS (2013)



LADDER



ROCK

## mount everest

"Because it's there."

- George Mallory

Mount Everest is the tallest mountain in the world. The peak rises 8,848 meters (29,029 ft.) above sea level, with the summit directly on the border of Nepal and China.

Like all the mountains of the Himalayas, Everest is a relative youngster in geological terms. Just 50-55 million years ago, the Indian subcontinent collided with the Eurasian tectonic plate. These churning continents cast up lighter, sedimentary layers that once formed the floor of the ancient ocean. Fossils from this ocean can be found on many of the Himalayan peaks, including Mount Everest.

There are two primary approaches to the mountain: the northern approach through China, formerly Tibet, and the southern approach through Nepal.

The northern approach was discovered by British mountaineer George Mallory during a survey mission in 1921. After three failed attempts to summit, Mallory returned to Everest in 1924. It

is unknown whether he and his partner Andrew Irvine reached the summit. The two climbers disappeared and remained lost on the mountain until their remains were discovered in 1999.

On May 29th, 1953, using the southern approach through Nepal, Sir Edmund Hillary and Nepalese Sherpa Tenzing Norgay became the first people to reach the summit of Mount Everest and return.

### SOURCES:

The medium mini museum contains a specimen cut from a ladder rung installed on Mount Everest. The large contains a specimen from the mountain itself. Together, these specimens represent the ever-changing nature of our planet and the extremes of both mental and physical human endurance.

Odell, N. E. "The highest fossils in the world." *Geological Magazine* 104.01 (1967): 73-74.

Fujita, Koji, Thompson, Lonnie. "Thirty-year history of glacier melting in the Nepal Himalayas." *Journal of Geophysical Research: Atmospheres* (1984-2012) 111.D3 (2006).

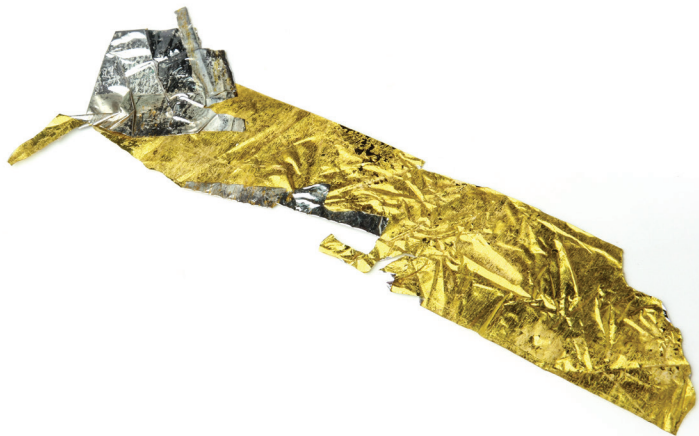
Krakauer, Jon. *Into thin air: A personal account of the Mount Everest disaster*. Random House LLC, 2009.

Davis, Wade. *Into the Silence: The Great War, Mallory, and the Conquest of Everest*. Random House, 2012.

More than 250 people have died trying to climb Mount Everest. Most perished in the "death zone" — above 8,000 meters (26,000 ft.) — where the air is too thin to sustain life, but danger is everywhere on the mountain.

On April 18th, 2014, a collapse at the Khumbu Icefalls killed sixteen Nepalese climbers. This highly unstable region, thick with fractures and hidden crevasses, marks the edge of the fast-moving Khumbu Glacier near the bottom of the South Col approach.





SPECIMEN TYPE:  
HUMAN ARTIFACT

DISTANCE TRAVELED:  
828,743 MILES (1.33M KM)



# apollo 11 command module foil

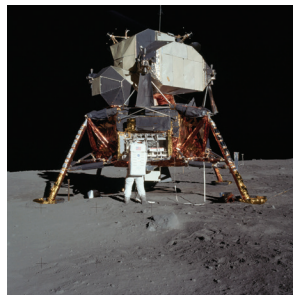
"That's one small step  
for a man, one giant leap  
for mankind."

- Neil Armstrong

The Apollo program was conceived during President Dwight D. Eisenhower's administration and later dedicated to President John F. Kennedy's goal of "landing a man on the Moon and returning him safely to the Earth" within a decade.

President Kennedy proposed this bold agenda during an address to the United States Congress on May 25th, 1961. On July 20, 1969, NASA fulfilled the mission when Neil Armstrong and Buzz Aldrin became the first humans to land on the moon. This was the 11th flight of the Apollo program, and the success was broadcast live to the entire world.

The technological and scientific breakthroughs associated with the Apollo program were vast and long lasting, but it is the human achievement which has held our imaginations for so many years.

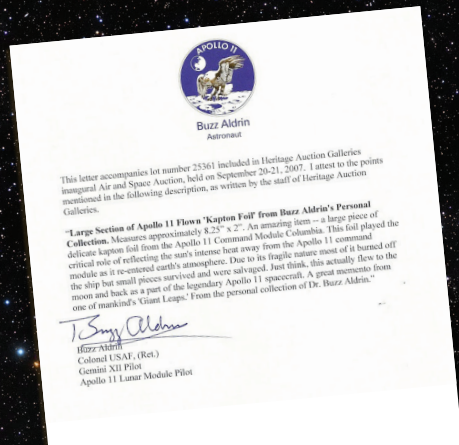


## SOURCES:

Hans waited for years to buy relics directly from any of the Apollo 11 astronauts. Finally, in 2007, Buzz Aldrin auctioned several of his Apollo 11 mission relics in Dallas, Texas. Hans went to the auction house and previewed the items carefully and decided the largest piece of kapton foil would be ideal for the mini museum.

Kranz, Gene. Failure is not an option: Mission control from Mercury to Apollo 13 and beyond. Simon and Schuster, 2001.

Chaikin, Andrew, and Victoria Kohl. Voices from the Moon: Apollo astronauts describe their lunar experiences. Viking Studio, 2009.



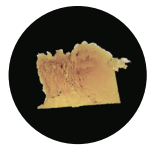
"This foil played the critical role of reflecting the sun's intense heat away from the Apollo 11 Command Module as it re-entered Earth's atmosphere. Due to its fragile nature, most of it burnt off the ship but small pieces survived and were salvaged. Just think, this actually flew to the moon and back as part of the legendary Apollo 11 Spacecraft. A great memento from one of Mankind's 'Giant Leaps.'"

- Buzz Aldrin's Letter  
of Authenticity



SPECIMEN TYPE:  
PLASTICIZED  
TISSUE

TOTAL NEURONS:  
100,000,000,000



## human brain

"Cogito ergo sum."

– René Descartes

The human brain is a hungry beast. Even though it only accounts for 2% of our body mass, the human brain consumes up to 20% of the energy produced by the body. The brain uses this energy for everyday things such as walking and breathing, but also for talking and thinking and the expression of emotion.

Over the last few decades, science has advanced our understanding of the brain in dramatic ways. Using magnetic resonance imaging, scientists have identified centers for many modes of thought. Computer simulations not only model our neural networks but have been used to create convincing artificial intelligences. This accumulation of data often yields dramatic breakthroughs in treatment for disease, and a deeper understanding of what makes us human.

But who is it that does all of that thinking?

Believe it or not, such philosophical questions are still deeply intertwined with the science of the mind because there is so much we still do

not know. For example, when a traumatic brain injury allows a person to acquire an incredible talent, we are left stunned at the possibilities.

Neuroscientist, V.S. Ramachandran put it very well, "As heady as our progress has been, we need to stay completely honest with ourselves and acknowledge that we have only discovered a tiny fraction of what there is to know about the human brain."

### SOURCES:

The specimen in the mini museum comes from a laboratory in Russia which uses the plastination methods described on the facing page to prepare subjects for various exhibits and research purposes worldwide.

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Von Hagens, Gunther. "Animal and vegetal tissues permanently preserved by synthetic resin impregnation." U.S. Patent No. 4,205,059. 27 May 1980.

Kurzweil, Ray. How to create a mind: The secret of human thought revealed. Penguin, 2012.

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In 1977, German doctor Gunther von Hagens invented a technique to preserve animal and plant tissues by replacing the water and fat with liquid polymers. The process, referred to as plastination, works on the cellular level. Tissue immersed in an acetone bath is subjected to a vacuum which causes the acetone to boil and evaporate. This draws the polymer into the cells, preserving detailed structures for permanent study. Dr. von Hagens has created many plasticine figures for study and display, including fish, giraffes, apes, and even human beings.





SPECIMEN TYPE:  
BONE

ESTIMATED AGE OF HOMO SAPIENS:  
200,000 YEARS



## human skull

"We pass through this world but once. Few tragedies can be more extensive than the stunting of life, few injustices deeper than the denial of an opportunity to strive or even to hope, by a limit imposed from without, but falsely identified as lying within."

– Stephen Jay Gould

The adult skull is comprised of 22 separate bones, including the mandible. It consists of two main regions, the viscerocranium, which supports the face, and the neurocranium, which houses the brain. This structure supports 4 muscles used for chewing and 17 muscles used for facial expressions. Our faces rely on this arrangement to give each of us a unique visual identity.

Many cultures have taken advantage of the process of cranial growth to modify the shape of the skull by means of straps, boards, and metal bands. The earliest evidence of intentional cranium deformation dates back to 45,000 BC. The reasons are complex but appear to revolve

around social status, spiritual connections, and cosmetic enhancement. Though most anthropologists would say the wider practice died out by the middle of the 20th century, hundreds of thousands of modern plastic surgeries still take place each year making one wonder if the methods have simply become more refined.

Still, if any ancient use for the skull has remained fixed in our modern conscience, it is the role of the human skull as a symbol of mortality. From burial practices to Shakespearean monologues, the skull is a universal symbol of death, sacrifice, and the memory of those who have preceded us.

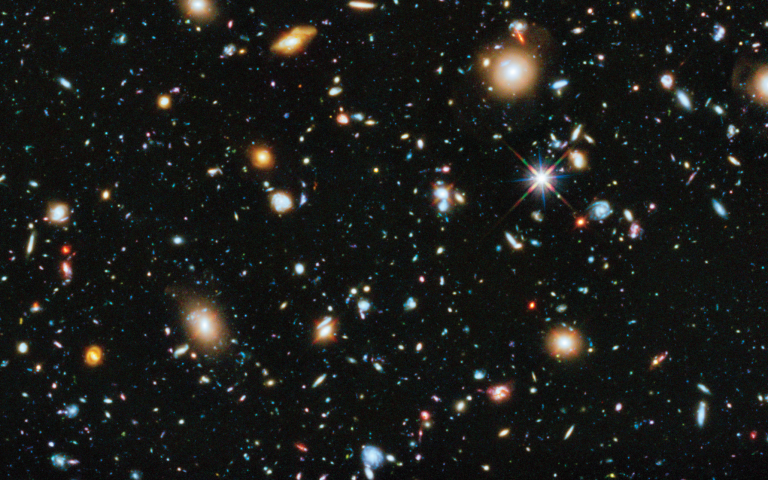
### SOURCES:

The specimens in the mini museum come from a variety of places around the world. Gerszten, Peter C., and Enrique Gerszten. "Intentional cranial deformation: a disappearing form of self-mutilation." *Neurosurgery* 37.3 (1995): 374-382. Gould, Stephen Jay. *The mismeasure of man*. WW Norton & Company, 1996. Quigley, Christine. *Skulls and skeletons: Human bone collections and accumulations*. McFarland, 2001.



The early 19th century saw the rise of a pseudo-science called "phrenology," which was centered on the idea that the shape of the skull could in fact determine some base aspects of one's personality. Though phrenology was generally discredited by 1840, some scientists couldn't let go of the fact that cranium size and shape might in fact determine general characteristics about entire classes of people, especially when it came to matters of race and gender. This practice continued on into the early 20th century and was most typically used to "prove" the superiority of one class of people over another.





SPECIMEN TYPE:  
EVERYTHING  
ELSE

ESTIMATED AGE:  
13,798,000,000 YEARS OLD  
±0.037 BILLION YEARS

## the universe

"Equipped with his five senses,  
man explores the universe  
around him and calls the  
adventure Science."

– **Edwin Powell Hubble**

The universe is amazing.

The image to the left is a section from the Hubble Ultra Deep Field taken by the Hubble Space Telescope. The vast majority of the bright spots in the image are distant galaxies. In the full image, there are approximately 10,000 galaxies, yet the entire frame depicts just 1/13,000,000 of the entire sky.

The Hubble Space Telescope is named for astronomer Edwin Powell Hubble. Much like Galileo, pictured opposite, Hubble's work challenged the scientific ideas of his day. He proved through careful observation of several spiral nebulae that there are in fact galaxies outside our own Milky Way. His theories also laid the groundwork for our modern understanding of an expanding universe.

I mentioned at the start of this guide that the mini museum is the realization of a lifelong dream. Yet, after traveling so far across time and space, the reader may be left wondering about the significance of a single life in such a grand and sprawling universe such as ours.

Questions of what we are, who we are, and how we came to be are just as important as where we are going. In truth, we are here together, but for each of us, life is an individual course. If we really take the time to look, we can discover that each person has an amazing story that's just as rich and deep as the universe itself.

Here at the end of the companion guide, I've decided to allow myself a little room to expand on certain themes that are central to the project and give the reader a chance to think about just how amazing the universe really is.

To begin, let's start at the beginning...



Galileo Galilei (1564-1642) is considered the father of observational astronomy and a key figure in many scientific advancements of his time. He is also famous for his defense of heliocentrism. Heliocentrism is an astronomical model that places the Sun at the center of our solar system. The model was proven mathematically by Nicolaus Copernicus in the 16th century, and fifty years later Galileo provided observational proof when he discovered the four largest moons of Jupiter.

"Philosophy is written in that great book which ever lies before our eyes - I mean the universe - but we cannot understand it if we do not first learn the language and grasp the symbols, in which it is written. This book is written in the mathematical language, and the symbols are triangles, circles and other geometrical figures, without whose help it is impossible to comprehend a single word of it; without which one wanders in vain through a dark labyrinth."

In 1633, Galileo was persecuted for his support of Copernican ideas and held under house arrest for the remainder of his life.

## TIME

“The only reason for time is so that everything doesn’t happen at once.”

– Albert Einstein

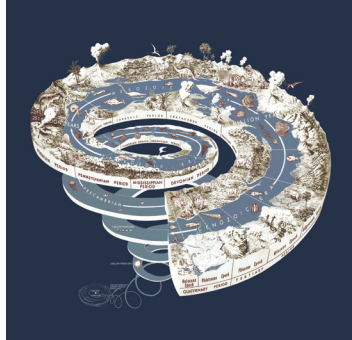
When we are very young, we may feel that a summer lasts forever. Each adventure creates a memory which adds to the bedrock of our individual histories. Decades later, when we look back, we sometimes feel things that happened decades before just happened yesterday while something we did last week is lost in some forever long ago.

This relative perspective of time is amplified a billion-fold when we study the history of our planet. Hundreds of years can disappear in a flash, and a few million years may pass in a single sunny afternoon. Really, just do the math!



\* SO, JUST ABOUT THREE MILLION YEARS BETWEEN LUNCH AND DINNER.

There are many ways to represent the passing of so many years. Timelines, bar graphs, clocks, even creative spirals like this classic image from the US Geological Survey:



As cool as this image is, there’s so much still missing. Time is complex, and each attempt to visualize time invariably leaves some element off the charts. We could try and write it all out, but even if we are very careful it can be confusing.

**We live in the Subatlantic Chronozone, which is part of the Holocene Epoch. The Holocene Epoch began 11,700 years ago and is part of the Cenozoic Era. The Cenozoic Era began 65 million years ago and is part of the Phanerozoic Eon. The Phanerozoic Eon encompasses roughly 542 million years and is part of the Supereon. The Supereon is the largest defined unit of geological time; it covers the entirety of Earth’s history or 4.54 billion years.**

Even with well-defined guideposts, that’s certainly a lot to keep straight.

While creating the mini museum, I was constantly reminded of the disorienting effects of time. In one day, I might touch a piece of the moon (some 4.45 billion years old) while also holding a piece of Apollo 11. The juxtaposition

of two related events separated by immense periods can be difficult to hold in one thought.

Scientists have a term for this philosophical quandary. It’s called deep time.

Deep time is mainly used when dealing with geological timescales. It can be helpful when thinking about the slow, but never-ending movement of continents or how one species might evolve into something quite new.

## SCIENTIFIC METHOD

“The only constant is change.”

– Heraclitus

I said before that it is certain a future reader will find that science has advanced in one way or another so as to render some of the information in this guide obsolete. This is the nature of making something that lasts a very long time.

In reality, our understanding of life and the universe changes every day. Even while compiling this guide, things have changed:

- Several new species of dinosaurs were discovered, including one sauropod in Argentina which is thought to be “the largest ever.”
- Earth experienced a completely new meteor shower called the May Camelopardalids.
- The Antarctic Circumpolar Current mentioned on page 19 made global headlines as NASA announced that the Western Ice Sheet of Antarctica was headed for an unstoppable collapse within a few centuries.

To compensate for the unrelenting pace of change, I’ve tried to incorporate the latest scientific thinking for each specimen. Occasionally, this meant taking a risk with certain information or techniques that may not be accepted by the entire scientific community. In those cases, I’ve made note of the situation as appropriate, but I think it is good to try and stretch a little. Stretching is where new thinking begins and new thinking is really at the heart of science.

In science, a new idea or proposed explanation is referred to as a hypothesis. Scientists working with a hypothesis designs experiments to test their ideas. They make observations and compare results with past work to reach more solid conclusions. In practice, these results and the methods are shared with other scientists who review and try to reproduce the work. As a body, this entire process is referred to as the scientific method.

While the scientific method can be seen a framework for asking big questions in a structured fashion, it also provides a way for scientists to challenge the ideas that have come before. If one thinks about it from this perspective, the scientific method is a way for us to say “What if?” about ourselves and the universe.

## EXTINCTION

“Earth will survive this. People say ‘save the Earth.’ No, Don’t worry about Earth. Earth will be here long after we render ourselves extinct.”

– Neil deGrasse Tyson

When describing the K-Pg Boundary Layer on page 35, I mentioned that there is evidence to suggest that massive extinction events happen perhaps every one hundred million years or so. Yet there are dozens of smaller events in the record as well. These “lesser” events, sometimes referred to as disruptions or turnovers, occur every twenty to thirty million years though there is some evidence they happen even more frequently.

I thought it might be interesting to take a deeper look at the events behind a single mass extinction event. If we’re going to dive into the mechanics of any single mass extinction event, let’s go for the largest, the Permian-Triassic Extinction Event.

The Permian-Triassic Extinction Event occurred 251 million years ago and wiped out nearly 90% of all species on the planet. Though there are many competing theories about this event, many scientists believe that a massive, million-year, plume event referred to as the Siberian Traps was the primary culprit.

A plume event is like a giant volcano up to 1000km wide in which superheated rock rises up through the mantle and then erupts through the crust creating a flood of basalt. In the case of the Siberian Traps, this eruption lasted for a million years, spanning the Permian-Triassic boundary in the geological record. At the peak of the eruption, it is thought that the basalt flood from the Siberian Traps covered an area three times the size of Western Europe.

As carbon dioxide levels soared, the Siberian Traps event triggered a dramatic shift in the

global climate. A 2014 study by researchers at MIT described in the Proceedings of the National Academy of Science suggests that the eruption released a significant amount of nickel from deep within the planet. The team, led by Dr. Daniel Rothman, found that a particular nickel-loving, methane-producing bacteria called Methanogens used the nearly limitless supply of nickel to bloom at the bottom of the ocean. The resulting release of methane wiped out nearly 96% of marine life and annihilated terrestrial species including animals, insects, and plants. The devastation was so severe it took millions of years for life to recover.

Twenty million years later in the Middle Triassic, new creatures such as *Nyasaurus* (one of the first dinosaurs) made their appearance. Older forms of life also began to rebound, including conifers which returned in force. Conifers filled in the gap in the ecosystem left by the disappearance of other plants, diversifying and establishing a dominance that still reigns today in the boreal forests of Canada and Russia.

As it just so happens a distant relative of one of these conifers happens to be in your mini museum. Can you spot it? Here’s a hint...

In a 2009 study published by the Royal Society, a team led by Dr. Alexander Wolfe of the University of Alberta, Canada named one particular family of conifers, known as *Sciadopityaceae*, as the likely source of all Baltic amber. Members of *Sciadopityaceae* entered the fossil record during the Middle Triassic period 230 million years ago, right about the time life really began to rebound after the Permian-Triassic Extinction Event. Today, the only living relative of *Sciadopityaceae*

is the umbrella pine of Japan, but in the millions of years between the event and now *Sciadopityaceae* could be found from Scandinavia to Antarctica and, of course, around the Baltic Sea.

## THE UNTOLD STORY

“Man selects only for his own good: Nature only for that of the being which she tends.”

– Charles Darwin

Perhaps one of the most difficult parts about creating the mini museum was deciding what specimens to leave out. Editing this guide presented similar challenges.

Here is an example that didn’t make the cut:

**On May 16th, 1975, Junko Tabei of Japan became the first woman to reach the summit of Mount Everest.**

While true, a statement like this hardly seems fitting to describe the career of one of the most remarkable figures in mountaineering or even the details of this one particular climb.

In fact, about ten days before reaching the summit, an avalanche at Camp 2 buried the all-female Japanese climbing team. Junko Tabei lost consciousness under the snow, and her body was so badly injured she could barely stand after being rescued by sherpas. The fifteen women on this team refused to give up. They stepped forward instead of retreating.



“Technique and ability alone do not get you to the top – it is the willpower that is the most important. This willpower you cannot buy with money or be given by others – it rises in your heart.”

– Junko Tabei

Inspiring words from a someone who not only met the challenge of Mount Everest but went on to climb the highest peaks on every continent. It is also symbolic of the challenge faced by anyone trying to grapple with large subjects. Frustrating to be sure, but at the same time inspiring, even in the face of rapidly changing conditions.

The reader may ask why I did not include this information on the Mount Everest specimen page, and it really comes down to the process of editing. Editing, curating, and deciding what will become the untold story is a painful task. It plagues many writers. Ties them up in knots, sometimes for years.

Charles Darwin was just such a writer. Darwin was not the first to write about the process of evolution. Much like Galileo in his day,

Darwin faced a hostile audience aligned with immutable ideas about the nature of the universe. The main ideas for his book, *The Origin of the Species*, were essentially complete in the 1844 but the book wouldn't be made ready for publication until 1859.

So why did it take so long?

In *The Reluctant Mr. Darwin*, author David Quammen, does an excellent job of explaining the internal struggle Darwin faced in the development of his life's work. How the work expanded and grew. How his own fear transformed the entire project into something like a prison. It wasn't until Darwin received a short essay by young naturalist outlining the very ideas that Darwin had spent his life working toward that he was spurred into action. Still, even when faced with losing his life's work to another, Darwin was reluctant to bring the work to its conclusion.

I can understand the hesitation. I've been working on the mini museum for most of my life. I've acquired many specimens, thought carefully about each and every one, and made difficult choices. At times, the project was so clear in my mind that I knew exactly what needed to be done. In other moments, I hesitated.

The untold story behind the mini museum is that I had all the reasons in the universe to finish the work, but it wasn't until I'd actually focused my entire being on completing the project that things moved forward. I risked everything I had to complete this project, and I received enormous support and encouragement from friends and family. At each step, I was faced with choices and challenges. Some I made on my

own, but most I made with the help of others.

Sitting down to write this closing to the companion guide, I thought about all of the people who helped me along the way, from my father's friends who encouraged me as a boy to all the wonderful Kickstarter backers who believed in my vision. There are so very, very many. I would list them all, but that would fill another volume entirely.

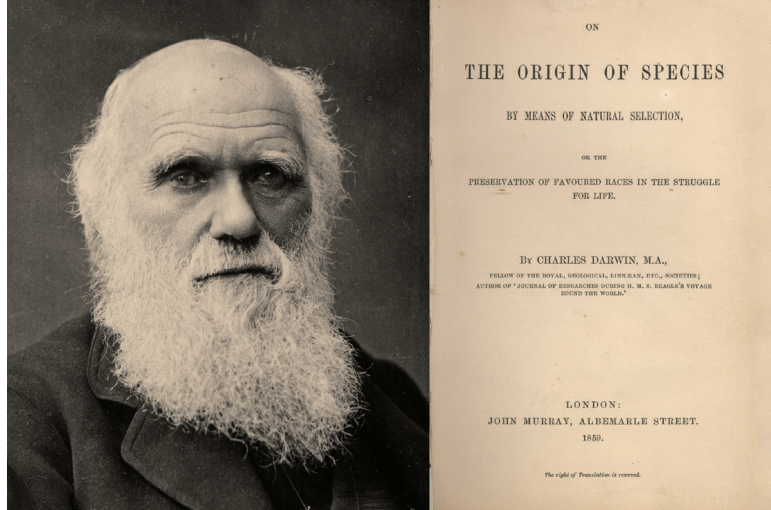
What I will say is that when I envisioned the mini museum project as a child, I anticipated what it would be like to hold a prototype in my hand, but I never realized the contentment I would feel watching a community evolve around my idea. I've received kind words and encouragement from all over the world. I only wish I'd done it sooner.

The universe is amazing, and now it's back to work!

"Man ska vara snäll." (Swedish)

"One should be nice"  
(English translation)

- Something my father used to say,  
expressing his thoughts on our  
responsibility of being human.



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