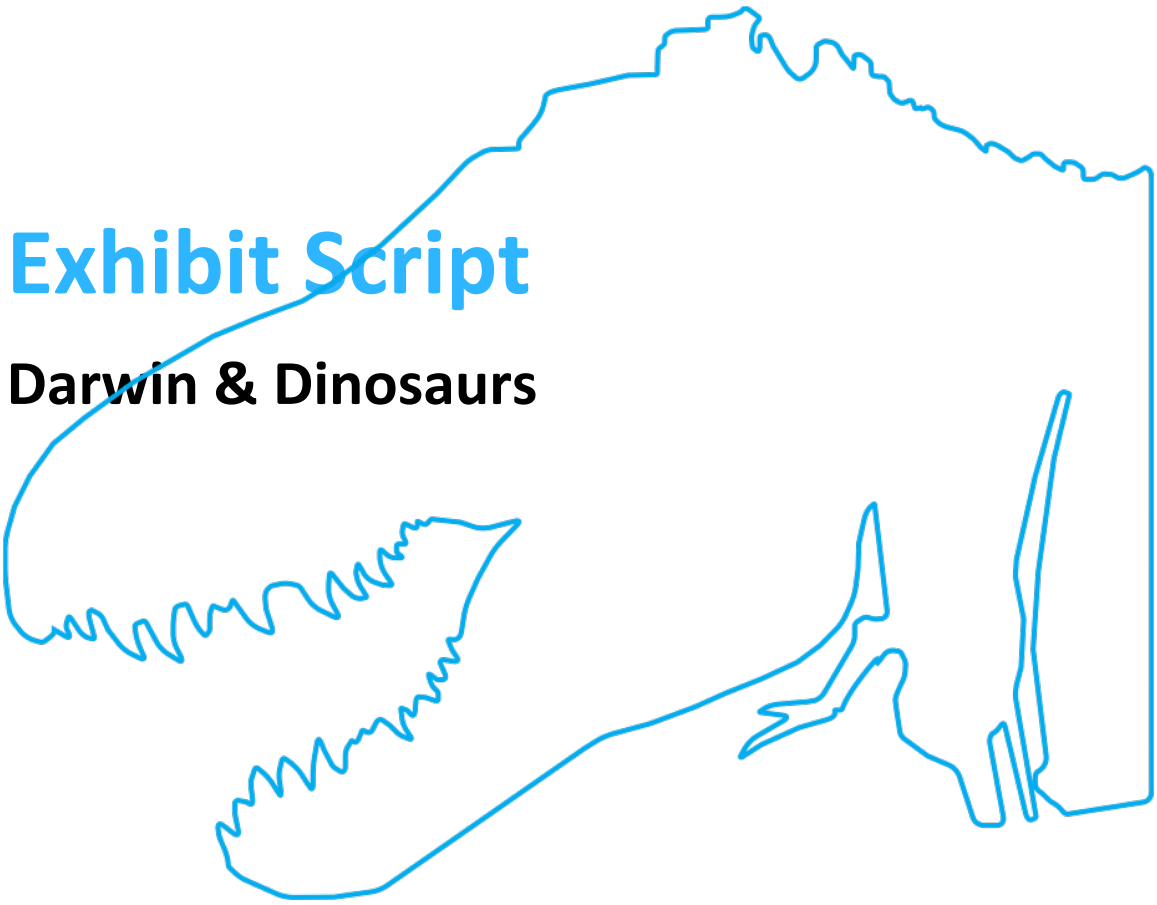
Exhibit Script

Darwin & Dinosaurs



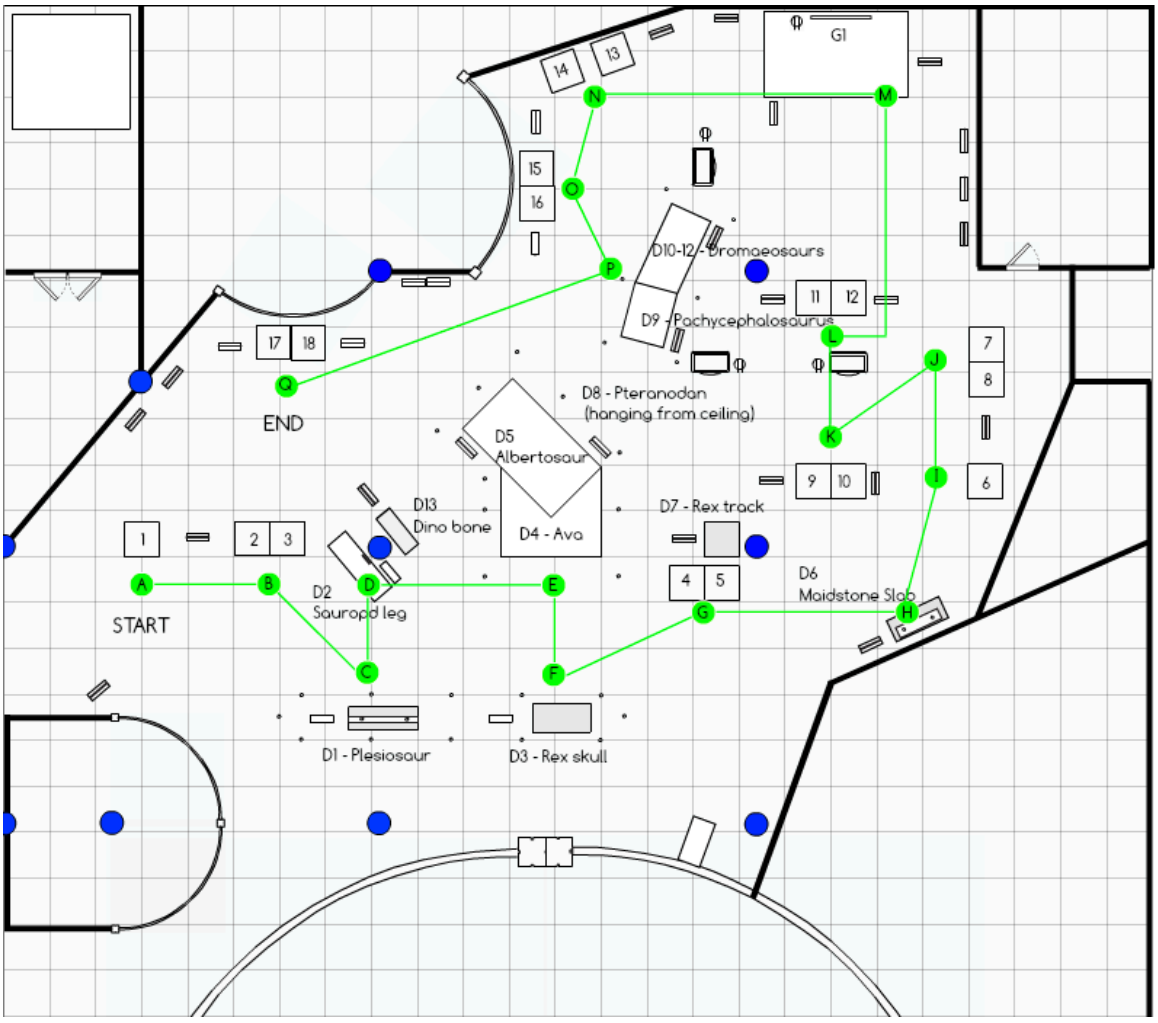
Embedded Exhibitions

Exhibit Script

Embedded Exhibitions provides this script for the D&D Exhibition. Host museums are free to edit the script and this may be necessary for a non-standard exhibit set up.

The script is approximately 45 minutes long. It covers all the major exhibit components and takes the visitor through Darwin's life and work and, ultimately, his formulation of the theory of natural selection.

The script is meant to be used for docent-led tours. The script is based on the exhibit layout at the MOSH, shown below.



Light blue boxes contain text that is especially important and/or interesting.

Light orange boxes are instructions to the guide.

Bright blue text color indicates the text refers to an object in the case.

FAQs are on page 25-26.

Draft visitor evaluation cards are shown on pages 27-28.

For clarification of any fact, visitor questions, or more information, email Angus Carroll, at angus.carroll@gmail.com, or call his cell at 256.783.0069.

DARWIN & DINOSAURS SCRIPT

Welcome to the Darwin & Dinosaurs exhibit at [the MOSH] which runs until [Date].

Darwin & Dinosaurs tells the story of how early geological and paleontological discoveries led to a deeper understanding of Earth's history. This in turn set the stage for a young Charles Darwin who set out on a five-year voyage with a new scientific worldview. What Darwin saw - and interpreted within the new context of the "new geology" - helped him solve one of the great mysteries of all time: the story of Life on Earth.

A: Case 1, Early Geology

In the early 1780's, James Hutton, often called the founder of modern geology, went on a series of geological expeditions. At Glen Tilt, Jedburgh, and most famously, Siccar Point (all in Scotland), he saw rock formations that puzzled him.

In these places, rock layers change direction abruptly, often running into layers above and below at right angles. He called these formations "unconformities." Hutton surmised the only way rocks could end up like this was over vast periods of time as the rock layers were deformed by powerful forces from below.

Hutton also looked at individual rocks such as granites and septarian nodules (samples are on lower shelf). These also indicated a long and tortured history. Based on these observations, he concluded Earth was very old (millions of years old, in fact), and had a hot, molten center.

He first presented his theories to the Royal Society of Edinburgh in 1785 and published it in the Society's Transactions in 1788. (An original copy of this paper, Theory of the Earth, is back of top shelf.)

In 1795, he published a more detailed two-volume account entitled, **Theory of the Earth with Proofs and Illustrations.** Unfortunately, he was a better observer than writer - it was written so poorly almost no one could understand it.

Fortunately, his friend, William Playfair, summarized his work in 1802 in a work entitled **Illustrations of the Huttonian Theory of the Earth**. It is Playfair's work that introduced Hutton's ideas to the world - and to one man in particular, Charles Lyell.

Lyell was a British geologist and he authored a three-volume work entitled **Principles of Geology** (front of top shelf). The first volume was published in 1830 and Darwin took a copy of it with him on the voyage (it was given to Darwin by the ship's captain, Robert Fitzroy).

Lyell's work further codified the theories of Hutton and laid out the principle of "uniformatism" – the idea that Earth we see today is the result of millions of years of slow imperceptible changes (like erosion) – changes still going on today – as opposed to "catastrophism" – events like the biblical Flood.

Darwin was heavily influenced by Lyell's work. He later said, "**I always feel as if my books came half out of Lyell's brain."**

B: Case 2/3, Mary Anning

This section is about Mary Anning, one of the great fossil hunters of all time. She discovered the first ichthyosaur and plesiosaur – two giant prehistoric marine reptiles – and the first pterosaur found in England. A cast of the ichthyosaur skull she found is in this case as is the pterosaur. A cast of the plesiosaur is mounted behind us. (All of the originals are in the Museum of Natural History, London).

Mary lived in a small town called Lyme Regis on the South coast of England. Her family was very poor and she would hunt for fossils along the shore that she could sell to tourists to help make ends meet.

She was the inspiration for the rhyme, **"She sells seashells by the seashore."**

The cliffs along the coast would collapse after rainstorms exposing new fossils, but it was dangerous. One day, a mudslide killed her dog which was sitting only a few feet from her.

In the nineteenth century women were not allowed to be members of scientific societies, so she was never credited with any of her incredible discoveries – scientists bought the fossils from her and published papers on them under their own names.

Although not credited with her discoveries, Mary was well-respected in the scientific community. Many of the leading geologists of the day traveled to Lyme Regis to meet her and get her opinion of the fossils.

And many helped her, too. At one point, Henry de la Beche, a well-known geologist, painted a prehistoric scene based on her discoveries. He then sold lithographs of the painting and gave the proceeds to Mary and her family (an image of the lithograph is in Case 2 on the right back panel). And near the end of her life, William Buckland (who published the first scientific paper on a dinosaur), convinced the British government to grant her a pension.

C: Plesiosaur

This is a cast of the plesiosaur that Mary Anning found. It was the first complete plesiosaur ever discovered and was the talk of the town when it was put on display in London. William Buckland (who described the first dinosaur, Megalosaurus), called it, **"A sea serpent run through a turtle."**

Although fragments had been found previously, it was Anning's specimen that allowed scientists to describe the new marine reptile accurately.

Technically, plesiosaurs and ichthyosaurs are not dinosaurs – dinosaurs walked on land. Both marine reptiles and flying reptiles (like pterosaurs), were sister classes to dinosaurs – but they all lived at the same time and fought epic battles.

D: Sauropod Leg

This is the hind leg of a large sauropod (lizard foot), called Apatosaurus (deceptive lizard – so named because its bone structure differed slightly from other known sauropods). The leg is made up of the upper leg bone called the femur, the two lower leg bones, the tibia and the fibula, and the foot bones. It is over 11 feet high.

Apatosaurs were typically 50-75 feet in length and weighed 40-50 tons, but some specimens are estimated to have been almost 100 feet long and weighed up to 80 tons.

E: New Species of Ceratopsian (AVA)

This dramatic scene shows an Albertosaurus (named after Alberta, Canada, where it was first discovered) attacking a juvenile ceratopsian (horned face). The ceratopsian is a new species and has not yet been given a scientific name (for now she is informally called Ava).

Unlike the well-known triceratops (three horns), Ava has only two horns.

Ava was found in Montana in 2014 by Mike Triebold, the president of Triebold Paleontology, and co-curator of Darwin & Dinosaurs. This is the first time Ava has been outside her home museum. It is her debut!

We can tell Ava is a juvenile by the state of her bone development. While a full-grown Ava might be too much for an Albertosaurus to take on, a juvenile would be a prime target and this reenactment is a very realistic scenario.

Albertosaurus is a type of tyrannosaurid (a large group of meat-eating dinosaurs that includes the famous T. rex). Albertosaurus was smaller and more gracile than T. rex, but still a fearsome predator.

F: T. rex Skull

Speaking of T. rex., here is a cast of a T. rex skull. This skull is from a specimen known as Stan. Whenever a T. rex is found (which is rare – only about 10–15 “sort-of complete” Rex skeletons have ever been discovered), it is named after whoever found it, in this case Stan Sacrison.

As you can see the skull is much larger than the skull of the Albertosaurus. T. rex was much bigger.

What's really interesting is the damage to the head and neck. It is hard to imagine that any other dinosaur could do such damage other than another T. rex, and several of the holes are the size of T. rex teeth. When two T. rex fight, it's gotta hurt.

G: Case 4/5, First Dinosaurs

While Mary Anning was discovering huge prehistoric marine reptiles on the south coast of England, scientists were finding giant bones of terrestrial animals a little farther north in Oxfordshire.

There, William Buckland found the jaw of what is now called Megalosaurus (giant lizard). You can see a model of the jaw in the case. It was clearly a giant meat-eating Godzilla-like monster – and more importantly, clearly no longer wandering around England.

Indeed, the concept of "extinction" was new and disturbing. Before the discovery of Ichthyosaurs and Megalosaurs, the Western world took the biblical story of creation as fact: God had created all the animals when he created the Earth about 5,000 to 10,000 years ago. But if God created all the animals, why would some go extinct? And what if Earth was much older?

And it was not just Megalosaurus. Dr. Gideon Mantell was making a house call one day in 1822, and while his wife waited outside by the carriage she found a number of very unusual teeth by the roadside – they looked like the teeth of an iguana, but they were ten or twenty times larger. Mantell found other bones as well and realized they were all from another extinct monster which he called Iguanodon (iguana tooth).

Under the direction of Richard Owen (a famous Victorian anatomist who came up with the name "dinosaur"), Benjamin Waterhouse Hawkins was charged with reconstructing these early discoveries to be displayed at the Crystal Palace just outside London. He built giant clay models (a scale model of the Megalosaurus is in the case, top right shelf), then molded them so he could cast cement sections.

For each Iguanodon (two were made) it took:

- 600 bricks
- 1,500 tiles
- 38 casks of cement
- 90 casks of broken stone
- 100 feet of iron bar

On New Year's Eve 1853, Hawkins held a dinner party inside the giant mold for the Iguanodon and twenty people dined inside the dinosaur. Invitations were hand-signed by Hawkins and one of them is the display case (bottom right shelf).

Between Mary Anning's discoveries and the dinosaurs discovered by Buckland and Mantell, it was becoming clear that there was an unknown prehistoric world no one had ever imagined existed, and the Earth was millions of years old.

H: Maidstone Slab

The slab contains the bones of an Iguanodon. It was found in a quarry in Maidstone, Kent, and is known as the Maidstone Slab. It was this slab, along with the teeth his wife found, that helped Gideon Mantell piece together a description of the Iguanodon.

Mistakes were made. For example, Mantell mistook one of the iguanodon's thumbs as a horn and placed it on its nose.

This concludes Phase I of the exhibit, the story of early geological and paleontological discoveries. The main points to summarize before starting the next section:

1. **Based on geological formations and certain types of rocks, scientists concluded Earth was millions of years old.**
2. **Dinosaurs and other prehistoric creatures proved that animals went extinct – a concept that did not fit with traditional creation stories.**
3. **Darwin was brought up learning the "new geology" and set off on a five-year voyage schooled in this "new worldview."**

I: Case 6, Darwin on the Beagle

Darwin was born in 1809 in Shrewsbury, England, about 140 miles northwest of London. His father first sent him to Edinburgh University to study medicine (Darwin's father and grandfather were both physicians), but Darwin was not cut out to be a doctor.

He attended two operations but could not stay to either finished. Pre-anesthesia operations were grisly affairs.

Switching to Cambridge, Darwin enrolled in a Bachelor of Arts degree and intended to join the clergy. He studied a number of classics at Cambridge including William Paley's Natural Theology, famous for its watchmaker analogy (if you found a watch lying on the ground, you would presume there was a watchmaker, design implying a designer). Darwin would later write in his autobiography that he was – at the time - quite convinced by Paley's arguments.

But he was also inspired by the works of famous scientists like Alexander von Humboldt and John Herschel and was determined to make a contribution to the knowledge of the world.

At Cambridge he met John Stevens Henslow, Professor of Botany, who became his mentor. In fact, the Admiralty first asked Henslow if he wanted to join the Beagle voyage as naturalist. Henslow turned them down, but recommended Darwin.

And the rest, as they say, is history.

Darwin set out in December of 1831 on a five-year voyage around the world. He made stops in South America, the Galapagos Islands, Tahiti, New Zealand, Australia, Mauritius, South Africa and many other places. He studied the geology, botany and zoology of every place he visited. He hacked his way through the Amazon rain forest, rode horseback across the Patagonian plains, and clambered to the top of the Andes.

But it was not all roses: He was sea-sick the entire time he was on board the ship, and it was not particularly comfortable – he had to remove a drawer at night to make room for his feet.

On the top shelf there is a Bancks microscope identical to the one Darwin took on the voyage. It's a so-called "simple" microscope because it had only one lens, the eyepiece (a compound microscope has the eyepiece and a second lens called the objective).

The gun is a double barrel percussion pistol by the London maker Joseph Lang. Darwin took a pair of pistols like this (called a 'brace') with him on the voyage (he also took a shotgun).

They are called **Howdah** pistols because they were used when hunting tigers in India. In the nineteenth century it was fashionable to hunt tigers from atop elephants in India and the seat on top of the elephant was called the Howdah. Now and then a tiger would get fed up with being chased and turn and attack, clawing its way up the side of the elephant. A long gun was of no use in such close quarters, so hunters carried large caliber double barrel pistols as a last resort.

Also on the top shelf is a small compass. In his Journal, Darwin remarked on how popular his compass was: **"In every house I was asked to show the compass, and by its aid, together with a map, to point out the direction of various places. It excited the liveliest admiration that I, a perfect stranger, should know the road (for direction and road are synonymous on this open country) to places where I had never been."**

On the bottom shelf is a writing desk – we know Darwin had one with him on the voyage for he wrote many letters home. Next to the writing desk is a small notebook. It has special paper and uses a metal pen, making an indelible mark that would not smudge or erase. Darwin carried these notebooks on his excursions, copying his notes to his journal on the ship.

J: Case 7/8, Captain Robert FitzRoy

Although famous as "Darwin's captain," Robert FitzRoy was a remarkable man in his own right: He was a first rate sailor and captain, meticulous surveyor, and pioneering meteorologist. Known now as "Darwin's Voyage," the real purpose of the Beagle expedition was to chart the coast of South America.

When he returned, FitzRoy was awarded the Gold Medal by the Royal Geographical Society. In total, FitzRoy produced eighty-two coastal sheets, eighty harbor plans, and forty views. FitzRoy's coastal surveys were so accurate many still form the basis of Admiralty charts today, and they replaced virtually all South American charts then in existence. In the 1849 Admiralty Catalogue, for example, entire sections of South America are marked, *"By Capt. FitzRoy, R.N.,… except when otherwise expressed."*

On the top shelf are two chronometers. Keeping near-perfect time while at sea was the key to determining longitude (latitude can be determined from the noonday sun).

FitzRoy took twenty-two chronometers with him on the voyage, six of them his own. Incredibly, at the end of the five-year voyage, FitzRoy's was off by only 33 seconds. To put that in perspective, a modern quartz watch is off by about 1 second per **day**.

But FitzRoy was much more than just a meticulous surveyor. He basically invented weather forecasting. As a ship's captain, he studied the weather carefully and depended heavily on his barometric instruments (like the marine barometer and sympiesometer in the case on the right).

He observed that sharp changes in atmospheric pressure often indicated severe changes in weather and he developed an entire science based on barometric readings. In 1854, he started analyzing the weather for the Admiralty and later formed the Meteorological Department.

On August 1, 1861, FitzRoy issued the world's first weather forecast in the Times. And it was right! (an actual copy is on the lower shelf on the left).

In 1863, FitzRoy published **The Weather Book** in which he explained his theories and methods. (Lower shelf at the back.)

Although FitzRoy and Darwin got along well on the voyage, FitzRoy became more religious after his return and began advocating a literal reading of the Bible. He became a fierce critic of Darwin's theory of natural selection. After spending years together at sea as close companions, their friendship would end with the publication of the **Origin.**

K: Case 9/10, Galápagos Islands

One of the most important places Darwin visited was the Galápagos Islands. A small group of islands six hundred miles off the coast of Ecuador, the Galápagos are an almost totally isolated ecosystem.

Home to a number of unusual animals including marine iguanas and Blue-footed Boobies, they are most famous for their giant tortoises.

It was here that Darwin came across an important clue. One of the locals told him that he could tell what island a tortoise came from by the shape of its shell. Darwin realized what this meant: They were evolving slight differences based on the slight environmental differences on each island.

Indeed, there are two main shell shapes, dome-shaped and saddle-shaped. The dome-shaped tortoises cannot reach very high because the shape of the shell prevents their neck from angling upwards. The saddle-shaped, on the other hand, can reach higher because the shape of the shell allows them to extend their neck upwards.

The dome-shaped are found on islands with lush highlands where there is plenty of food on or near the ground. The saddle-shaped are found on more scrubby islands where the tortoises have to reach higher to eat the vegetation.

You can see how this works on the models in this case which were sculpted based on real tortoises.

The tortoise on the right (saddle-shaped) is modeled after Lonesome George. Lonesome George was the last tortoise from Pinta Island (the map on the back panels show where the tortoises live today). Although attempts were made to breed him with other tortoises, he produced no offspring. He died in 2012, the last of his sub-species.

Lonesome George was estimated to be about 100 years old. Giant tortoises have been known to live almost 200 years. It is possible there is a tortoise on one of the Galápagos Islands that actually met Charles Darwin!

Today, there are about 20,000 tortoises in the Galápagos, but they are still classified as endangered. It is estimated there were over 250,000 as recently as the sixteenth century. Habitat destruction and the introduction of goats, rats, and pigs (which eat their eggs), have seriously impacted their numbers.

But the biggest impact was eighteenth and nineteenth century buccaneers and whalers who discovered the tortoises could survive up to a year with no food and water and who loaded hundreds of them at a time into their holds (upside down) as a source of fresh meat.

L: Case 11/12, HMS Beagle

HMS (His Majesty's Ship) Beagle was a small ship, only 90 feet long. On Darwin's voyage it carried seventy-four men. Darwin shared the poop cabin with two others. It also served as the chart room and it had a mast running through the middle of it.

The voyage with Darwin aboard (1831-1836) was the Beagle's second surveying voyage. She had previously conducted survey work in South America (1826-1830) under the command of Captain Pringle Stokes. Depressed and exhausted by the work, Stokes had committed suicide on that expedition and command of the Beagle went to FitzRoy.

The ship undertook a final surveying assignment in Australia under the command of John Wickham (1837-1842), who had sailed on the second voyage as a Lieutenant. After then serving as a customs ship for twenty years, she was sold in 1870 and broken up.

Fitzroy had her extensively re-fitted before the second voyage, raising the decks and adding lightning rods, among other changes. The model here was built based on the original dockyard plans but reflecting the modifications FitzRoy made.

FitzRoy had raised the decks to make the ship more stable – Cherokee-class ships like the Beagle were known as "coffin" brigs due to their tendency to capsize.

In the lower right, under the ship, is the first edition of the Voyage Narrative by FitzRoy (3 volumes plus an appendix volume). The third volume is Darwin's **Journal** (now known as the **Voyage of the Beagle**) and his first published book (1839). In front of the set is the map showing the route of the Beagle as it circumnavigated the globe.

The Beagle spent most of its time in South America, surveying the coast. This allowed Darwin to mount numerous inland expeditions and several of them provided important clues.

In September 1832, at Bahía Blanca, south of Buenos Aires, Darwin excavated several huge skeletons, the remains of giant prehistoric animals.

One was a giant sloth similar to the present-day sloth—but much bigger—and there were also bones of a giant armadillo. Darwin marveled at their close resemblance to modern species.

He would later write in his *Journal*, **"This wonderful relationship in the same continent between the dead and the living will, I have no doubt, hereafter throw more light on the appearance of organic beings on our earth and their disappearance from it, than any other class of facts."**

In February 1835, Darwin experienced nature's terrifying power. While in the town of Valdivia, the ground shook as an earthquake struck the west coast.

Two hundred miles north at Concepcion, the cathedral was left in ruins and a twenty-foot tidal wave hit the city, carrying a schooner into the center of town. Fires blazed everywhere.

Amidst the wreckage, however, Darwin made another important discovery: the beds of dead mussels were now above the high tide mark. The ground had risen several feet—proof that Lyell was right.

Indeed, over millions of years, the continents rise and fall, creating and destroying mountains and reshaping the world in small, imperceptible steps.

All these clues led Darwin to conclude that species were evolving. But he needed to figure out how.

It is amazing to think, but Darwin's voyage almost didn't take place because of his nose.

When FitzRoy first met Darwin he did not think him suitable for the assignment. FitzRoy was a follower of Johan Lavater, a Swiss theologian who believed you could tell a lot about a person by their face and countenance (a practice known as "physiognomy").

As Darwin later recalled, **"[FitzRoy] doubted whether anyone with my nose could possess the sufficient energy and determination for the voyage,"** adding that after the voyage, **"I think he was well-satisfied that my nose had spoken falsely."**

This concludes Phase II of the exhibit, the story of Darwin's voyage. Summarize the three main clues Darwin came across that made him think species evolve:

1. **How modern animals resemble their extinct ancestors (i.e., the Megatherium) – indicating descent;**
2. **That the tortoises in the Galapagos varied from island to island, indicating adaptation;**
3. **How the ground had risen as a result of the earthquake he experienced in Chile – supporting Lyell's theory of "uniformatism" and an Earth millions of years in the making.**

INTERACTIVE TOUCHSCREENS

[Here the tour guide should quickly demonstrate how the touchscreens work, using the menu, expanding images and clicking on the information button in the lower left corner of each object.

Rather than interrupt the flow of the tour, the guide should explain how they work and say that they can return and use them after the tour is complete.]

M: Hungry Birds Game

And now for the fun part of the tour: Hungry Birds!

We need two volunteers to step up and play the game. It takes about 3 minutes. You are a bird flying through the forest and you have to eat as many moths as possible – birds expend a lot of energy flying and they need a lot of food.

[The game is self-explanatory and requires little input or guidance from the tour guide. To keep the tour on track, one game should be played (either one or two players) and then the group should move on – the guide should tell others in the group they can play the game after the tour.]

N: Case 13, Case 14 (The Delay, Darwin's Life)

One of the great myths about Darwin is that he delayed publishing his theory over twenty-five years because he was afraid of the controversy that would ensue. But the facts don't support this popular misconception.

True, he sketched out his theory in 1842 and did not publish the **Origin** until 1859, but he had no intention of publishing his theory until he had gathered all the facts, and that would have to wait until he was done with the work he already had on his plate from the voyage.

Between 1839 and 1854 (when he seriously started working on his theory), Darwin published his Journal, three books on the geology of the voyage, edited a massive three volume set on the zoology (these are on the lower shelf), published a four volume monograph on barnacles (that remains the definitive work today), and published sixteen major scientific papers.

He also got married, moved twice and had ten children.

There is also evidence Darwin thought he needed to establish his credibility as a serious zoologist before claiming to have solved the "mystery of mysteries," as the astronomer John Herschel called the origin of species.

In 1845, Hooker had written to Darwin criticizing the work of a French amateur named Gérard, saying, **"I am not inclined to take much for granted from any one [who] treats the subject in his way & who does not know what it is to be a specific Naturalist himself."**

There is no doubt this hit home, because Darwin wrote back to Hooker the next day: **"How painfully (to me) true is your remark that no one has hardly a right to examine the question of species who has not minutely described many."**

Hooker did not mean it as a criticism of Darwin (as he quickly explained in his next letter), but the exchange took place just before Darwin started on the barnacles and he probably realized the truth in Hooker's words, whether or not they were meant for him.

Darwin was not hesitant; he was busy. He did not "delay" twenty-five years; he was busy. Only when he wrapped up the work from the voyage—and established himself as an expert on an entire taxonomic group—did he then return to the species question.

The microscope in the case (top shelf) is by James Smith – Darwin had an identical microscope which he bought specifically for his barnacle research. The letter (also top shelf) is from Darwin to the Revd Smith and covers a number of scientific subjects including bird beaks and caves on Caldy Island. But what's most interesting is the seal.

The seal, impressed in red wax, shows a griffin, facing left, holding a shell, all within an oval border inscribed with the motto **Cave et Aude**, which means Beware and Dare.

Darwin's seal is rare—he wrote thousands of letters after 1840, but no other is described as having the seal. It is possible Darwin had the seal made in a fit of youthful enthusiasm, used it for a short period of time and then stopped, realizing it was a bit ostentatious. A simpler explanation: He lost it.

Interestingly, the family motto was not always **Cave et Aude**. In the late 18th century, Darwin's grandfather Erasmus changed the motto to **E Conchis Omnia** (Everything from shells), reflecting his belief that all life descended from one simple form, a concept he put forward in his work Zoonomia (1794).

Erasmus not only put the new motto on his bookplate, he put it on the side of his carriage. Unfortunately, Thomas Seward, who was Canon of nearby Lichfield Cathedral, noticed it and accused Erasmus of having "renounced his Creator." He wrote a satirical poem about Erasmus, part of which read:

> **Great wizard he! By magic spells**
> **Can all things raise from cockle shells.**

Having been called out by the Canon, Erasmus painted over the motto on his carriage to avoid offending his clients. Nevertheless, he kept it on his bookplate, as did his son, Robert Waring Darwin, Charles' father. Thus, Charles grew up in a house where all the books carried an evolutionary declaration.

Charles, however, used the original motto when he had his seal made, even though by then (1840) he had read Malthus and was an evolutionist himself. It may be he had forgotten (or never noticed) Erasmus' version, and went on whatever Fox told him, probably the original.

In any case, both suit Darwin well, for if not Everything from Shells, Beware and Dare nicely sums up Darwin's career: He went cautiously, weighing the evidence slowly, but when he was sure, he turned the world on its head.

In the next case we learn a little bit more about Darwin's life. At Cambridge, for example, he was an enthusiastic collector of insects. In fact, Darwin's first scientific citation is for a moth he collected (*Graphiphora plecta*, known as the Flame Shoulder, is highlighted in the case).

Darwin later recalled, **"No poet ever felt more delight at seeing his first poem published than I did at seeing in Stephen's *Illustrations of British Insects* the magic words, 'captured by C. Darwin, Esq.'"**

But the bugs may have had the last laugh. Darwin was sick almost his entire life and it may have all started in South America.

He spent one night in a small village just south of Mendoza and remembered it well. He wrote in his *Journal*: **"At night I experienced an attack (for it deserves no less a name) of the Benchuca (a species of Reduvius), the great black bug of the Pampas. It is most disgusting to feel soft wingless insects, about an inch long, crawling over one's body."**

A Benchuca bug (known as the Kissing Bug) is in the case on the top shelf. It is now known the Benchuca bug can transmit Chagas disease, a debilitating (potentially fatal) disease that causes symptoms similar to many of those Darwin reported after he returned to England.

Unfortunately, the medicines of the day may have done more harm than good. At different times he was prescribed opium, morphine, and of all things, arsenic. A typical mid-nineteenth century home apothecary chest is on the bottom shelf, along with an electroshock therapy device (Darwin tried that, too), and a pamphlet on the so-called "water-cure" (whereby you are constantly doused in cold water and forced to eat really bad food).

Darwin claimed the only thing that seemed to help was the "water-cure" though it certainly didn't "cure" him – and it was probably more the bland diet and long walks that helped, as opposed to being half-drowned every day.

O: Case 15/16, Origin of Species

In this case is a first edition of Darwin's main work (top shelf, left side), **On the Origin of Species**, published in 1859. It is considered a landmark in the history of science, changing not only our understanding of the world, but of our place in it.

Given its explanatory power, the theory of natural selection is remarkably simple: Limited resources (there isn't enough food for all the offspring produced) leads to competition. Some individuals will do better than others because they happen to have certain characteristics that give them an edge: speed, strength, etc. Because those individuals are more likely to survive, they are more likely to reproduce and pass on their characteristics to their offspring. Thus the population of a species evolves as more and more individuals are born (and survive) who have inherited the characteristics that provide advantage.

When T.H. Huxley first read the **Origin** he is reported to have said, “How extremely stupid not to have thought of that.”

You can tell a first edition of the **Origin** by the fact it has only two quotes facing the title page – later editions had three (the first American edition also has two quotes, but the title page makes it clear it was published in 1860 and in the U.S.).

A little known fact is that the theory of natural selection first appeared a year earlier (in 1858) in the **Journal of the Proceedings of the Linnean Society.**

In June 1858 Darwin received a letter from Alfred Russel Wallace, a naturalist working in the Malay Archipelago (what is now Indonesia and the Philippines). Wallace had come to the same conclusions as Darwin. He wrote up a paper on it and sent it to – of all people – Darwin.

When Darwin got Wallace’s letter he was stunned. It was almost identical to his own theory. Because T.H. Huxley and Charles Lyell both knew Darwin had already devised the theory, they arranged for Wallace’s paper to be jointly published along with a short abstract by Darwin. Called the Darwin-Wallace paper (to the left of the Origin on the top left shelf), it is the first official announcement of the theory of natural selection.

On the bottom shelf are early reviews of the Origin. Contrary to popular belief, many of them were positive. The first review appeared in the Athenaeum, on November 19, 1859 (it was skeptical, if not negative).

On the top right shelf are many of the works of Alfred Russel Wallace. Almost forgotten in the shadow of Darwin, Wallace is in every sense the co-discoverer of the theory of natural selection.

Why does Darwin get all the credit? Because he worked out the details. It is not enough to simply announce a hypothesis. Darwin spent years studying artificial selection (how animal breeders create varieties), gathering evidence of adaptation, and working out the many problems.

It was the scope and depth of Darwin’s work that convinced the scientific community that evolution had taken place.

P: Pachycephalosaur & Dromaeosaurs

This dynamic scene of three dromaeosaurs (running lizards) attacking a pachycephalosaur (thick-headed lizard) demonstrates the never-ending struggle to survive in nature.

The reason dinosaur skeletons are rare is because whenever a dinosaur died, scavengers would typically rip the carcass apart before it could be buried (being buried quickly is the key to being fossilized).

Why do we think dromaeosaurs hunted in packs? The best evidence is an extensive dromaeosaurid trackway in China that indicates that at least six individuals were walking together in the same direction along the edge of a lake and at slow speed, indicating coordinated group behavior.

Most interesting is the similarity between dromaeosaurs and modern birds. Both had feathers, similar limb structures and hollow bones. **The prevailing view now is that birds are dinosaurs, having branched off from the theropod group sometime in the Mesozoic Era.**

The idea that birds and dinosaurs are closely related is not new. Indeed, the dinosaur-bird controversy dates back to Darwin with the discovery of Archæopteryx (ancient wing), in 1861. That was quite fortuitous because Darwin's **Origin** had just been published and transitional forms were a topic of debate.

Archæopteryx was a strange fossil. It had feathers, but it also had reptilian features like a long, bony tail and unfused bones in the wrist and ankle. It also had teeth.

Owen (who opposed Darwin's theory) was quick to classify it strictly as a bird and downplay its transitional nature, but to others it was further evidence of a close evolutionary link between the two groups.

Recent evidence has confirmed the bird-dinosaur connection. In China, for example, a number of dromæosaurs (small theropods) have been found with feathers, including **Caudipteryx** and **Sinornithosaurus**.

Today, there is near-universal agreement among scientists that birds are descended from dinosaurs. How fitting that dinosaurs would not only trigger a rethinking of the history of life on Earth (when first discovered), but end up a key example of evolution in the twenty-first century.

Q: Case 17/18, DNA

Most people have heard of DNA. It is the basic molecule of life, storing the genetic information that defines living things.

In 1953, Francis Crick (1916-2004) and James Watson (1928-) elucidated the now-famous double-helix structure of DNA, a model of which you can see in this case. A copy of their original 1953 paper is in the case on the right.

Here is the structure that explains how information can be replicated and passed on biochemically from generation to generation. Here is the mechanism through which variation can arise. Most importantly, here is the common denominator of all living things.

The language of life, written in staggeringly long sequences, but with only four letters—the four bases that pair up to connect the two phosphate sugar backbones of the double-helix: adenine, cytosine, guanine and thymine. A—C—G—T. Four letters that illustrate the common origin of all life on Earth.

Beyond its role in crime-solving, DNA has proved invaluable in determining the evolutionary relationships between life forms. For example, our closest living relatives are the chimpanzee and the bonobo (a lesser-known African great ape). Our DNA is about 98% identical to both.

There have also been surprises: DNA sequencing has shown that elephants are closely related to manatees and scientists have even found some proteins in dinosaur bones that are clearly related to proteins in modern birds!

This concludes Phase III of the exhibit, the theory of natural selection and evolution in general. Summarize the three main points:

1. **Natural selection works blindly and inevitably through differential success: Individuals within a population vary and if individuals that have advantageous traits (i.e., can run fast) will live longer and reproduce more (on average), and pass on that advantage onto their offspring.**
2. **That over millions of years, tiny changes that result from natural selection can add up and result in new species.**
3. **How the discovery of DNA allows us to understand how traits are inherited, how variation takes place through mutations, and how all life on Earth is related through descent.**

At this point the tour is over and the guide should answer questions. Then the guide should encourage the visitors to walk around by themselves and look at the displays, use the touchscreen interactives to explore the story of Darwin and Dinosaurs, and play the Hungry Birds game to get the high score (record so far is 89).

FAQs

Q: Are the Dinosaur skeletons real?

A: No. The dinosaurs are casts – casts are made by molding the original bones one at a time and then making a copy of each bone with a special resin that duplicates even the tiniest surface detail. The casts are the painted and mounted. It's almost impossible to tell the difference between a cast and a real bone without holding it (casts weigh a lot less).

Most dinosaurs you see in museums are casts. The originals are too heavy and too fragile to mount. One famous exception is Sue at the Field Museum in Chicago, where they did actually mount the real skeleton, but that is very rare.

Q: Is it true that human DNA is 98% identical to the DNA of chimpanzees?

A: The "98% identical" number comes from comparing the protein-coding sequences of the two genomes. It ignores what is often called "junk DNA," which accounts for the vast majority of the total DNA sequence. This has been challenged on the basis that so-called "junk DNA" may be more important than currently believed, but most geneticists stand by the methodology as the most meaningful way to establish the genetic "distance" between species.

SOURCE: http://www.scientificamerican.com/article/tiny-genetic-differences-between-humans-and-other-primates-pervade-the-genome

Q: Is it true scientists have found dinosaur DNA?

A: No. They have found proteins in a dinosaur bone that survived from when the dinosaur was alive (a T. rex, no less), but a protein is not DNA. Nevertheless, it was possible to identify the protein as collagen, very similar to collagen found in modern birds, thus supporting the dinosaur-bird evolutionary relationship.

SOURCE: http://www.livescience.com/41537-t-rex-soft-tissue.html

Q: How did Darwin & Dinosaurs come about?

A: Darwin & Dinosaurs (D&D) was first created in 2009 to celebrate the 150th anniversary of the **Origin's** publication (1859). It is a joint venture between Mike Triebold and Angus Carroll. Mike is the founder and president of Triebold Paleontology, one of the largest paleontological companies in the world – there are casts of Triebold dinosaurs in over 100 museums worldwide. Angus is a Darwin collector. Together they created the exhibit to illustrate the fascinating story of how early dinosaur discoveries set the stage for Darwin and how he then developed the theory of natural selection.

Q: How are Darwin and Dinosaurs connected?

A: It was the discovery of dinosaurs in the early nineteenth century that led to the concept of extinction and that made scientists realize Earth was very old. Darwin was introduced to this new thinking just before he went on the voyage and it was within this new context that he viewed the world. Had Darwin gone on his voyage ten years earlier, it is unlikely he would have realized what certain things meant or come to the same conclusions.

Q: Did the scenario in the Hungry Birds game really happen?

A: Yes. Burning coal in the mid-nineteenth century really did turn trees around Manchester black with soot, and the moth population changed dramatically, the black moths becoming dominant because the birds could see the white moths against the darkened trees.

The "Case of the Peppered Moth," as it is known is a well-documented instance of natural selection. It was challenged in the early 2000s by creationists, but subsequent experiments proved the basic evolutionary mechanism and the "Case" is considered closed.

The **Hungry Birds** game has won several international awards and is recommended by the NSTA (National Science Teachers Association).

Darwin & Dinosaurs

Exhibit Evaluation Card

MOSH
Museum Of Science & History

DATE

- ☐ I had a tour guide
- ☐ I am a MOSH member!

Please indicate if you agree or disagree with the following statements.

	STRONGLY DISAGREE	DISAGREE	NIETHER AGREE NOR DISAGREE	AGREE	STRONGLY AGREE
1. I found the exhibit to be educational.	○	○	○	○	○
2. I found the exhibit to be engaging.	○	○	○	○	○
3. I liked the touchscreens and the game.	○	○	○	○	○
4. I like this type of exhibition.	○	○	○	○	○
5. My kids enjoyed it, too!	○	○	○	○	○

PLEASE WRITE IN ANY ADDITIONAL COMMENTS

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