

**THE UNIVERSE:  
THE DAY THE MOON WAS GONE  
History Channel/Flight 33 Prods.  
WRITER/DIRECTOR/PRODUCER:  
ADRIAN MAHER**

	<b>TEASE</b>
<b>VFX - View of moon (from earth) disappearing through skyscrapers.</b>	<b>T-01 What would happen if our moon suddenly disappeared?</b>
<b>Reuse VFX from main body of show- tsunamis and sea currents.</b>	<b>T-02 Global tsunamis decimate coastlines around the world as ocean waters surge toward the gravitational pull of the sun.</b>
<b>Drought footage</b>	<b>T-03 Sea currents shift, changing weather patterns and destroying food supplies.</b>
<b>Reuse VFX from main show- axis tilting, jungles, ice sheets</b>	<b>T-04 Eventually, earth's axis tilts wildly, turning the poles into tropical jungles and the equator into frigid wastelands.</b>
<b>Reuse VFX from main show-creatures and time-lapse footage of plants going extinct.</b>	<b>T-05 New species emerge, while others go extinct.</b>
<b>Reuse VFX from main show – earth transforms into more watery planet.</b>	<b>T-06 Our planet becomes unrecognizable.... the day the moon was gone.</b>
<b>ACT ONE</b>	
<b>Reuse VFX moon disappearing, footage of farmland darkening</b>	<b>101 The moon is a barren lifeless rock. But it plays a surprisingly important role in the story of life on earth. How important? Let's remove it from the sky, and find out.</b>
	<b>102 Strange things start to happen almost immediately. People on the coast are the first to notice the change.</b>
<b>Chyron: Dana MacKenzie, Author – The Big Splat See Tsunamis/hear screaming etc</b>	<b>FUN4027]05:15:06MACKENZIE this would probably create something like a tsunami, a tidal wave, which would be very</b>

NOTE: This is the last line of the Mackenzie bite that was further down in the script.	dramatic indeed.
	<p><b>103</b></p> <p><b>It's well known that the moon controls earth's tides. As it orbits around us, its mass tugs our oceans toward it, causing a tidal bulge on the side of the planet nearest the moon. And—through a strange quirk of gravitational physics—it forms a second bulge on the side farthest away from the moon.</b></p>
	<p><b>104</b></p> <p><b>Few people realize the sun also plays a role in governing the tides. But because it's 400 times farther from us than the moon, its gravitational influence on the oceans is relatively small—about one third as strong.</b></p>
<p><b>Reuse VFX from other shows</b></p> <p><b>Footage of tidal flow – Bay of Fundy</b></p>	<p><b>105</b></p> <p><b>But with the moon out of the picture, the sun is now in control.</b></p>
<p><b>NEW VFX</b></p> <p><b>MG - 1</b></p> <p><b>Chyron: Laura Danly, Curator of Griffith Observatory, Los Angeles</b></p>	<p>PUN 4019 01:11:19</p> <p>LAURA DANLY:</p> <p>with the moon up here, that gravitational pull is sort of pulling a dome of water up. There's a big sort of bulge, ..... Then imagine you just snip the cord and the water had to flow back out.</p>
	<p><b>106</b></p> <p><b>The water rushes toward the gravity of the sun in a massive global tsunami.</b></p>
<p><b>Footage of tides with sun in background</b></p>	<p><b>107</b></p> <p><b>The force of the waves depends on where the moon is in relation to the sun when it disappears.</b></p>
	<p>[F U N4027) 05:14:28 MACKENZIE</p> <p>if the moon vanished at full moon or at new</p>

	<p>moon, that's when the moon is lined up with the Earth and the sun.</p>
<p><b>NEW VFX MG-3 LINED UP SOLAR AND LUNAR BULGES: Moon vanishing while lined up in straight line with Earth and Sun. (During full and/or new moon.) Lunar bulges drops 2/3rds to solar bulges.</b></p>	<p><b>107A The lunar tidal bulges would shrink to solar tidal bulges in the same spots and the extra water from the lunar bulges would quickly flow to other parts of the globe. But there's an even more dramatic possibility.</b></p>
<p><b>NEW VFX – MG- 4  LATERAL SHIFTING TIDAL BULGES (NOTE: Graphic should show position of moon in  first quarter in relation to sun and earth  with associated lunar tidal bulge laterally shifting to solar tidal bulge – 1/3 the bulge size of former lunar bulge.)</b></p>	<p>FUN4027]05:15:06MACKENZIE  If the moon vanished when it's at quarter moon, either first quarter or last quarter, then the moon's tidal bulge is not in the same place as the sun's tidal bulge. And so I expect you would see a very quick motion of Earth's oceans from the lunar tidal bulge to the solar tidal bulge.</p>
<p><b>NEW VFX MG - 5  Pedro: Find A&amp;E Tsunami VFX</b></p>	<p><b>108 Some experts believe this more drastic lateral shift in ocean water would blast coastal spots around the world. The powerful pulses would be similar to the 2004 Southeast Asian tsunami except the waves would cause even more death and destruction since they'd be worldwide. Two massive east to west and west to east waves would be initiated on opposite ends of the earth. A seaside city like Miami would be pummeled by a 50-foot wall of water that would destroy most coastal buildings and sweep across the entire width of Southern Florida, putting nine million lives at risk.</b></p>

<p><b>NEW VFX MG - 6</b></p> <p><b>Water time-lapse: Earth goes from elliptical shape (because of bulge at equator to more of a sphere as water slowly moves north/south and redistributes to poles. )</b></p>	<p><b>109</b></p> <p><b>But with such a titanic shift of water, could there be other unpredictable results?</b></p>
<p><b>Footage of Roaring 40's of ocean currents colliding off coast of South Africa.</b></p> <p><b>Pedro: Use VFX you showed me yesterday depicting Gulf Stream moving from Caribbean up to England and Northern Europe (Adrian)</b></p> <p><b>Footage of icy Northern Europe</b></p> <p><b>Desert footage morphs into lush green foliage</b></p>	<p>PUN4019 01:01:40 LAURA DANLY One can imagine that perhaps the...east, west or north south motion of that water could disrupt the currents.</p> <p>01:04:02</p> <p>LAURA DANLY: the Gulf Stream carries warm water from the Caribbean up to Great Britain and it helps keep Great Britain a lot warmer than it otherwise would be considering how far north it is... Climate is a very delicate system and you tweak one part of it and another part responds</p> <p>01:06:55 LAURA DANLY: one can imagine that food productivity and, um, you know, just the overall way of life would be dramatically altered if it were cooler in northern Europe.</p> <p>01:06:03 LAURA DANLY: the Sahara desert is a great example of some place that used to be green and lush and now is, completely a desert ... having changes with climate can really have an impact on our survival.</p>
<p><b>RE-USE VFX</b></p>	<p><b>110</b></p> <p><b>But the biggest impact on our planet would be the changes to earth's steady tilt—a unique feature that gives us our four regular seasons.</b></p>
<p><b>Chyron: Mark Richardson: Asst. Professor of Planetary Science, Caltech</b></p>	<p>PUN4016]01:10:22MARK RICHARDSON The thing that locks our planet's tilt to about 23.5 degrees so consistently is the</p>

<p><b>VFX showing Mars tilting. Or VFX/ footage of different topography of Mars.</b></p>	<p>presence of the moon that acts as a large stabilizer. If we don't have the moon anymore, we may get into a regime that's much more like Mars. And Mars, instead of being at a stable 23 1/2 degrees, goes through wild variations of .... the tilt ..... varying from maybe as low as 15 degrees in low side all the way up to something like about 75, 80 degrees ..... on the high side.</p>
<p><b>NEW VFX – MG - 7 Earth tilts, add arrow or lines to illustrate axis, zoom into pole region to see ice subsiding</b></p>	<p><b>111</b> <b>Without the moon, our axis begins fluctuating erratically over several hundred thousand years. The gravitational pull from other planets in the solar system starts wreaking havoc on earth. Our stable seasons shift dramatically as different parts of our planet tilt radically toward the sun during some periods and away at others.</b></p>
	<p>PUN4009 02:57:35 HARTMANN As soon as you get rid of the moon, you're stuck with this radical shifting of the axis back and forth and...radical climate changes that you don't see today.</p>
	<p><b>112</b> <b>Earth becomes a very strange world, as mankind struggles to adapt and survive.</b></p>
<p><b>NEW VFX – MG - 8</b></p> <p><b>MATTE PAINTINGS SHOWING TROPICAL AREAS IN SNOW AND ICE ETC</b></p> <ul style="list-style-type: none"> <li>- Anarctica Morph</li> <li>-</li> <li>-</li> <li>- Africa Morph</li> </ul>	<p>PUN4016]01:11:09MARK RICHARDSON</p> <p>If we go to a situation where we don't have that stabilization, those very small changes become very, very big. We may go to situations where the ice becomes .....over the tropics.</p> <p>PUN4016]01:11:51MARK RICHARDSON</p> <p>Imagine jungles and forest in Antarctica and ice sheets and glaciers in central</p>

	<p>Africa. .... The tilt would vary on time scales of a few hundred thousand years. These are time scales of ice ages coming on the Earth. ....we know how much of an impact that had .... humanity had a hard time adjusting to those changes as we came out of the last ice age.</p>
<p><b>Chyron: Alex Filippenko, Professor of Astronomy, U.C. Berkeley</b></p>	<p>FUN4026]04:22:25 ALEX FILIPPENKO</p> <p>It's very difficult to predict exactly what would happen to humans because we're not sure how rapidly we're able to adapt to radically changing environments.</p>
<p><b>Footage of disappearing full moon over dark ocean</b></p>	<p><b>113</b> <b>And if our moon disappeared permanently, life in the sea and on the shore would be drastically transformed.</b></p>
<p><b>Footage: sharks, fish at night. Crabs mating during low tides in lunar light. Grunion dropping eggs during full moon. Translucent plankton floating on top of ocean under moonlight.</b></p>	<p><b>114</b> <b>Sharks would lose their hunting prowess, unable to track the schools of fish swarming above them in the moonlight. Crabs, used to mating at extreme low tides become disoriented at the loss of lunar phases. Even primitive aquatic plant life would be affected.</b></p>
<p><b>Chyron: Ken Nealson, Professor of Geobiology, USC</b></p> <p><b>Footage: Species on ocean surface under moonlight. Species moving to lower ocean depths in morning.</b></p> <p><b>Footage: Moon rises over ocean, organisms start moving up, followed by fish and sharks</b></p>	<p>[PUN4017]01:03:58 KEN NEALSON</p> <p>Many species .... spend their evenings on the surface interacting with moonlight [PUN4017]01:07:35 NEALSON the moon comes up, the algae are moving up ....they're followed by all of the organisms that eat the algae, and the organisms that eat them, so the whole ecology of the ocean is tuned to light [PUN4017]01:08:35NEALSON all of these organisms ..... will be completely disrupted. None of their ecology will work because they won't have the usual sensing signals,</p>
<p><b>Footage: Poor fisherman in third world countries fishing from their boats, using</b></p>	<p><b>115</b> <b>Millions of people would suffer from</b></p>

nets, etc.	<b>food shortages and coastal economies would be devastated by the worldwide crash in marine life populations.</b>
	PUN4017]01:11:40 NEALSON I would liken it to one of us suddenly waking up one morning and discovering we were blind or deaf, and that would be a chaotic thing,
<b>Reuse VFX earth tilting wildly on its axis</b>	<b>116</b> <b>An earth without the moon is a rudderless planet, highlighting just how critical this big rock is to sustaining life here.</b>
<b>RE-USE VFX</b>	<b>117</b> <b>There are 150 moons in our solar system, but earth's moon is truly unique.</b>
<b>Footage/photos of earth-rise from moon AND huge full-moon rise as seen from earth.</b>	PUN4019 02:41:56 LAURA DANLY: our moon is unlike any of the other moons on the solar system. It is huge compared to Earth. It's about a quarter of the size of Earth. And you don't see that in any of the other planets.
<b>Same</b>	01:43:17 WILLIAM HARTMANN: Because the moon is so big relative to the Earth, it's as if we're really in a double planet system.
<b>Chyron: William Hartmann, Senior Scientist, Planetary Science Institute, Tucson</b>  <b>Footage of tightrope walker balancing with large pole</b>	01:34:45 WILLIAM HARTMANN: there's a crude way to think about the effect of the moon stabilizing this axial tilt of the Earth. .... if you notice tightrope walkers will carry this long pole and that gives them more stability 'cause there's mass out there on the end of the pole and it's harder to fall off the, the line. So it's that same kind of thing that the mass, at a distance can affect the stability of the system.
<b>Reuse VFX of early earth as red, molten magma planet with craters</b>	<b>118</b> <b>But the moon has not always been by our side. There was a time, early in earth's history, when there was no</b>

	<p><b>moon. A period when our planet was a strange place with 8 hour days and a molten landscape too harsh for life....and then suffered the most violent collision in its history.</b></p>
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<b>ACT TWO</b>	
Same as below	<b>201</b> It's hard to imagine, but there was a time when our earth did not have a moon.
<b>NEW VFX OF EARLY EARTH MG – 10</b>	<b>202</b> Our planet was formed four and a half billion years ago by accumulating and fusing large amounts of debris in the early stages of our volatile solar system.
Same	<b>203</b> During that early period, our moonless earth was a monstrous stew of flowing lava, molten rock and liquid iron.
Closeup footage of belching Yellowstone hotsprings, volcanic vents – steam emitting from earth.	<b>204</b> Its atmosphere was filled with carbon dioxide, belched from the bowels of the earth – thick, heavy and uninhabitable for life.
Footage of lava in Hawaii (or from other volcanic eruptions.)	NEALSON: PUN4017 02:01:47 there was almost nothing on the planet, ...This was a nasty place to be.  [PUN4017]02:02:13NEALSON Lots of things were condensing. It was an extremely hostile place even to rock chemistry. So the rocks were melting. ....everything was a mess.
	<b>205</b> Our original earth without its moon was an unrecognizable world.
	02:11:00 PUN4019 LAURA DANLY: Uh, the early Earth, uh, was a really hot place. In fact that era of the Earth is called the Hadean like Hades because, well, because it was really hot. [LAUGHS] ....there was a tremendous amount of volcanism and a lot of impacts coming in. Uh, there was probably a lot... of lightning and .... Out-gassing both from the volcanoes and from steam.
<b>PULL FROM STOCK SHOTS IN THIS FOLDER/BIN: “JT ANIMATIONS”</b>	<b>206</b> The stability of our early solar system was not much better. It was created out of a huge disc of gas, debris and dust that swirled around the newly formed

	<b>sun.</b>
<b>Footage: Roller derby competitors crossing lanes, colliding and clumping, big mash-ups.</b>	02:19:55 LAURA DANLY: Our early solar system was kind of like a roller derby in that everybody was generally going in the same direction but there was a lot of chaos. There was a lot of clumping and accreting and things getting flung to the inside and crossing lanes to the outside and people all spilling over each other mashing up on the corner. It was a real mess.
	<b>207</b> <b>Without the moon, we can only guess at earth's early tilt and rotation rate. That would have been determined by the multiple glancing collisions from the innumerable asteroids and proto-planets that ricocheted throughout our early solar system.</b>
<b>Reuse VFX of planets in our solar system rotating</b>	HARTMANN: PUN4009 - 01:06:10 if you kind of average over the solar system you sort of, look at all the planets and the big asteroids and make a bell curve of rotation speeds, it looks like the typical rotation speed might be eight .... hours, something like that, so we could make a guess ....that that might have been the likely rotation speed before the moon was formed.
<b>STEFFEN NOTE: There is a depiction of this in the JT Animations folder. Please see if it works so that we can avoid producing this sequence.</b>	<b>208</b> <b>Then, about 10 million years after our moonless earth began taking shape, there was a massive collision.</b>
<b>NEW VFX</b> <b>MG-10A</b> <b>Showing Giant Impact</b>  <b>Note: We have lots of Dr. William Hartmann's paintings of Great Impact but obviously they're not as compelling as VFX.</b>	<b>209</b> <b>Now widely accepted by astronomers, the Giant Impact Theory says that a Mars-sized planet collided at an oblique angle at 25,000 mph with earth. The impactor blasted more than 70% of the earth's molten crust into space. A giant whirling arm, made up of five billion cubic miles of blazing rock and light metals was launched into orbit around our planet.</b> <b>The gravity of the larger chunks began pulling smaller particles towards them,</b>

	<p><b>forming bigger and bigger pieces. Within one year it coalesced into our moon.</b></p>
	<p>PUN4009 01:39:50 WILLIAM HARTMANN: the only materials that were blown out from the Earth were the crustal rocky material and that's what the moon's made out of.</p>
<p><b>Reuse VFX of asteroids belts circulating in our solar system</b></p> <p><b>Footage/Photos: Of humans handling moon rocks.</b></p>	<p>PUN4009 01:38:37 HARTMANN if you go to any other place in the solar system, for example Mars or you look at meteorites that come from the asteroid belt, ... there, are certain ratios of the different types of oxygen.</p> <p>PUN4009 01:39:20 HARTMANN That ratio, in other parts of the solar system is very different than what we see in the Earth. Now we fly to the moon, we get the moon rocks, we bring them back. They have exactly the same oxygen and isotope ratio as the Earth. So that material came out of the Earth, and that fits this idea of an impact theory.</p>
<p><b>Hiroshima footage</b></p> <p><b>Reuse VFX of Great Impact</b></p>	<p><b>210</b> <b>The energy released in the giant collision equaled a force of six trillion atomic bombs. That's a thousand atom bombs for every person of earth's current population of six billion people.</b></p>
<p><b>NEW VFX</b> <b>MG - 11</b> <b>Production to provide diagram of where points are. (NOTE: PEDRO: Please provide to Michael Heinz.)</b></p>	<p><b>211</b> <b>The impactor planet that hit earth was thought to have formed in an area of our solar system called the Lagrangian Points.</b></p>
	<p>FUN4025 03:25:11 FILIPPENKO These are regions 60 degrees, either ahead of or behind the earth, but at a similar distance from the sun.</p>
	<p><b>212</b> <b>Debris can stay fixed in the Lagrangian Points for tens of millions of years, locked between the gravitational influence of the sun and earth. But</b></p>

	<b>eventually something knocked the impactor off its fixed course. That something was Jupiter.</b>
<b>Reuse VFX of Jupiter in orbit coming near another planet</b>	FUN4028 06:22:46 MACKENZIE every time Jupiter surpassed by us in its orbit it would be giving a little tug to this impactor planet.  [FUN4028]06:23:28MACKENZIE And each little tug wouldn't be very big but if you think about, for example, having a car that's stuck in a ditch or stuck in a snow bank, how do you get that car out of the snow bank? Well, the way you do it is you rock the car. You push it a little bit, it comes back. Push a  little bit more, it comes back little further. And this way with a bunch of little pushes, you eventually free it .... And that's exactly what Jupiter did to this impactor planet. [FUN4028]06:23:57MACKENZIE And once it gets away from the Lagrange point, it's no longer stable and it's doomed. ...It's eventually going to collide with Earth.
<b>NEW VFX MG-10B Showing heavier iron core clump forming closer to earth and re-colliding with earth.</b>	<b>213</b> <b>After the giant cataclysm, the inner part of the whirling arm of ejected debris forms a clump that consists of materials from the impactor's iron core. That heavier clump re-collides with earth and is absorbed into our planet's center.</b>
<b>Reprise VFX of earth's larger molten core (used in VO # 14)</b>	FUN4028 06:03:00 DANA MACKENZIE  The giant impact was really the biggest thing that ever happened to Earth. // [FUN4027]05:13:08MACKENZIE what we have now is a core and a half. That makes our planet denser and our gravity stronger than it would be otherwise.
<b>Footage of lava, magma, fissures</b>	<b>214</b> <b>The larger, molten core takes longer to cool than earth's original core would have. Heat is constantly pushed up and through the earth's thin crust creating fissures. It's possible that this larger core helped create the plate tectonic system that forms our continents - a unique planetary feature</b>
<b>NEW VFX of plate tectonics MG-12</b>	

	<b>in our solar system.</b>
<b>Reuse VFX of Mars</b>	PUN4019 - 02:21:08 DANLEY Mars was much smaller it, it cooled much quicker and, uh, so it has no crustal plates.
<b>NEW VFX MG – 13</b> <b>Impactor planet knocks fiery molten earth to side and speeds up rotation.</b> fiery <b>MOLTEN EARTH</b> HouseOfTheFuture should refer t molten earth in JT Animations	<b>215</b> <b>Most critically, the collision knocks the earth on to its current axial tilt of twenty three and a half degrees and speeds up its rotation from eight hours to just five hours.</b>
POV of molten Moon. Backplate: Hawaii, volcanic	<b>216</b> <b>Within a year, the moon forms roughly 14,000 miles away from earth, significantly closer than its current distance of 234,000 miles.</b>
<b>NEW VFX MG - 14</b> – New York, time-lapse plate? <b>ICONIC SKYLINE FROM PERSON ON SIDEWALK POV, STARTS AS CURRENT SMALL WHITE MOON THEN GROWS 15 TIMES AND BECOMES RED AND MOLTEN FROM PERSPECTIVE OF PERSON LOOKING UP.</b>	[FUN4029]07:14:36MACKENZIE you got this immense moon in the sky--so 15 times as big as the present moon. So think about this thing rising and rising and rising until, you know, it fills up a pretty big chunk ..of that evening sky. And imagine having that moon over your head, and imagine it being red because it's full of this molten lava around the surface....it's mind-boggling.
Reprise Moon ovr Hawaii landscape <b>NEW VFX MG - 15</b> – cutaway to crust layers lifting and dropping	<b>217</b> <b>The early moon's gravitational pull on earth is roughly 225 times stronger than today because of its much closer distance. Though no oceans exist yet, the lunar tidal forces are 3400 times more powerful. They lift and drop large crusts of molten rock to more than half a mile high, twice a day.</b>
<b>NEW VFX – MG - 16</b>  <b>Early Moon Early Earth, b-roll</b>	<b>218</b> <b>Our early planet's axial tilt stabilizes due to the moon's formation and its mass acts as an anchor. But the earth's spin begins slowing because the moon's gravitation creates a tidal bulge around our planet's mid-section causing a drag</b>

	<b>on the earth's rotation.</b>
<b>Filippenko demonstration with green balloon.</b>	<p>FUN4024 02:20:03 FILIPPENKO Let the earth be this green balloon, and here's the moon.</p> <p>02:21:06ALEX FILIPPENKO If the earth weren't rotating, the tidal bulge would point directly toward the moon. But the earth is rotating pretty quickly. So, in fact, the tidal bulge tends to be a little bit ahead of the direction toward the moon. 02:22:13 That means the moon's gravity is pulling back on the earth's bulge a little bit. Retarding its rotation ever so slightly.</p>
<b>Reuse VFX of tidal bulge on earth</b>	<b>219</b> <b>But the tidal bulge on earth also has a reactive force on the moon.</b>
<b>NEW VFX MG – 17</b>	<p>[FUN4029]07:07:49MACKENZIE this tidal bulge ...pulls the moon ahead in its orbit, constantly trying to tug the moon faster.</p> <p>[FUN4029]07:08:27MACKENZIE But the moon doesn't want to go faster in its orbit. Instead, what happens if you imagine throwing a slingshot and swinging it faster, it wants to go out. And that's what the moon does--it goes outward because it's being tugged faster in its orbit. So, gradually over the years, the moon is moving further and further out.</p>
<b>Space footage of moon and earth in same shots.</b>	<b>220</b> <b>The complex gravitational dance between the two partners is now pushing the moon away from earth at a rate of one and a half inches per year. Over billions of years the moon's recession has slowed the earth's rotation from five-hour days to our 24-hour day today.</b>
<b>Footage of figure skater pulling in her arms close and spinning faster, then opening her arms and slowing spin down.</b>	<p>01:33:48 PUN4009 WILLIAM HARTMANN: the whole idea of this rotation of the Earth being influenced by the moon, uh, is a little bit like what you see when a figure skater is spinning and when she pulls her arms in close and spins, she spins faster and she throws her</p>

	arms out to slow down. And this is all what the physicists would call angular momentum, but it's the same idea, as the moon moved out it's kind of like throwing those arms out and that slows down the rotation in the whole system.
<b>Reuse VFX of watery earth world with less continents/land.</b>	<b>221</b> <b>But what if the Giant Impact had never happened? The changes to earth would be even more drastic than if the moon now suddenly disappeared. Today, would we recognize an earth that never had a moon? And would humans even exist?</b>

<b>ACT THREE</b>	
<p>Reuse VFX and footage of tsunamis, ocean currents, seafood industry, climate swings.</p> <p>Reuse VFX of water-world earth.</p>	<p><b>301</b>  <b>If the moon disappeared instantly, earth would undergo changes like possible tsunamis, a shift in ocean currents, sea-life extinctions and eventual massive climate swings. But if the moon had never existed, earth would be unrecognizable to anyone today.</b></p>
	<p>[FUN4023]05:06:33 ALEX FILIPPENKO  Without the moon, life on earth would probably look quite different. In particular, humans might well never have come into existence.</p>
<p>Reuse VFX of early earth cooling</p>	<p><b>302</b>  <b>About 150 million years after a moonless earth forms four and a half billion years ago, it moves out of its hot, molten phase and begins cooling. The day is only about 8 hours long.</b></p>
	<p>PUN4009 03:01:15 HARTMANN: You can imagine everything being speeded up in this little four hour day and four hour night.  PUN4009 03:00:25 HARTMANN: The nights would be totally black</p>
<p>Footage of steamy atmosphere, water, rivers</p>	<p><b>303</b>  <b>Once cooled, our planet is temperate enough to retain water. Heat escaping from Earth's core drives steam and carbon dioxide beyond the surface, creating a thick atmosphere.</b></p>
<p>Footage of rainstorms (with volcanic surroundings simulating an early earth.)</p>	<p>PUN4016 01:22:31 RICHARDSON All of the atmosphere would've kind of collapsed back out and then as it cooled... the oceans would have reformed in torrential rainstorms.</p>
<p>Reuse VFX of asteroids hitting early earth???</p> <p>NEW VFX  MG - 18  – another planet with uniform crust,</p>	<p><b>304</b>  <b>Icy asteroids continually pummel the planet bringing in another large source of water. With a smaller, cooler molten core there are no plate tectonics, resulting in no large mountains and huge ocean basins. Water soon covers</b></p>

<b>little land, covered with water.</b>	<b>most of the planet's more uniform crust.</b>
	PUN4017 01:57:55 DANLY We certainly would have a higher sea level ..... less continental area and that would be a different world.....our blue marble would be even bluer.
<b>Footage of tides with sun in background</b>	<b>305</b>
	<b>Ironically, even with all that water, the early moonless earth would have smaller tides. Determined only by the gravitation of the sun, they would be just 1/3 the size of our current lunar tides. The range between high and low tide would remain constant throughout the year and would occur at exactly the same time each day.</b>
<b>Footage of tides and narrow tidal regions (maybe ocean water lapping right up against cliffs with no beaches.)</b>	[FUN4026]04:01:00ALEX FILIPPENKO
	that means the inter tidal regions would of been narrower. Probably leading to less diversification of life, and perhaps even ... impeding the progress of life from the oceans to the land. Because, it's in the intertidal regions where creatures had to develop the ability to survive both in the water, and on land.
<b>Reuse VFX of earth spinning faster</b>	<b>306</b>
<b>Footage of howling winds with short stubby plants/trees flattened out</b>	<b>With an 8-hour day, just four hours of light followed by four hours of moonless black, the early earth spins three times faster than today. The winds howl due to the aerodynamics of earth's quicker rotation.</b>
<b>RE-USE VFX (also Jupiter with Great Red Spot)</b>	FUN4025
	ALEX FILIPPENKO{04:24:38:25} Jupiter for for example, is a giant planet that spins very rapidly.  It has a 10 hour spin period, and its got ferocious winds in its upper atmosphere, hundreds of mile an hour, and incredible storms like the Great Red Spot like has been around for centuries. Now, Earth probably .... would be spinning more rapidly than it is now, and that would generally lead to stronger winds, and more

	violent hurricanes, and other storms.
	<b>307</b> <b>Early earth's fast spin results in another important side effect.</b>
<b>NEW VFX</b> <b>MG - 19</b> CUTAWAY, EXPANDING MAGNETIC FIELD	[FUN4027]05:10:13MACKENZIE The rotation of Earth's core, particularly the molten part of the core, is believed to be what generates our ...magnetic field. And so the Earth rotates three times faster, the magnetic field is three times stronger.
<b>NEW VFX –</b> <b>MG - 20</b> Treat footage of Aurora. Production to provide back-plate of aurora. Note: DO NOT USE SHOTS FROM ARTBEATS  <b>VFX to also show deflection of solar flares to poles????</b>	<b>308</b> <b>The enhanced magnetic field over the moonless earth more effectively deflects high-energy solar flare particles towards the earth's poles resulting in larger, more spectacular auroras. But by blocking the solar flares, not as much radiation zaps life in the lower atmosphere, decreasing mutations that drive evolution.</b>
	LAURA DANLY: PUN4019 01:44:32 A stronger magnetic field might have slowed the rate at which life evolved on earth.
<b>Reuse VFX of moon's AXIS being pushed and pulled??????</b>	<b>309</b> <b>Without the moon, the developing earth suffers intense climate volatility. Over many periods, each lasting several million years, the earth's axis is pulled and pushed by the sun and other planets without the stabilizing influence of the moon. Conditions would have paralleled what happened to Mars.</b>
<b>RE-USE VFX (variety of shots of Mars topography – including empty river channels, ocean basins, glacial deposits, etc.)</b>	01:16:10 PUN4009 WILLIAM HARTMANN:  what we've learned in the last fifteen or twenty years is that Mars, has, a very unstable axis because it has no big moon. ... when we look at Mars and we can actually see on the surface of Mars geological features that formed under very different climate regimes when the polar axis was tilted over. // 01:14:07 On Mars, we actually see these features like, uh, the dry river channels and glacial deposits and other features, uh, ice close to the ... equator, .... And so the big realization was oh

	<p>yeah the climate has been changing on Mars and this explains that we're seeing older features.</p>
	<p><b>310</b>  <b>Like the Red Planet, a moonless earth's axis would tilt wildly, turning our planet topsy-turvy.</b></p>
<p><b>NEW VFX</b>  <b>MG - 21</b>          rotating earth, TEXTURE OF PLANET MORPHS, CUED WITH VO</p> <p><b>NEW VFX</b></p> <p><b>MG – 22A : Big ship plows through jungle swamps and then morphs into icebreaker cutting through ice.</b></p> <p><b>Reuse VFX of ice sheets and tropical regions on earth shifting with axial tilt</b></p>	<p>FUN4027            05:22:56MACKENZIE</p> <p>our axis, over a period of million of years, would wobble chaotically, it would sometimes be vertical, it would sometimes be close to horizontal.....When it's horizontal, you could actually have the poles pointing towards the sun and the poles actually getting jungles.</p> <p>] FUN4027            05:23:28MACKENZIE</p> <p>So, you would see very big changes in Earth's climate as a result of this chaotic wandering of Earth's axis and this would make it more difficult for life to flourish because it would constantly have to adapt to different conditions, to ice ages and to extremely hot ages.</p>
<p><b>Pick VFX and footage from ACT FOUR</b></p>	<p><b>311</b>  <b>So what would life on earth look like today if we had never had a moon? Short days, high winds and other changes could produce a freakish world with creatures that look like they're straight out of science fiction.</b></p>

<b>ACT FOUR</b>	
<p><b>Reuse VFX of alien-looking earth??? (ie. Lots of water, little land, a few volcanoes poking through ocean water)</b></p>	<p><b>401</b>  <b>The Moon was formed billions of years ago when a planet sized asteroid crashed into Earth.</b></p> <p><b>But what if that violent collision never happened?</b></p> <p><b>If the moon never came along to stabilize our planet, Earth would be an alien place.</b></p>
<p><b>Reuse VFX of watery earth with slower spin??</b></p>	<p><b>402</b>  <b>The spin of early earth was very fast ... with about 4 hours of daylight followed by 4 hours of darkness.</b></p> <p><b>Over billions of years, the sun's gravity and tidal friction would lengthen that 8 hour day to 12 hours.</b></p>
<p><b>Space footage of earth's hurricanes and jet-stream winds looking down on earth's atmosphere. Footage from earth's vantage point of ferocious winds.</b></p>	<p><b>403</b>  <b>But this is still twice as fast as the current earth spins, which makes for some extreme weather, including devastating storms and high winds.</b></p>
<p><b>Footage of storms, lightning</b></p>	<p>PUN4009 02:54:56  WILLIAM HARTMANN:  if the moon hadn't formed, you, .... certainly get, a wildly different environment on the Earth..... with a faster turning Earth you get more jet streams. You get, more turbulence ... Maybe bigger storms, // more lightning because of the friction of the different masses of air moving.</p>
	<p>FUN4026 04:23:29 FILIPPENKO  In some places the winds could reach one or two hundred miles an hour. There would also be stronger hurricanes and .....Earth would ... have larger waves battering the coastline.</p>

<p><b>Reuse VFX of massive shifts in climate on earth.</b></p> <p><b>Footage of extreme climates on earth.</b></p>	<p><b>404</b></p> <p><b>And without the moon’s stabilizing effect, the rapidly spinning Earth tilts back and forth. Over many millennia, our planet suffers the ravages of ever-shifting climate because of the erratic changes in axial tilt ... as different regions are blasted by heat then covered by ice again and again.</b></p>
	<p><b>405</b></p> <p><b>And without the moon, there is another layer of axial instability.</b></p> <p><b>Even though today’s Earth is stabilized by the moon, there is still a wobble to the earth’s rotation, known as precession.</b></p>
<p>Filippenko demonstration with spinning top.</p> <p><b>(Note to Editor:</b> Please also check Filippenko’s other duplicate demonstration at FUN4024 02:17:04)</p>	<p>[FUN4024]02:11:17ALEX FILIPPENKO Earth's tilt is 23-1/2 degrees, but over a period of 26,000 years it goes through conical variations like this.</p>
	<p><b>VO405A</b></p> <p><b>And if the moon had never formed, this wobbling would be even more extreme.</b></p>
	<p>[FUN4024]02:12:38ALEX FILIPPENKO If we didn't have the moon, the earth would precess much more slowly and this is one cause for chaotic variations in the axial tilt. A slower precession of the earth would lead to a much more unstable axis of rotation for the earth.</p>
<p><b>RE-USE VFX</b></p>	<p><b>406</b></p> <p><b>Without the moon, Earth’s axis today would be like the slower spinning top – precessing, gyrating and wobbling in ever larger conical circles.</b></p>
<p>Editor Note: Please go to FUN4028 06:10:48 MACKENZIE to pull the phrase “26,000 years” for insertion into adjacent soundbite.</p>	<p>[FUN4028]06:13:40MACKENZIE Right now, 26,000 years is a very stable zone. You get it going slower and slower, maybe 40,000, maybe 50,000, maybe 60,000, then you hit the chaotic range and then everything goes wrong.</p>

<p><b>NEW VFX MG – 23</b></p> <p><b>FOOTAGE/B-ROLL OF WEIRD LIFE-FORMS</b></p> <p>Reuse VFX of time-lapse plant extinction</p> <p>Footage of weird looking, low-lying, stubby plants.</p>	<p><b>407</b></p> <p><b>With the more forbidding and shifting climate, evolution on a moonless earth varies between bursts of adaptation and violent extinction. Bizarre life-forms mushroom. Plant species are vulnerable, as they don't have the mobility to stay ahead of speedy climate change. And complex life forms like humans probably wouldn't stand a chance at all.</b></p>
<p><b>Shots/Drawings of early Homo Sapiens/Neanderthals struggling in the face of extreme weather</b></p>	<p>FUN4025                      04:06:45 ALEX FILIPPENKO</p> <p>The variations in climate would be extreme and rather rapid. And it would probably make it difficult for complex creatures to evolve, because most complex creatures can't evolve very quickly to changes in their environment.</p>
	<p><b>408</b></p> <p><b>Instead, primitive organisms would predominate and endure.</b></p>
<p><b>Footage of hot and cold environments. Closeup chemistry drawings/shots of primitive bacteria forms.</b></p>	<p>PUN4019 - 02:03:01 LAURA DANLY:</p> <p>Bacterial life is able not only to adapt more quickly but also to withstand, ... more extreme environments. We see bacteria ... under the deep ice cores of the Antarctic or Greenland and we see bacteria that live ... in steaming boiling pots in ... in Yellowstone.</p>
<p><b>STOCK RE-USE VFX</b></p>	<p><b>409</b></p> <p><b>If complex life were to evolve, it would look very different due to short days, high winds and other features of a moonless earth.</b></p>
<p><b>Footage of weird creatures moving from sea to land. Galapagos Island footage of giant amphibious lizards???</b></p>	<p>[PUN4017]01:24:40 NEALSON all of these winds, all of the noise and all of the clouds, ... moving from water to life on land would be very tough</p> <p>[PUN4017]01:26:31 NEALSON we might see shorter life spans because things are going on faster.</p> <p>[PUN4017]01:27:52 NEALSON during the day there would be a limited time to metabolize and gain energy and do</p>

	things. Organisms would have to be a little more clever.
<p><b>Reuse VFX from Alien Faces show of short, stubby creatures???</b></p> <p><b>Footage of ferocious twisters, winds.</b></p> <p><b>Footage of jungles and monkeys swinging from tree to tree</b></p>	<p><b>410</b></p> <p><b>Evolution would favor short, stout creatures and plant life that could withstand ferocious hurricanes. Jungles wouldn't exist since they need wind barriers to flourish. And there probably wouldn't be any creatures swinging from branch to branch due to stubbier plant life and high winds.</b></p>
<p><b>Reuse VFX of short creatures.</b></p> <p><b>Footage palm trees bending over in wind.</b></p>	<p>[FUN4026]04:29:34ALEX FILIPPENKO</p> <p>I would expect that creatures generally wouldn't be as tall 'cause they'd have a harder time holding themselves up. And, trees with shallow root systems wouldn't become very tall. Palm trees for example, probably wouldn't survive too well.</p>
	<p><b>411</b></p> <p><b>The constant gusts would push other adaptations.</b></p>
<p><b>Footage of flying squirrels</b></p>	<p>HARTMANN: PUN4009 03:03:20</p> <p>Sailing...you know maybe membranes that let you take off and leap through the air.</p>
<p><b>Loud windy footage</b></p>	<p><b>412</b></p> <p><b>And the perpetual gale-like conditions would create an exceptionally loud planet. If animals made noises to communicate, they'd have to be very different from the constant, shrieking wind sounds.</b></p>
<p><b>Nealson speaks in high pitch</b></p>	<p>[PUN4017]01:35:14NEALSON</p> <p>the use of sound and wavelengths that are not the sound of the background noise...if you have a receptor that just zeros out that noise, we might be able to speak like this and be heard perfectly....we might be all...sopranos..and have ears tuned to a different pitch.</p>
<p><b>NEW VFX</b></p> <p><b>MG – 24</b></p> <p><b>CREATURE B-ROLL, FIGHTING STRONG WINDS</b></p> <p><b>Reuse VFX- same creature with extra limbs for signaling on volcanic type</b></p>	<p><b>413</b></p> <p><b>Or more visual cues might be developed to cut through the audio overload. Creatures might develop extra limbs to not only shield themselves from the wind, but also use their appendages to communicate like sailors using</b></p>

<p><b>islands. (Note: Is this another new VFX even though creatures look the same???)</b></p>	<p><b>semaphore signals.</b></p>
<p><b>Footage of weird looking creatures</b></p> <p><b>Reuse VFX of creatures from Alien Faces</b></p>	<p>PUN4009 03:03:20 HARTMANN Perhaps speech would not develop, so maybe other forms of communication, whether color changes, expression changes...hand language...who knows?</p>
<p><b>Footage of squids, krill, jellyfish, changing colors in dark waters.</b></p> <p><b>Reuse VFX of creatures from Alien Faces underwater</b></p>	<p><b>414</b> <b>Even today, many of earth's beings such as fireflies, squids, krill and jellyfish communicate by changing their body colors.</b></p>
<p><b>Reuse VFX NIGHT VISION POV – two infrared POV shots from Alien Faces show.</b></p>	<p><b>415</b> <b>Because of the dark nights, creatures might also develop enhanced vision and sensory systems similar to the night vision goggles and infrared displays used by the military.</b></p>
<p><b>Footage of creatures with giant protuberant eyes glowing in the dark</b></p>	<p>PUN4017 01:04:35 NEALSON The interesting possibility is that life might be able to develop sensors that were so good that they could actually sense starlight and this would be something colossal.</p>
<p><b>Footage of rough, alien world – lava in Hawaii, steaming Yellowstone volcanic vents</b></p> <p><b>Reuse VFX of Great Impact and/or Hartmann paintings</b></p> <p><b>Space footage of earth and moon in same shot.</b></p>	<p><b>416</b> <b>It looks and sounds like a rough and too tough world... unfit for human habitation. Luckily, when the moon formed, it created the conditions for people to develop and prosper. But our moon is also moving farther away from earth every year. Does that mean there will there be another time in earth's future without the moon?</b></p>

<b>ACT FIVE</b>	
<b>Reuse Great Impact VFX</b>	<p><b>501</b>  <b>Four and a half billion years ago, the young earth was a hellish, molten place unfit for life. So then how did a violent collision by an object the size of Mars, soon after the earth's formation, create the conditions for the complex life we're part of today? The body blow to earth knocked our planet to its current tilt and the formation of the moon kept it there.</b></p>
<b>Footage of earth and moon</b>	<p>PUN 4016 01:45:26 RICHARDSON The ... mass of the moon out there, what it's done is it prevented the tugs of the other planets from causing the earth's tilt to change too much. So it provided a real stabilizing effect on our climate.</p>
<p><b>Reprise VFX with large molten core sending heat up through fissures in crust</b></p> <p><b>Reuse VFX of volcanoes, oceans and crust spewing out gas.</b></p>	<p><b>502</b>  <b>The collision also created a chain reaction of forces that set the stage for life.</b></p> <p><b>When the iron cores of the two planets combined, it created a larger core for the new earth.</b></p> <p><b>The collision also knocked off much of the earth's crust.</b></p> <p><b>This combination, with large amounts of heat pushing up from a giant core through a thin crust, likely created the conditions for plate tectonics. The movement of these plates formed mountain ranges and deep basins. And the resulting volcanic activity spewed out the gasses that created our atmosphere. Water eventually settled in the basins creating oceans, leaving continents of land above.</b></p>
<b>Footage of bacterial life mutating.</b>	<p><b>503</b>  <b>But life still had a tough time getting started in the early days of Earth.</b></p>

<p><b>Reuse VFX of moon and earth getting pelted with meteors, AND lots of reuse of VFX of chaotic solar system with lots of debris colliding, asteroid belts etc.</b></p> <p><b>Reuse VFX of primitive life mutating</b></p>	<p>[FUN4026]04:11:22ALEX FILIPPENKO For the first half billion years of the Earth's and the moon's existence they were bombarded by debris that was still finishing up the formation of the solar system. So, even if primitive life micros, and bacteria had formed in the first few hundred million years, they might easily have been wiped out by these giant things crashing into the Earth. Now, we have evidence for life dating back to 3.8 billion years ago. That's shortly after the end of the era of heavy bombardment.</p>
<p><b><u>Space footage of earth and moon together</u></b></p> <p><b>Footage of Bay of Fundy or other places with huge tides.</b></p>	<p><b>504</b> <b>By then, due to tidal friction between the earth and moon, the moon had moved slightly farther away from earth, and earth's rotation had slowed to roughly a 10-hour day. But since the moon was still much closer than today, the tides in earth's early oceans were humungous.</b></p>
<p><b>Footage of large tides churning up sand, soil and earth material – sweeping back and forth</b></p>	<p>02:40:02 LAURA DANLY: the tides were so much bigger ....They, ...went way inland and poured back out to sea twice a day you'd get a big gulf of water in .... And when it drained back out it carried a lot of minerals and, ..., soils and other.....parts of the Earth's crust back out sea with it. So there was this constant erosion and scrubbing of the land ....certainly a unique environment that might have been just right for life to develop.</p>
<p><b>Footage of tides lapping up against cliffs (narrow inter-tidal area.)</b></p> <p><b>NEW VFX</b> <b>MG-25:</b> <b>Diagram/Map showing tides sweeping in on West Coast as far as Arizona and Nevada twice a day.</b></p>	<p><b>505</b> <b>The area between high and low tide, known as the inter-tidal region, was enormous. High tides would rush hundreds of miles inland, then back out a few hours later.</b></p>
<p><b>NEW VFX or footage</b> <b>MG-26</b></p>	<p><b>506</b> <b>During the extreme low tides molecular strands began forming in the endless miles of tide pools.</b></p>

Same as above	02:18:12 WILLIAM HARTMANN: What happens when water evaporates, the H2O molecules go away and everything else is left so the organic sludge in the pool gets more and more concentrated.....So this was the idea that life formed in these little pools.
Footage of amphibious lizard/beast moving from wet tidal area on to land.	<b>507</b> <b>Around 570 million years ago, almost 3.9 billion years after the Giant Impact, earth's ocean life begins moving on to land, giving birth to complex species.</b>
Same as above (can also include underwater creatures)	[FUN4025]03:22:40ALEX FILIPPENKO The bigger the inter-tidal regions, the greater the resulting diversity of life because you can have species that live in these environments that are sometimes exposed to the sun and sometimes underwater.
Reuse VFX and space footage	<b>508</b> <b>Over billions of years, our earth seems to have reached a perfect equilibrium that has allowed for the evolution of a diverse, intricate, and fragile ecosystem.</b>
Same above	PUN4009 01:44:56 HARTMANN are there some climates that are too... uniform, no seasonal changes and so on, and don't lead to life because, there's no...environmental stress? And, on the other hand, climates that are too variable, where, the seasons are changing all the time and you're getting hit by an asteroid every million years, planets like that, would probably try to form life but they couldn't get it going because things would change too fast.  01:45:52 So maybe .... there's a situation that's just right in the middle and maybe the Earth itself, the Earth moon system is somewhere in that range, which has fostered not only formation of primitive life but the evolution of that life into - - folks like us.
Footage of moon passing by earth.	<b>509</b> <b>But though our moon stabilizes things, it</b>

	<b>continues to recede from us at a rate of an inch and a half per year while it slows our spin. Scientists estimate that we are adding two seconds to our day every 100,000 years.</b>
	FUN4029 07:12:07 MACKENZIE A billion years from now, our days might last 26 hours rather than 24 hours, which is great if you're a procrastinator like me.
<b>Reuse VFX from Mysteries of the Moon of moon taking off out of frame.</b>	<b>510</b> <b>So what will happen to the unique earth-moon partnership that made life on earth possible? Will the moon eventually just drift away out of earth's gravitational influence?</b>
<b>Reuse VFX of Sun turning into Red Giant and engulfing the Earth and Moon.</b>	PUN4019 02:50:38 DANLY The rate will be so slow that it won't be a very big effect and long periods of time will pass without much change so long that we will have had time for our sun to run out of fuel and become a red giant. At that time the earth will be engulfed probably and destroyed and so will the moon....we'll all get baked together.
	<b>511</b> <b>So maybe it's comforting to know, that five billion years from now, on the day the earth faces its end, we won't be alone. Our anchor in the sky will be there, the glowing orb that made life on earth possible.</b>
	<b>END</b>