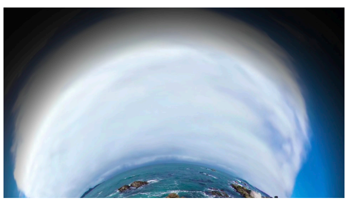
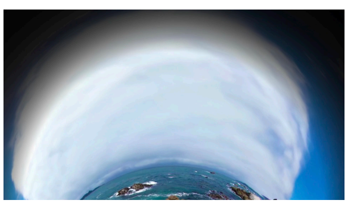
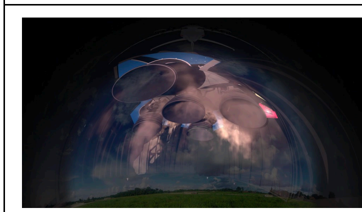
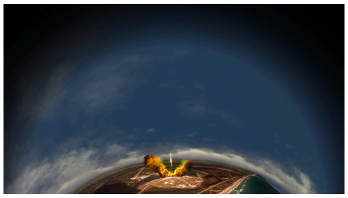
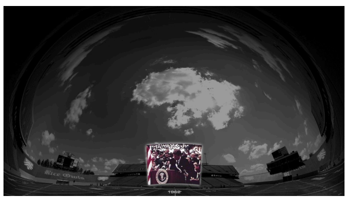
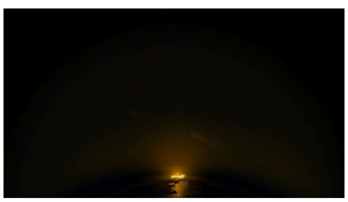
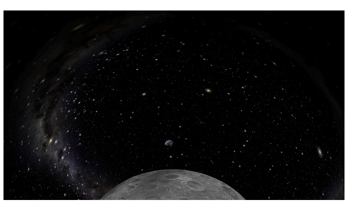
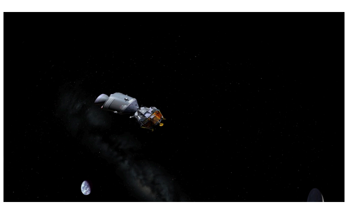
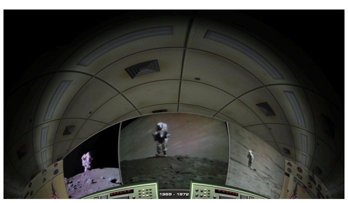
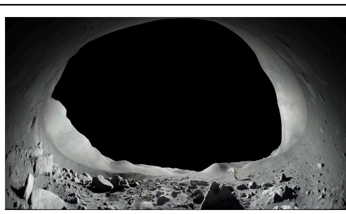
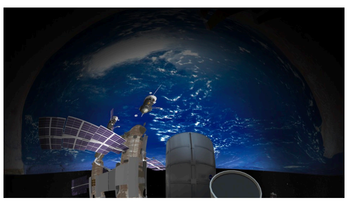
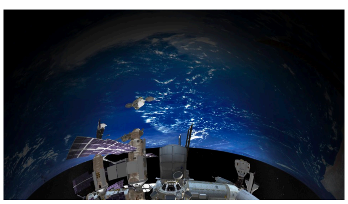
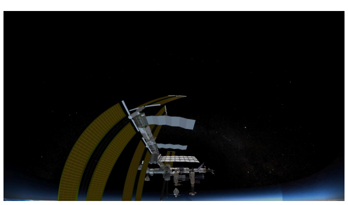
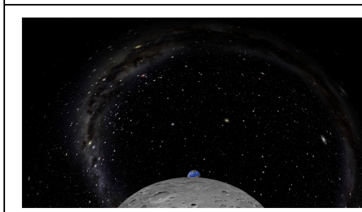
APOLLO AND BEYOND

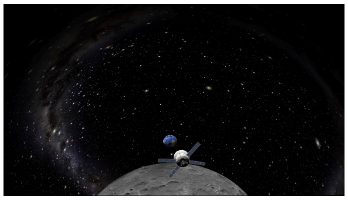
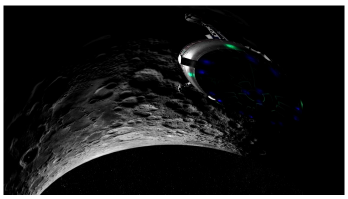
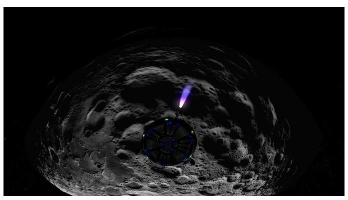
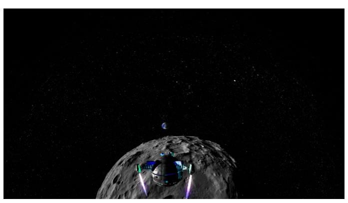
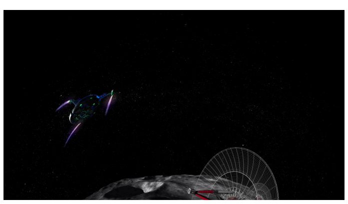
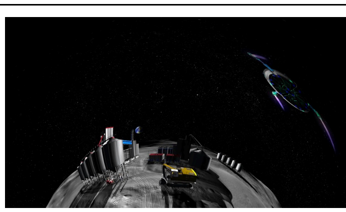
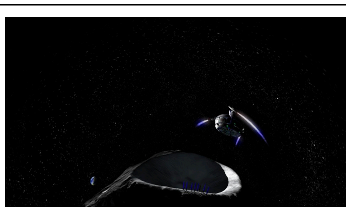
VERSION (SUBTITLES) REVISED: JUN 17, 2019

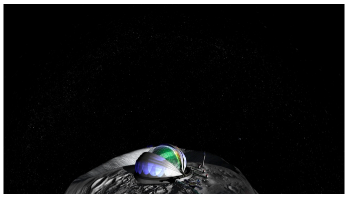
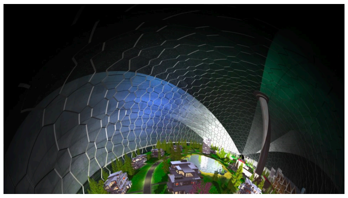
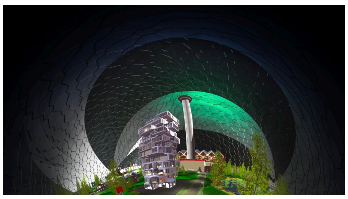
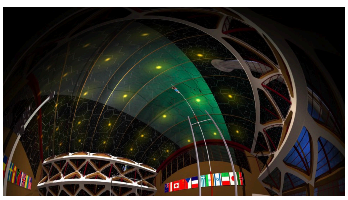
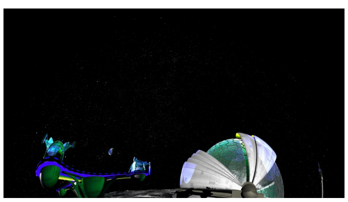
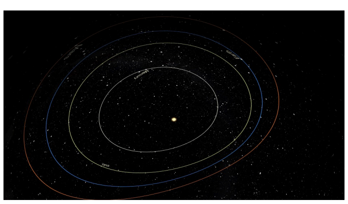
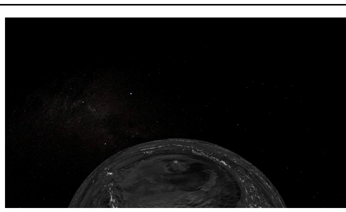
SCENE	TIME	SCRIPT
INTRO		**INTRODUCTION**
	00:00	Four fundamental forces control the universe. The strong and weak nuclear forces act inside atoms and molecules, like the hydrogen and oxygen atoms in a water molecule. The third force, electromagnetism, binds atoms and molecules together.
	00:29	Gravity, the fourth force, is dramatically different. You can feel gravity. It is the force of attraction connecting you to everything else in the universe. It extends across space: never going away.
	00:44	For millions of years, gravity trapped life in Earth's oceans. But eventually life defied gravity as it rode ocean waves onto the land.
	00:55	By the 18th century we had built hot air balloons to carry us above the Earth's surface.
	01:02	To challenge gravity in the 20th century, we invented jet engines, powering airplanes that could fly around the world.
	01:10	Then we built rockets powerful enough to defy the pull of Earth's gravity and carry 24 Apollo astronauts to the Moon.

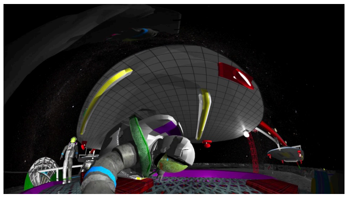
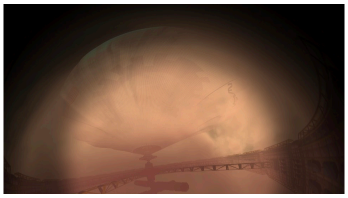
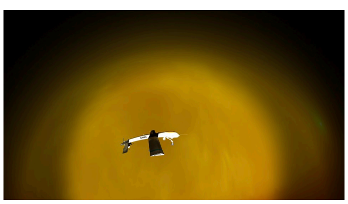
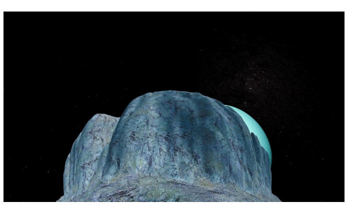
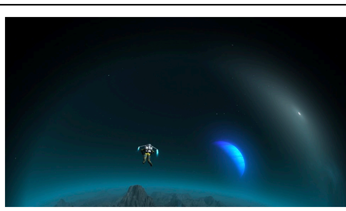
	01:31	Meanwhile astronomers discovered how gravity affects the entire universe: controlling the motions of stars and the formation of galaxies. In this program we'll pay tribute to the astronauts and astronomers who defy gravity as they uncover its secrets.
TITLES		**OPENING TITLES**
	01:50	Apollo & Beyond Conquering Gravity Jim Bratton, Walter Cronkite, and The Apollo Astronauts
PART 1		**Apollo Past**
	01:58	Our gravity adventure began in 1962 at Rice Stadium in Houston, TX. "*We choose to go to the Moon. We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard*."
	02:29	Less than a decade later, we watched as a 36-story Saturn V rocket overcame gravity's bonds and propelled 50 tons of cargo including three brave humans, toward the Moon.
	02:54	In December 1968, the Apollo 8 astronauts saw Earth rising above the lifeless lunar surface. Our planet had lost its grip on these three astronauts, now orbiting another world. Also for the first time, we saw our Earth, fragile and alone in the blackness of space - a world whose gravity no longer bound us.
	03:22	On July 16th, 1969, the cylindrical Command Module Columbia, piloted by Michael Collins, carried a lunar lander on a 100-hour trip to the Moon. Columbia remained in orbit while the Lunar Module Eagle took Neil Armstrong and Buzz Aldrin to the Sea of Tranquility. The TV journalist Walter Cronkite described the experience of all the Apollo astronauts as they explored the Moon.
	03:52	"Here men from the planet Earth first set foot on the Moon, July 1969 AD. We came in peace for all mankind."

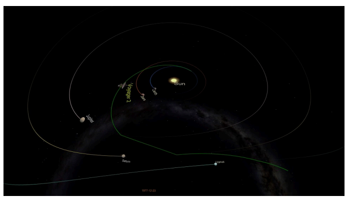
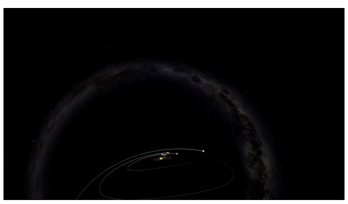
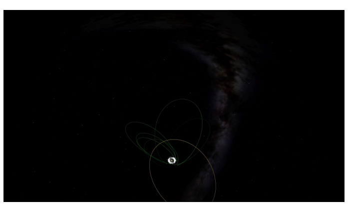
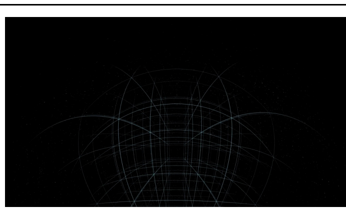
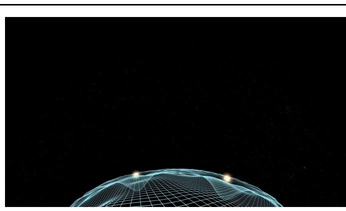
	04:05	Imagine being the first geologists on a huge unexplored world full of rocks, dust, and unsolved mysteries. The lunar soil is rocky debris crushed by meteor impacts into a substance that clings to everything it touches - turning space suits a dingy gray.
	04:26	To go farther and see more, NASA invented a battery powered lunar rover with wire mesh wheels - capable of exploring the Moon and perhaps becoming a prototype for tomorrow's lunar dune buggies.
	04:41	This is really a rock and roll ride, isn't it? I've never been on a ride like this before. Boy oh boy! I'm glad they've got this great suspension system on this thing. Yahoo. Golly, this is so great you can't believe it!
	05:00	Imagine being the first humans on this barren world ... the first to see a place, kick a rock, stir up dust or leave footprints and rover tracks in its timeless soil. All expressions are inadequate, the experience of a lifetime wrapped in a few precious hours, in a place to which you can never return.
	05:22	“I was strolling on the Moon one day in the merry, merry month of December, no May, when then much to my surprise, a pair of funny eyes, te dum, te dum, te dum."
	05:39	“Oh this is a neat way to travel. Isn’t this great! tum te dum dum dum, tum te dum dum dum, tum te dum dum dum. I like to skip along. Not me boy. Gene, I’m going to take that SEB number two and my camera and I’m heading home. OK, Boy is this fun.”
	06:08	Gene Cernan, the last man to walk on the Moon, remembers… "I slowly pivoted, trying to see everything, and was overwhelmed by the silent, majestic solitude. Not so much as a squirrel track to indicate any sort of life, not a green blade of grass to color the bland, stark beauty, not a cloud overhead nor the slightest hint of a brook or stream. But I felt comfortable, as if I belonged here. From where I stood on the floor of that beautiful mountain-ringed valley, the Moon seemed frozen in time.”

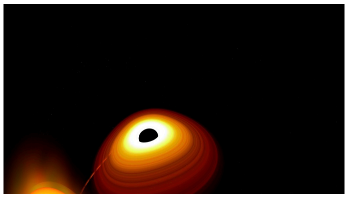
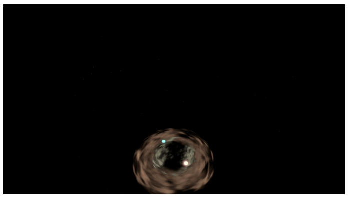
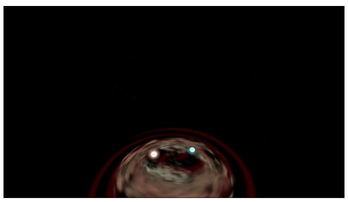
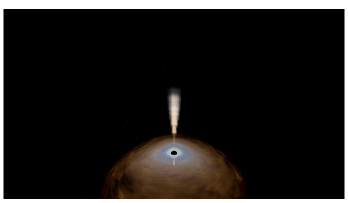
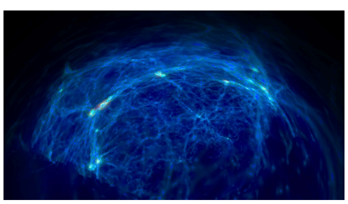
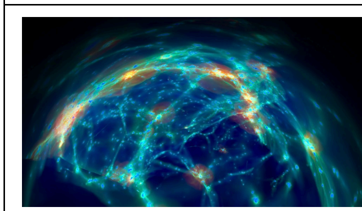
	00:00	On December 14, 1972, Apollo 17 left the Taurus-Littrow valley and headed back to Earth. “Three, two, one, ignition. We’re on our way, Houston.” This would be the last time in 50 years for humans to leave Earth’s gravity field.
PART 2		**Spacecraft Present & Future**
	07:21	Since 2000, there have always been astronauts orbiting Earth in the International Space Station, but no one has conquered the Earth's gravity pull since Apollo.
	07:42	Orbiting astronauts appear to defy gravity by floating, but they really haven't escaped Earth's gravity at all. The International Space Station and the astronauts inside are free-falling around the Earth, traveling at a speed of almost 28,000 kilometers per hour. This is fast enough to prevent the falling space station from crashing to Earth and to keep it in orbit.
	08:10	Although orbiting astronauts are still bound to Earth, the floating sensation in orbit is a welcome reprieve from Earth's surface gravity. In this century tourists will also experience this freefall sensation. Space X, a private company, docks its cone-shaped Dragon capsule at the International Space Station. Small private space ships begin carrying humans into space.
	08:37	Larger vehicles like NASA's Orion spaceship, might dock at the International Space Station before traveling to the Moon and beyond.
	08:49	To journey to the Moon, Orion will leave Earth orbit with enough speed to escape Earth's gravity and then coast toward the Moon and into lunar orbit.
	09:14	Astronauts orbiting the Moon will once again watch the distant Earth rising above the barren lunar surface. The Earth is as fragile and beautiful as it was in 1968. But our perception of the Moon has changed.
PART 3		**Tomorrow’s Moon**

	09:29	This time we are here to stay. Soon there will be a new space station, orbiting the Moon: a Lunar Orbital Platform called the Gateway. This is a research station and a jumping off point for astronauts traveling to other worlds. Astronauts on the Gateway will be the first humans to defy Earth's gravity for an extended period by living in a space station in lunar orbit. The Gateway is an all-in-one solar-powered communications hub, science laboratory, outpost, and supply center -- as well as a staging point for lunar exploration and eventually for journeys to other worlds like Mars. Following Gateway, our next gravity challenge could be the construction of a lunar colony – permanently defying Earth's hold on life.
	10:45	A world with only a sixth of Earth's surface gravity cannot hold onto an atmosphere. Without air to fly through, our lunar transport has no need for wings or a nose cone. Jets will do all of the maneuvering.
	11:05	The airless Moon is frozen in time. Here wind and water have not erased the impacts of rocky asteroids and icy comets. The Moon is a museum, preserving the scars of dramatic events in our solar system's past.
	11:22	Our destination is the dark cratered terrain of the Moon's South Pole. Here the sun circles the horizon each month and its light never reaches deep crater floors.
	11:34	Astronomers work on the Moon's Far Side, escaping Earth's stray light and radio chatter. Perhaps these lunar radio telescopes will detect signals from distant alien worlds.
	11:54	We can cast the Moon's surface material into beams, rods, plates, tubes and glass fibers. Solar cells, made of lunar regolith, collect sunlight to power our colony. On a world without life, there is no wood for buildings and no ancient life to become oil, coal, or natural gas. With no wind, waves, or fossil fuels, solar energy is our only readily available power source.
	12:27	Our colony lies near the rim of Shackleton Crater at the Moon's South Pole. The low sun's light never reaches the crater floor. Any ice brought to the Moon by comets is still here. We mine this crater for this ice, which we can turn into water to drink and oxygen to breathe.

	12:50	We will live in an enclosed biosphere - with a recycled atmosphere, balanced for humans and plants. At the South Pole, the low sun circles the horizon once every month, providing uniform light and energy. Glass panels shield colonists from the most dangerous solar radiation, while holding in air and water.
	13:26	On a low gravity world without weather, our buildings can be lightweight and easily constructed. If you jump into that pond, your splash would be 6 times higher than an Earth splash. Here trees absorb carbon dioxide and provide oxygen to breathe. We will also plant vegetable gardens to grow our food.
	13:51	On the low-gravity Moon, we lose most of our weight. In the air of this dome, humans wearing wings can actually fly, gliding like the flying pterosaurs of Earth long ago.
	14:23	Tomorrow's Lunar Olympics will break all terrestrial records -- featuring pole vaults 6 times higher, long jumps 6 times farther, and weightlifting of over an Earth-ton. Here graceful gymnasts can leap much higher than they can on Earth and slowly fall to the ground.
	14:55	Life on the low-gravity Moon might become so pleasant that astronauts dread returning to the oppressive surface gravity pull of Earth.
PART 4		**Solar System Gravity**
	15:08	There are other worlds in our solar system, each in a unique path defined by its distance from the Sun. Planets farther from the Sun experience a weaker gravitational force, move more slowly, and have longer years. Orbital periods range from 88 Earth days for nearby Mercury, to 248 Earth years for the distant Pluto.
	15:44	Every surface you could walk on - from Mercury to Pluto - will pull less on you than the force of Earth's gravity, holding you down right now.

	15:54	On Mercury you would lose about 2/3rds of your weight and could easily zip line across a crater.
	16:11	On Venus, the surface gravity is about the same as Earth's, but you would have to live in the clouds, above the planet's toxic, scorched surface.
	16:25	On Mars, your lighter weight would make it easy to rappel into the canyons of the Valles Marineris, one of the planet's most dramatic surface features.
	16:42	On an asteroid like Eros, you would weigh almost nothing. After you jump, you would need a tether to return to the asteroid's surface.
	16:57	On Jupiter's moon Europa the gravity pull is much less than on Earth's moon. Here you could easily go spelunking in an ice cave, looking for signs of alien life.
	17:10	On Saturn's moon Titan, you would weigh a sixth of your Earth weight and could easily power glide in the moon's Earth-like atmosphere.
	17:24	Uranus's moon Miranda has a very low gravity pull. Here jumping off Verona Rupes, the solar system's tallest cliff, would result in a long slow majestic fall. This cliff is taller than the height of Mt. Everest above sea level.
	17:44	In the low gravity of Neptune's moon Triton, you could use your jetpack to explore erupting ice geysers, as they resurface this moon.

	18:01	On the distant Pluto, you're so light that skiing would be wonderful, especially if you arrive when Pluto's atmosphere snows out. All ski jumps would be a slow motion delight on this low gravity world.
	18:14	Earth traps us on its surface, but freedom is as close as the neighboring worlds of our solar system. We just have to defy Earth's gravity as the Apollo astronauts did!
	18:35	In 1977 a rare alignment of the outer planets allowed the Voyager 2 spacecraft to ride the force of gravity from Jupiter to Saturn and then to Uranus and Neptune. In this gravity assist, the spacecraft grabbed a bit of energy from each planet's gravity field to increase its velocity and change its direction. Voyager 2 gained enough speed to escape the Sun's gravity forever.
	19:03	But where does the Sun's gravity stop? What lies beyond Pluto? Now we have found objects much farther away – dwarf planets in orbit around the Sun at more than 3 times the distance to Pluto. One object, nicknamed Farout, takes 1,000 Earth years to orbit the Sun. The orbit of this tiny body may play a big role in the discovery of other worlds, even farther from the Sun, but still held by the Sun's gravity.
PART 5		**Cosmic Gravity**
	19:34	Gravity is at work on a more dramatic scale in stars like our Sun. Gravity holds the Sun together as energy rises from its core. Gravity pulls most of the matter ejected in loops and arcs back to the Sun's surface. In the Sun's core, the inward gravity push from the matter above creates enough heat and pressure to crush hydrogen into helium, trading mass for energy, and generating light to illuminate the solar system. To visualize the Sun's gravity, we must imagine space as lines extending in all directions.
	20:28	Now add the Sun and watch how these lines bend inward, creating a dip called a gravity well. The well is deeper for more massive objects, like the Sun and giant planets.
	20:39	Gravity wells collide, when twin stars are close together. Here the stronger gravity of one star can pull matter off the other. The extra mass can make the star unstable, leading to a massive nuclear explosion.

	21:10	When the core of a massive star collapses, its intense gravity can produce an escape velocity surpassing the speed of light. We use the term Black Hole to describe such an object. A black hole's gravity traps everything, even light. Although we cannot see a black hole, we can observe how its gravity pulls on any visible companion.
PART 6		**Riding the Gravity Wave**
	21:38	We have recently confirmed another characteristic of gravity: the production of gravitational waves by orbiting objects. In 2017, our Ligo detectors measured the gravitational waves produced by two very dense orbiting neutron stars.
	21:56	As the neutron stars moved closer together, the increased gravity pull caused them to orbit faster and emit stronger gravitational waves. This process led to a cataclysmic collision called a kilonova. This kilonova produced gravitational waves rippling across space and through the Earth. We detected our planet trembling slightly as the space time warp of gravitational waves passed by. At a distance of 130 million light years, the gravitational waves from this event generated a space-time distortion less than the width of a hydrogen atom.
	22:54	Gravity causes spacetime to vibrate and undulate like an object falling into water. Gravitation waves are kinks or ripples in the cosmic spacetime ocean.
	23:23	At the beginning of the universe, gravity was there. Gravity from dark matter created structures where galaxies formed. Mysterious voids separated these islands of matter. Wherever there is mass, there has always been the force of gravity controlling its behavior, until now.
	23:47	Life first challenged gravity as creatures crawled out of the sea onto the land. Finally at great energy cost, we built rockets to overcome Earth's gravity and leave the planet. We celebrate the Moon missions of Apollo because they represent our victory in life's ancient quest to defy the force that has defined our lives and shaped our universe: gravity.
CREDITS		**ENDING CREDITS**
Narration	24:21	Jim Bratton Walter Cronkite Gene Cernan and the Apollo Astronauts on the Lunar Surface
Script		Carolyn Sumners
Score and Audio		Fish-I Studios

Post-Production		Shai Fishman
Animation		Houston Museum Of Natural Science Adam Barnes Tony Butterfield Geoffrey Baring Will Yokley
		Home Run Pictures Tom Casey Gerry Crouse
		Rice University Don Davis - Animation
Other Animation		Evans & Sutherland The Illustris Collaboration The eXtreme Gravity Institue at Montana State University
Photography		Apollo Astronauts on the Moon Shuttle Astronauts on the International Space Station Massachusetts Institute of Technology Charles Hayden Planetarium at the Museum of Science, Boston
Partial Support		NASA Future Space Grant 09-2009CP4SMP-0047 Awarded to the Louisiana Art and Science Museum
Copyright		Houston Museum of Natural Science
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