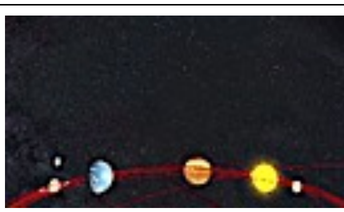
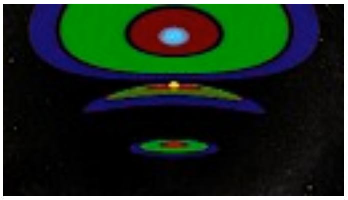
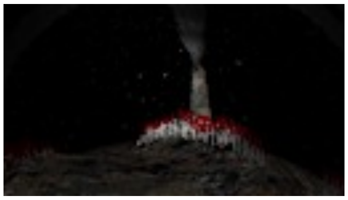
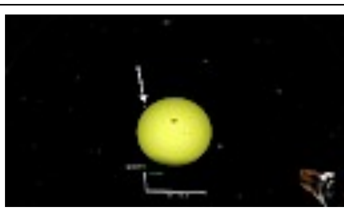
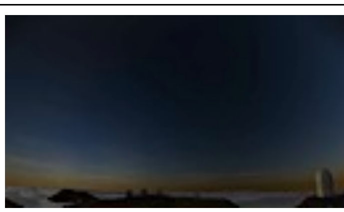
X-PLANETS

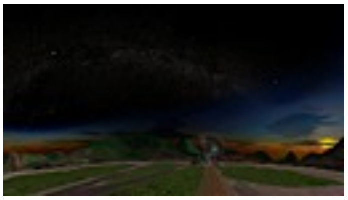
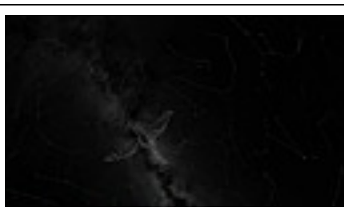
VERSION (SUBTITLES) REVISED: JULY 26, 2013

SCENE	TIME	SCRIPT
SCENE 1		**INTRODUCTION**
	00:07	We are more optimistic about finding life beyond Earth than ever before. Astronomers have found hundreds of giant planets orbiting other stars and many smaller worlds as well. Meanwhile biologists have found microscopic life on Earth in places they never expected. As biologists dramatically expand the conditions where life can survive, astronomers are finding alien planets with environments suitable for life. We will search the Earth for these tiny survivors and the heavens for alien worlds where they could survive. We will also use artistic interpretations to show the alien worlds we discover as they might look in a universe full of possibilities.
TITLES		**OPENING TITLES**
	00:56	The X-Planets Discovery Other Earths Narrated by Jim Bratton Music by Shai Fishman Featuring Animations from The Planetary Traveler Project
SCENE 2		**LIFE IN OUR SOLAR SYSTEM**
	01:10	The Sun's family of planets provides clues about planets we may find orbiting other stars. The outermost of the gas giants, Neptune, is cold, and lacks a solid surface like Earth's. The same is true of its twin planet, the tilted Uranus - the beautiful Ringed Saturn - and the enormous Jupiter - largest of the planets. The red Mars has a solid surface, but is probably too dry today for complex life. The surface of cloud-covered Venus is too hot. Mercury lies too close to the Sun, leaving Earth, our solar system's only home for advanced life forms.
	02:01	Many factors contribute to the stability of our blue life-bearing world, including the existence of both ocean and landmasses. Its nearby Moon causes tides, stabilizes Earth's tilt and slows its spin. The distant Jupiter redirects asteroids and comets that could otherwise destroy Earth life. And the Sun has been a stable energy source for billions of years. These are all factors we must consider in the search for life-bearing worlds orbiting other stars.
	02:37	To focus their search, astronomers draw a habitable zone around a star. This zone shaded green, shows where planets could have liquid water, and where life, as we know it, might be possible. This is the habitable zone for our solar system. Venus lies at the inner hotter edge of the zone. Mars lies at the outer cooler edge. Earth orbits in the middle of the habitable zone. For a star hotter than

		our Sun, the habitable zone is larger and farther from the star. For a star cooler than our Sun, the habitable zone is smaller and closer to the star.
	03:26	We wonder if life could be possible beyond this habitable zone. Have astronomers considered the tenacity and adaptability of Earth life when limiting the habitable zone to the orbits where planets could have liquid water? We must look at Earth as a laboratory where life survives in environments more extreme than all expectations - ranging from the hottest and driest equatorial deserts, to the coldest glaciers near Earth's poles.
SCENE 3		**LIFE IN THE EXTREMES OF EARTH**
	04:10	The plants, animals, and microbes living on Earth today are all survivors on a planet that has undergone dramatic change over 4 and a half billion years. Within a few hundred million years of its formation, Earth might have had conditions much like those in the hot springs and volcanic pools of Yellowstone National Park Here today we find probable descendants of ancient life forms - the Archaea - surviving in the most primordial environments. Will microbes like these tiny survivors be similar to the first aliens we find on other planets?
	04:50	Scientists discovered these extreme-loving microbes, which we call extremophiles, in the geysers and hot springs of Yellowstone National Park. The microbes thriving in these pools and their runoff channels may be heat-loving descendants of the earliest life forms on Earth. Their existence at temperatures near the boiling point of water extends the inner boundary of the habitable zone. Mud pots in Yellowstone Park, also harbor tiny creatures called acidophiles - thriving in acids that would destroy the DNA in most creatures. Scientists speculate that toxic clouds on planets like Venus could harbor acidophiles such as these.
	05:36	Scientists believe that during the first two and a half billion years of Earth's history, microbes called cyanobacteria, gradually transformed the planet's oxygen-free atmosphere into one that could support more complex life. In colorful mats and streamers, these microbes convert carbon dioxide to oxygen, in a process called photosynthesis. Gradually these bacteria and the algae that appeared later create an atmosphere that would eventually support human life.
	06:09	Billions of heat loving microbes inhabit a tiny square of this mat - outnumbering all the people on Earth. Microbes at the top of the mat need sunlight. Below are species that survive by combining inorganic chemicals to produce energy. Such energy sources may have fueled Earth's earliest life forms, and support organisms living in hot springs and geysers today.

	06:37	On Earth Life exists in the deep ocean near undersea hydrothermal vents, similar to Yellowstone's geysers. The area around these Black Smokers hosts a complex microbe community fueled by the chemicals in the vent fluids. These barophiles are adapted to the high pressure and lack of sunlight in the deep ocean. Active hydrothermal vents like these could exist below the icy surface of Jupiter's moon Europa or Saturn's moon Enceladus. On Enceladus jets of water burst from fractures in the moon's icy surface and indicate an ocean below.
	07:17	Chemical energy requires no sunlight, and provides the most likely energy source for life beneath the soil of Mars, a planet that once had surface water. By recognizing the adaptability of life on Earth, we can identify new places to look for life on nearby planets like Mars and on the exoplanets we discover around other stars.
SCENE 4		**DETECTING PLANETS BEYOND OUR SOLAR SYSTEM**
	07:43	Observatories on Earth and telescopes in space have discovered well over 700 planets orbiting other stars and expect to find thousands more.
	07:55	In a focused search for exoplanets, NASA launched a satellite telescope called Kepler. Kepler has looked for light level changes in over a hundred thousand stars within a very small area of the sky between the constellations Cygnus and Lyra. Kepler has detected well over a thousand possible planets. Data from the Kepler mission, which is limited to a very small part of the sky, indicate that there could be 50 billion planets orbiting all the stars in our Milky Way Galaxy.
	08:28	To detect the presence of an exoplanet, the Kepler telescope measures the tiny dip in a star's brightness when an orbiting planet crosses in front. The dip may be only a fraction of a percent of the star's total brightness, but if it repeats, it indicates the presence of a planet crossing in front of its star once in each orbit. The amount of the dip tells us the size of the planet - whether the planet is a giant, or a smaller Earth-size world. The time it takes to cross the star's face, and the time between dips, tell us how far the planet orbits from its star. Detecting an exoplanet in this way is like finding a firefly crawling across a searchlight by looking for the decreasing brightness of that searchlight from 1,000 kilometers away.
	09:20	Observatories on Earth confirm the discoveries of satellites like Kepler. The Keck Telescope complex on Mauna Kea in Hawaii has identified more extra solar planets than any other observatory on Earth. The high altitude and isolation from any urban lighting make it easier for these telescopes to detect small changes in the color of a star. Astronomers use a high-resolution spectrograph to display the different colors in a star's light. They can then detect an exoplanet by a tiny shift in a star's color as the planet orbits it. The star's light becomes bluer as the star moves toward us, and then

		redder as the star moves away from us. This motion is caused by the tug of the orbiting planet. Astronomers can measure a change as small as a meter per second in the star's speed, thereby detecting worlds as small as Earth orbiting other stars.
SCENE 5		**DISCOVERING THE FIRST EXOPLANETS**
	10:21	In the 1990's, astronomers discovered the first planets circling distant stars. Inspired by these discoveries, digital artists around the world began designing possible alien worlds to represent the conditions on these exoplanets. They called their combined work the Planetary Traveler project. We can now match the most significant discoveries of exoplanets with animations depicting what spaceships of the future might discover when exploring these alien planetary landscapes. We can then add extremophiles that might exist on each animated world for a view of possible life elsewhere in the universe.
SCENE 6		**THE FIRST EXOPLANETS**
	11:06	Astronomers discovered the first planet orbiting a Sun-like star in 1995. This planet, called 51 Pegasus b, is just 50 light years away in the constellation Pegasus, along one side of the pattern's great square. 51 Pegasus b has about the mass of Jupiter, but lies closer to its star than Mercury does to our Sun. The easiest exoplanets to detect are large and close to their suns, like 51 Pegasus b. With their deep and violent atmospheres, these hot Jupiters are too close to their stars to harbor life. More sensitive instruments and software are required to find smaller and cooler exoplanets.
	11:57	Six years later, in 2001, astronomers at the Keck Observatory detected a planet orbiting the star HD28185. Unlike the hot Jupiters lying so close to their sun, this is the first planet we found in the habitable zone of its star. Although this planet orbits at the right distance from a Sun-like star, it is far too big, over 7 times the Earth's diameter, and as much as a 1,000 times it's mass. This is a giant world like Jupiter. It could have moons with solid surfaces and even atmospheres and liquid water. Extremophiles on Earth might be able to survive on a moon of HD28185b, or even in water clouds in the atmosphere of the planet.
SCENE 7		**THE FIRST EARTH-SIZE EXOPLANET**
	12:49	In 2007, six years after finding HD28185b, astronomers finally detected a smaller Earth-size planet in the habitable zone of its star. This planet orbits a red dwarf star called Gliese 581, only 20 light years away. Astronomers have confirmed that one of the planets in this system, Gliese 581d is in this star's habitable zone, and is almost as small as Earth. It may be covered in oceans with an atmosphere that supports clouds and rain. Unfortunately one side of the planet probably faces its sun, while the other side lies in perpetual darkness. Perhaps life could survive in the waters of Gliese 581d, if the life were far below the hostile temperatures of the planet's watery surface.

	13:45	Humans waited eagerly and a bit impatiently over 10 years from the discovery of 51 Pegasus b, to the discovery of Gliese 581d. Soon after astronomers announced the existence of a solar system around Gliese 581, a networking website used a large radio telescope to beam a message from Earth. This transmission is due to reach the Gliese 581 system by the year 2029. The earliest possible date to receive a response is 2049. As part of its 2009 National Science Week, Cosmos Magazine launched a website called "Hello From Earth", to collect messages for transmission to Gliese 581. In total, 25,880 messages were submitted from 195 countries around the world. There can be no doubt that humans are eager to find life-bearing planets around other stars.
SCENE 8		**FINDING A ROCKY EXOPLANET**
	14:48	While radio telescopes were sending greetings to Gliese 581, a satellite discovered the first Earth-size rocky exoplanet called Corot 7b, a world less than twice the diameter of Earth. One side is always facing its sun, and the other side may be cold enough to be covered in ice. It orbits so close to its sun, that the surface may well look like Dante's inferno, with a temperature over 2,000 degrees on the dayside, and dropping to minus 220 degrees on the night side. The planet may also have lava and boiling oceans on its surface. The thermophiles in Yellowstone may help us predict whether life could exist in the twilight region, of hot rocky worlds like Corot 7b.
	15:41	Soon after the Corot satellite detected Corot 7b, astronomers discovered a more favorable rocky planet called Gliese 370b, only 36 light-years from Earth in the constellation Vela. Gliese 370b is one of the smallest exoplanets discovered, and it lies on the edge of its star's habitable zone. If this planet has 50% cloud cover, water may exist here in liquid form, thus making the planet habitable. A rocky clouded world, even one with extreme temperatures, is a possible place for extremophiles called endoliths to live.
	16:33	Endoliths hide deep within Earth rocks, down to a depth of over 3 kilometers. They survive on minerals in the rock, and may be a likely candidate for life on Mars, or an exoplanet like Gliese 370b. These tiny rock dwellers have survived for centuries in some of the most inhospitable environments on Earth and are also among Earth's oldest living microbe colonies.
	17:02	By 2011, observatories on Earth began confirming the discoveries of the Kepler satellite. Kepler-22b is the first confirmed extrasolar planet that Kepler found within the habitable zone of a Sun-like star. Kepler-22b, a possible super-Earth, is 600 light years away and just over twice the Earth's width. If it is mostly ocean with a small rocky core, life could exist here.
SCENE 9		**PLANETS AROUND MULTIPLE STARS**

	17:39	Kepler 16b is an exoplanet 200 light years away in Cygnus. It is a large planet, half rock and half gas, orbiting the binary star, Kepler-16, once every 229 days. This is the first confirmed example of a circumbinary planet - a planet orbiting not one, but two stars. The planet orbits on the outer edge of the habitable zone, and probably has a surface temperature far below freezing, perhaps as cold as the coldest Arctic winter. Some of the oldest organisms on Earth are bacteria found in Antarctic ice and Siberian permafrost: creatures that have tolerated the cold for thousands of years. Perhaps cold-resistant microbes called psychophiles could inhabit a planet like Kepler 16b or one of its moons.
	18:35	In 2012, astronomers finally discovered a planet with all of the right characteristics to support life. Gliese 667C is a red dwarf star that orbits two larger orange stars, with all three stars less massive than our Sun. Gliese 667Cc is also the first exoplanet orbiting a star in a triple star system, that is sitting squarely in the middle of its stars' habitable zone.
	19:07	Gliese 667Cc receives 90% of the solar energy that the Earth does. The light of its red dwarf sun would make this a world of warmer colors than our own, but still able to support life. This planet could be just one of billions of habitable worlds in our galaxy.
	19:29	On Earth, we have found life inside rocks, surrounding deep-sea geysers, buried in permanent ice, and surviving in acid pools and lakes near boiling. Some of these extremophiles exist without sunlight, but all require water. Detection of oxygen and water vapor in the atmosphere of an alien planet like Gliese 667Cc would be the strongest indicator of suitable conditions, and perhaps the presence of life.
SCENE 10		**SEARCH FOR ADVANCED LIFE**
	20:01	Conditions required for complex life are far more specific and demanding than those needed to support simple organisms. A stable star, water in liquid form, an atmosphere with water vapor and oxygen, and a protective magnetic field - if we can find all of these, we could be looking at a world that can support life, and perhaps intelligent life.
	20:27	An advanced alien civilization will change its world as humans have changed Earth. We can imagine a distant watery world with the unique construction of an alien intelligent life. The ultimate goal of our search, is to see if the circumstances that produced human awareness and creativity occur frequently, or rarely among the stars. The answer will tell us... whether we are unique, or one of many intelligent civilizations in the universe... whether civilizations are more likely to survive or to self-destruct... whether we are alone or no longer lonely.
CREDITS		**ENDING CREDITS**
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