# Cosmic Castaways Scene Chart (Final Production Version)

| Narration | Visuals | Scene |
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| There are places where the night sky has no constellations. No Orion, no Big Dipper, nothing but a few lonely, far away stars and a few faint, ghostly patches of light.<br><br>Most stars lie within the crowded boundaries of galaxies, traveling with their brothers and sisters in a vast galactic family.<br><br>But some find themselves on their own, deep within the voids between the galaxies. These are the cosmic castaways… | Sunset on planet – nearly empty sky. Pull back off of planet to show star, zoom out to show isolation. | 1 |
| ***Title Sequence*** | Title enters from behind, whole scene fades out. | 2 |
| The Universe is full of stars. Some are huge, hundreds of times the size of the Sun. Others are tiny, barely larger than the familiar planet Jupiter. They come in a wide variety of colors – from the deepest red to dazzling blue. Most of these stars lie within galaxies; huge collections of stars, gas, dust, and dark matter that include our own Milky Way in their number. | Crowded star field; superimpose red star, yellow star, orange star, white star, blue star. Crossfade to cool Hubble Galaxy pic. | 3 |
| Galaxies are held together by the force of gravity. Just as gravity keeps the planets of our Solar System orbiting around our Sun, gravity from all of the mass inside our Milky Way Galaxy keeps stars orbiting its center. Our own Sun majestically circles the center of the Milky Way. The Milky Way is so large that the last time the Sun was at its current position, the first dinosaurs roamed the Earth. | Zoom into galaxy to show our Sun's position. Galaxy rotation | 4 |

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| Just as our Solar System is one of many in our Milky Way galaxy, our Milky Way is just one of a myriad of galaxies.<br><br>Galaxies do not exist alone. They are found in groups, held together by the same gravity that keeps their stars in orbit. Our Milky Way lies in a small galaxy group known as the Local Group, which contains a handful of large galaxies, and dozens of small galaxies. | Pull back to Local Group | 5 |
| As galaxies move within galaxy groups, sometimes wandering too close to one another, they can tug at each other through the force of gravity. These gravitational forces cause colossal changes to the shapes of the galaxies.<br><br>Since this process takes place over hundreds of millions of years, astronomers cannot watch it from beginning to end. Their telescopes only catch snapshots in time, of different galaxies seen at different stages of this interaction sequence. With tools like the Hubble Space Telescope, dozens of these interacting galaxies have been imaged in amazing detail. | Galaxy Merger with HST crossfade; more galactic collision photos. | 6 |
| From what they've seen, astronomers have created computer simulations to show how galaxies change their shapes. As the galaxies approach, gravity rips the stars out of their normal paths, and some are pulled out of the galaxies into long tail-like structures. Even though there are billions of stars in each galaxy, the distances between the individual stars are vast, so they rarely -- if ever – collide with other stars. Instead, the two galaxies eventually merge together to form a new more massive | Mihos Galaxy Merger flythrough. | 7 |

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| galaxy as their torn-off tails drift away. The remaining stars floating within these abandoned tails are forever stranded in the vast space between the galaxies. | | |
| This sort of collision is rare in small groups like our own Local Group. But, as we look beyond our home group, we encounter much larger collections of galaxies, called galaxy clusters. These immense systems are some of the largest structures in the Universe and contain thousands of galaxies. If the Local Group is like a small village of galaxies, galaxy clusters are like a big city – crowded and busy. | 3D Map of Virgo Cluster flythrough?<br>Wide view of Virgo Cluster? | 8 |
| In galaxy clusters, the interactions between galaxies are much more common because the galaxies are crammed so close together. Computer simulations show us that in these dense environments many more stars will be gravitationally torn from their homes and left in the cosmic void.<br><br>As we study these giant clusters, we witness numerous galaxies interacting with one another at the same time. Sometimes, long tails of stars are wrenched from galaxies during their too-close passages. Other times, the interactions produce fan-shaped plumes of castaways. One by one, gravity continually pries stars away from their galactic homes until 10 to 20 percent of the galaxies' stars are castaways - lost in the voids between the galaxies. | Mihos big galaxy cluster collision sequence. | 9 |
| Let's pay a visit to a typical star in one of these galaxies. This star formed billions of years ago in a cloud of gas and dust, and orbits near the edge of a spiral galaxy. The star has a slightly lower temperature than our | Galaxy zoom in to our orange star, hold for a moment. Zoom back out to show approaching galaxy. Galaxy collision sequence. | 10 |

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| yellow-white Sun, so it appears orange.<br><br>But this star's long journey around its galaxy is not uneventful. Its galaxy, and the star's own orbit around the galaxy, are disturbed when an unwelcome neighbor comes for a visit. | | |
| The intruder galaxy distorts the spiral galaxy and our star is hurled from its home along with many other stars as they are stretched out to form an enormous tidal tail. But the tail is fragile – eventually, these stars will be scattered from gravitational pokes and prods of the other galaxies within the cluster, like a leaf torn from its tree in a windstorm. While evicted from its home, the star itself was not damaged, and its planets continued to orbit around it as they always had, oblivious to the large-scale chaos around them. | Zoom into tidal tail, show stars moving away from collision. Fade out. | 11 |
| Looking at the cluster as a whole, the light of our lost star and all its fellow castaways seems to be absent from our image. Like smoke from a fire disappearing in the wind, the light of the ghostly tidal tails has faded into the cosmic background as it spreads over tremendous distances.<br><br>The starlight from these cosmic castaways is now so diffuse that it is much, much fainter – a *hundred times fainter* – than the dark, moonless night sky, making their light almost invisible. Too many other lights shine brighter than these castaways, and so they are all but lost in the glare of our busy universe.<br><br>But they are *not* lost. It wasn't until the late 20$^{th}$ century that astronomers had the tools they needed to search | Show moonless light sky on Earth w/ prominent Milky Way. | 12 |

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| for these elusive objects. | | |
| The most promising place to seek the light of these castaways is the nearby Virgo Cluster of Galaxies; the nearest galaxy cluster to Earth. It is about 55 million light years away, and contains several thousand galaxies.<br><br>Using a special telescope designed to search for this very faint light, astronomers spent months observing the center of the Virgo Cluster to search for its cosmic castaways. At first, the telescope saw only the bright galaxies in Virgo, as well as some stars from our own Milky Way in the foreground. But as it looked longer, probing deeper, an intricate web of tails and fans came into view in the space between the galaxies. | Visible VC. Slowly crossfade to IC light image starting at "as it looked longer" | 13 |
| This stunning image is a snapshot of the history of the Virgo Cluster. In this long exposure, the light of the cosmic castaways is able to shine visibly in the spaces between galaxies. | Crossfade complete. Fade out. | 14 |
| There is another way to see cosmic castaways – by observing the individual stars directly. This is only possible for the brightest castaway stars, because galaxy clusters are so far away. The most abundant of these bright stars are the majestic Red Giants.<br><br>Our cosmic castaway's journey lasted billions of years. Over this time, it has swelled to several hundred times its original size and cooled, becoming a Red Giant star. Now, in the darkness far from its original home, it is nearing the end of its life. Because of the star's enormous size, it also very bright, several thousand times brighter than our Sun, making it | Orange star swells and turns red. Fast zoom back to Earth orbit – Hubble pointed in star's direction. | 15 |

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| visible to powerful telescopes like the Hubble Space Telescope. As bright as the Red Giant is, it is very far away, so it will be very faint even to the Hubble Space Telescope. | | |
| Here is an image of one piece of the Virgo Cluster. Zooming in, we find a faint sprinkling of red objects. These are individual Red Giant castaways, peers to the star that we have followed, each of them lost forever between the galaxies. | VC HST image. Fade out. | 16 |
| If some stars can become cosmic castaways, we have to wonder, can our Sun, traveling within the Milky Way galaxy, get lost to the voids as well? Our Milky Way galaxy is not part of a cluster, but it is not alone in the Universe. There is a bigger galaxy nearby – the Andromeda Galaxy - and it is on a collision course with the Milky Way. Billions of years from now, the two galaxies will collide and begin to merge due to their gravitational pull.<br><br>When this happens, many stars will be flung into the void. Our Sun is currently about halfway out from the center of the Milky Way so there is only a small chance of our solar system leaving the massive "Milkdromeda" galaxy that will form in the wake of our own encounter.<br><br>But a small chance is not a zero chance. No matter what happens, in the last days of our Sun's life, it will be in a very different location with different neighbors. Perhaps, in our Sun's dying days, our descendants will gaze into a night sky with no constellations, and nothing but a few lonely, far away stars and a few faint, distant star clusters as it drifts in space as a cosmic castaway. | Start with Sun/ SS pull back to Cox and Loeb Sequence starting at "collision course". At the end of the sequence, zoom back in and parallel opening scene, this time with Sun/ Earth. | 17 |

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| ***Credits*** | Slow roll from bottom to top superimposed over final scene. | 18 |