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## ***The Future of Humanity (2018)***

### **Prologue**

**[1]** One day about seventy-five thousand years ago, humanity almost died. A titanic explosion in Indonesia sent up a colossal blanket of ash, smoke, and debris that covered thousands of miles. The eruption of Toba was so violent that it ranks as the most powerful volcanic event in the last twenty-five million years. It blew an unimaginable 670 cubic miles of dirt into the air. This caused large areas of Malaysia and India to be smothered by volcanic ash up to thirty feet thick. The toxic smoke and dust eventually sailed over Africa, leaving a trail of death and destruction in its wake.

**[2]** Imagine, for a moment, the chaos caused by this cataclysmic event. Our ancestors were terrorized by the searing heat and the clouds of gray ash that darkened the sun. Many were choked and poisoned by the thick soot and dust. Then, temperatures plunged, causing a “volcanic winter.” Vegetation and wildlife died off as far as the eye could see, leaving only a bleak, desolate landscape. People and animals were left to scavenge the devastated terrain for tiny scraps of food, and most humans died of starvation. It looked as if the entire Earth was dying. The few who survived had only one goal: to flee as far as they could from the curtain of death that descended on their world. Stark evidence of this cataclysm may perhaps be found in our blood.

**[3]** Geneticists have noticed the curious fact that any two humans have almost identical DNA. By contrast, any two chimpanzees can have more genetic variation between them than is found in the entire human population. Mathematically, one theory to explain this phenomenon is to assume that, at the time of the explosion, most humans were wiped out, leaving only a handful of us— about two thousand people. Remarkably, this dirty, raggedy band of humans would become the ancestral Adams and Eves who would eventually populate the entire planet. All of us are almost clones of one another, brothers and sisters descended from a tiny, hardy group of humans who could have easily fit inside a modern hotel ballroom.

**[4]** As they trekked across the barren landscape, they had no idea that one day, their descendants would dominate every corner of our planet. Today, as we gaze into the future, we see that the events that took place seventy-five thousand years ago may actually be a dress rehearsal for future catastrophes. I was reminded of this in 1992, when I heard the astounding news that, for the first time, a planet orbiting a distant star had been found. With this discovery, astronomers could prove that planets existed beyond our solar system. This was a major paradigm shift in our understanding of the universe. But I was saddened when I heard the next piece of news: this alien planet was orbiting a dead star, a pulsar, that had exploded in a supernova, probably killing everything that might have lived on that planet. No living thing known to science can withstand the withering blast of nuclear energy that emerges when a star explodes close by. I then imagined a civilization on that planet, aware that their mother sun was dying, working urgently to assemble a huge armada of spaceships that might transport them to another star system. There would have been utter chaos on the planet as people, in panic and desperation, tried to scramble and secure the last few seats on the departing vessels. I imagined the horror felt by those who were left behind to meet their fate as their sun exploded.

**[5]** It is as inescapable as the laws of physics that humanity will one day confront some type of extinction-level event. But will we, like our ancestors, have the drive and determination to survive and even flourish?

**[6]** If we scan all the life-forms that have ever existed on the Earth, from microscopic bacteria to towering forests, lumbering dinosaurs, and enterprising humans, we find that more than 99.9 percent of them eventually became extinct. This means that extinction is the norm, that the odds are already stacked heavily against us. When we dig beneath our feet into the soil to unearth the fossil record, we see evidence of many ancient life-forms. Yet only the smallest handful survive today. Millions of species have appeared before us; they had their day in the sun, and then they withered and died. That is the story of life.

**[7]** No matter how much we may treasure the sight of dramatic, romantic sunsets, the smell of fresh ocean breezes, and the warmth of a summer's day, one day it will all end, and the planet will become inhospitable to human life. Nature will eventually turn on us, as it did to all those extinct life-forms. The grand history of life on Earth shows that, faced with a hostile environment, organisms inevitably meet one of three fates. They can leave that environment, they can adapt to it, or they will die. But if we look far enough into the future, we will eventually face a disaster so great that adaptation will be virtually impossible. Either we must leave the Earth or we will perish. There is no other way. These disasters have happened repeatedly in the past, and they will inevitably happen in the future. The Earth has already sustained five major extinction cycles, in which up to 90 percent of all life-forms vanished from the Earth. As sure as day follows night, there will be more to come.

**[8]** On a scale of decades, we face threats that are not natural but are largely self-inflicted, due to our own folly and shortsightedness. We face the danger of global warming, when the atmosphere of the Earth itself turns against us. We face the danger of modern warfare, as nuclear weapons proliferate in some of the most unstable regions of the globe. We face the danger of weaponized microbes, such as airborne AIDS or Ebola, which can be transmitted by a simple cough or sneeze. This could wipe out upward of 98 percent of the human race. Furthermore, we face an expanding population that consumes resources at a furious rate. We may exceed the carrying capacity of Earth at some point and find ourselves in an ecological Armageddon, vying for the planet's last remaining supplies.

**[9]** In addition to calamities that we create ourselves, there are also natural disasters over which we have little control. On a scale of thousands of years, we face the onset of another ice age. For the past one hundred thousand years, much of Earth's surface was blanketed by up to a half mile of solid ice. The bleak frozen landscape drove many animals to extinction. Then, ten thousand years ago, there was a thaw in the weather. This brief warming spell led to the sudden rise of modern civilization, and humans have taken advantage of it to spread and thrive. But this flowering has occurred during an interglacial period, meaning we will likely meet another ice age within the next ten thousand years. When it comes, our cities will disappear under mountains of snow and civilization will be crushed under the ice.

**[10]** We also face the possibility that the supervolcano under Yellowstone National Park may awaken from its long slumber, tearing the United States apart and engulfing the Earth in a choking, poisonous cloud of soot and debris. Previous eruptions took place 630,000, 1.3 million, and 2.1 million years ago. Each event was separated by roughly 700,000 years; therefore, we may be due for another colossal eruption in the next 100,000 years.

**[11]** On a scale of millions of years, we face the threat of another meteor or cometary impact, similar to the one that helped to destroy the dinosaurs 65 million years ago. Back then, a rock about six miles across plunged into the Yucatán peninsula of Mexico, sending into the sky fiery debris that rained back on Earth. As with the explosion

at Toba, only much larger, ash clouds darkened the sun and temperatures plunged globally. With the withering of vegetation, the food chain collapsed. Plant-eating dinosaurs starved to death, followed soon by their carnivorous cousins. In the end, 90 percent of all life-forms on Earth perished in the wake of this catastrophic event.

**[12]** For millennia, we have been blissfully ignorant of the reality that the Earth is floating in a swarm of potentially deadly rocks. Only within the last decade have scientists begun to quantify the real risk of a major impact. We now know that there are several thousand NEOs (near-Earth objects) that cross the orbit of the Earth and pose a danger to life on our planet. As of June 2017, 16,294 of these objects have been catalogued. But these are just the ones we've found. Astronomers estimate that there are perhaps several million uncharted objects in the solar system that pass by the Earth.

**[13]** I once interviewed the late astronomer Carl Sagan about this threat. He stressed to me that "we live in a cosmic shooting gallery," surrounded by potential hazards. It is only a matter of time, he told me, before a large asteroid hits the Earth. If we could somehow illuminate these asteroids, we would see the night sky filled with thousands of menacing points of light. Even if we avoid all these dangers, there is another that dwarfs all the others. Five billion years from now, the sun will expand into a giant red star that fills the entire sky. The sun will be so gigantic that the orbit of the Earth will be inside its blazing atmosphere, and the blistering heat will make life impossible within this inferno.

**[14]** Unlike all other life-forms on this planet, which must passively await their fate, we humans are masters of our own destiny. Fortunately, we are now creating the tools that will defy the odds, so that we don't become one of the 99.9 percent of life-forms destined for extinction. In this book, we will encounter the pioneers who have the energy, the vision, and the resources to change the fate of humanity. We will meet the dreamers who believe that humanity can live and thrive in outer space. We will analyze the revolutionary advances in technology that will make it possible to leave the Earth and to settle elsewhere in the solar system, and even beyond.

**[15]** But if there is one lesson we can learn from our history, it is that humanity, when faced with life-threatening crises, has risen to the challenge and has reached for even higher goals. In some sense, the spirit of exploration is in our genes and hardwired into our soul. But now we face perhaps the greatest challenge of all: to leave the confines of the Earth and soar into outer space. The laws of physics are clear; sooner or later we will face global crises that threaten our very existence.

**[16]** Life is too precious to be placed on a single planet, to be at the mercy of these planetary threats. We need an insurance policy, Sagan told me. He concluded that we should become a "two planet species." In other words, we need a backup plan. We will explore the history, the challenges, and the possible solutions that lie before us. The path will not be easy, and there will be setbacks, but we have no choice. From near extinction approximately seventy-five thousand years ago, our ancestors ventured forth and began the colonization of the entire Earth. This book will, I hope, lay out the steps necessary to conquer these obstacles that we will inevitably face in the future. Perhaps our fate is to become a multi-planet species that lives among the stars.

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*"If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds."* —CARL SAGAN  
*"The dinosaurs became extinct because they didn't have a space program."* —LARRY NIVEN