ONE CANNOT LIVE IN THE CRADLE FOREVER

> *We live during the hinge of history. Given the scientific and technological discoveries of the last two centuries, the world has never changed as fast. We shall soon have even greater powers to transform, not only our surroundings, but ourselves and our successors. If we act wisely in the next few centuries, humanity will survive its most dangerous and decisive period. Our descendants, could, if necessary, go elsewhere, spreading throughout this galaxy.—Derek Parfit* (1)

Life is a marvel of thermodynamics. Living things are sustained eddies of structure in the flow of energy. They are islands of order in a universe that tends toward disorder. Simple, self-reinforcing chemical systems evolve into cells, plants, and animals capable of extracting usable energy from their environment. Some even become intelligent creatures capable of designing machines, building cities, and loving one another.

But life can cheat entropy only locally and only temporarily. Eventually the universe will come to equilibrium and all life in it will end. Eventually—to borrow a phrase—the pitcher will be shattered at the fountain, the wheel will be broken at the well, and the dust will return to the earth as it was.

Humanity must not squander the temporary miracle of its existence. We are still in the pivotal early days of our potential life as a species. We cannot say what our descendants—whatever they may be like—should choose to do with their lives. But we owe those who come after us the greatest possible chance to survive and flourish. What we do now could mean the difference between a long, prosperous future and extinction.

The Struggle for Existence

First—and most of all—we have to make sure that we survive. We should do our best to make sure that complex life in general survives. But more than anything else we should do whatever we can to make sure that the only form of intelligent life we know—ourselves—does not disappear from the universe.

Humans cannot accomplish or experience anything if we cease to exist. Where exactly we choose to steer humanity for that reason matters less than that that we steer away from the rocks. Although suffering is part of the human experience, each life is intrinsically valuable and almost certainly worth living. The premature extinction of the species would mean not just the end of those who currently live. It would mean an astronomical number of human lives—billions or even trillions—would never be lived. It would mean countless books never written, countless things never built, and countless loves never shared. Extinction, as Carl Sagan said, would be "the undoing of the human enterprise". (2)

Merely surviving—as if being able to live were something we could take for granted—may seem an unambitious goal. Merely surviving would certainly not be enough. We have to be free to explore, create, and learn—to steer, in some sense, our own ship—to lead meaningful human lives. But to a large extent the same things that will guarantee our survival will also give us the freedom and resources to reach our potential as people.

Survival will be a challenge. Modern humans are insulated to an extraordinary degree from the day-to-day struggle for existence. We are, as a species, so adaptable that in the short time that we have lived, we have come to occupy and dominate practically every ecological niche on Earth. Nevertheless, intelligent life on our planet may face more of what Nick Bostrom called "existential risks" now than ever before. (3) Our existence is more tenuous than we generally realize.

The history of life as we know it on Earth is already 70% over. As the sun gets brighter, the planet's oceans will evaporate more and more rapidly. Recent studies conclude that sometime in about a billion years water vapor in the atmosphere will trigger a runaway greenhouse effect and the oceans will boil off completely, transforming the Earth into a planet more like Venus. (4)(5) Sooner or later we will have to leave the planet in order to survive.

Life on Earth is not secure in the meantime. Life on any single planet is vulnerable to local catastrophes like volcanic supereruptions, asteroid and comet impacts, rapid climate change, or bursts of high-energy radiation from nearby astronomical events. In normal times—like the times we have mostly lived in—the danger of extinction is relatively low. But the fossil record shows that the extinction rate can sometimes increase dramatically.

There have been at least five catastrophic extinction events in Earth's history. (6) The most recent mass extinction seems to have been triggered when an asteroid or comet (7) at least 10 km in diameter crashed into what is now the Yucatán peninsula. (8) The enormous amounts of soot and sulfur the impact kicked into the atmosphere blocked out enough sunlight to rapidly cool the climate. (9) Roughly three-quarters of all species on Earth—including all the non-avian dinosaurs—died off in the aftermath. (10) As many as 96% of all marine species died in the end-Permian extinction almost 200 million years earlier when, for reasons that are still not clear, carbon levels surged and the planet warmed dramatically. (11) Mass extinction events mean that even though the normal "background rate" of extinction is fairly low, the overwhelming majority of the species that have lived on Earth did not survive to leave descendants. While some species are better adapted to survive a disaster than others, no species is really adapted for a global catastrophe.

Nor do humans have a particularly long track record of survival. Anatomically modern humans have just been around for roughly 200,000 years. (12) That is just a small fraction—less than 0.01%—of the 3.6 billion year history of life on Earth. It is also not a long time relative to our animal cousins. One plausible recent estimate from the fossil record is that in normal times mammal species go extinct after an average of roughly 550,000 years. (13) And since humans were not around for previous mass extinctions, we have no history of surviving a global catastrophe.

We certainly cannot conclude from our relatively short history that humans will survive indefinitely. As the physicist J. Richard Gott argued, we are as likely—all else being equal—to be at the end of the human history as at the beginning of human history. If we assume that we are as likely to be living at any time in human history as at any other, then we can conclude with 97.5% confidence that the human race as we know it will last less than another 7.8 million years. (14)

Nor is there any evidence that advanced civilizations like ours generally survive very long. The fact that we have not encountered another species as technologically sophisticated as we are is not a promising sign. From what we know, it should be possible for a single civilization just a little more advanced than our own to spread out across the galaxy in a relatively short period of geological time. In fact, any alien civilization will, like us, eventually have to leave their home planet if it wants to survive. Although it is possible that spacefaring civilizations are hard for us to detect for some reason, the fact that we have not been able to find any evidence of them suggests that civilizations more advanced than ours may be very rare in the universe.

Even assuming that complex life can only develop on planets similar to our own, there should be quite a few spacefaring civilizations in the galaxy unless such civilizations are either unlikely to develop or unlikely to survive very long. A recent Kepler telescope survey suggests there are around 11 billion Earth-sized planets that orbit within the habitable zones—where the surface of planets could support liquid water—of stars similar to our sun in our galaxy alone. (15) If we are in fact largely alone in the galaxy, then the chance a planet like ours produces a spacefaring civilization must be extremely small. One or more of the filtering steps along the way from nonliving matter to spacefaring civilization—like the production of genetic material, the evolution of multicellular organisms, or the development of intelligence—must be extremely rare. (16)

One possibility is that we are special. Earth may be one of the first or one of the only planets in the galaxy to develop intelligent life. It may be, for instance, that the climates of habitable planets without an unusually large moon like ours are not stable enough for intelligent life to develop. If we are really special, then our survival is that much more important, since the prospect for intelligent life in the galaxy to some extent lives or dies with us. If we are really special it is also good news for us, because it means that the most stringent filtering steps—and therefore the greatest dangers—are already behind us.

But while the idea that we are special might satisfy our primate egos, it goes against the "Copernican principle" that we are unlikely to occupy a special position in the universe. Without better evidence that we are really unusual, it seems more likely that civilizations as advanced as ours are fairly common, but that they generally do not survive long. It seems more likely, in other words, that the next step we have to take—the transition to a sustainable technological civilization—is one of the most dangerous.

There are reasons to think that our rapidly developing technology and recent rapid growth may make this the most dangerous time in human history. In addition to ordinary danger of natural disasters, there is also the danger that by we could cause—or are already causing—a global catastrophe. We have already directly modified more than half the planet's ice-free land. (17) Human industry has disrupted the biological, chemical, and physical processes of the planet to such an extent—most dramatically, by increasing the concentration of carbon dioxide in the atmosphere and oceans—that stratigraphers have begun to debate whether we are at the beginning of a new epoch of geological time. (18)

Humans appear to be in the process of causing the planet's sixth mass extinction. (19) The disappearance of megafauna around the world over the last 50,000 years coincided—although natural climate change probably played a role as well—with the arrival of humans. (20) We are now driving numerous species to extinction all around the world by hunting them, destroying their habitats, warming the planet, increasing the acidity of the oceans, transporting invasive species, and spreading disease. We are generally transforming the planet so rapidly that other species are hard pressed to adapt fast enough. The most recent Intergovernmental Panel on Climate Change report found compelling evidence that warm-water coral reef and Arctic ecosystems have already begun to undergo "irreversible regime shifts". (21)

Although human numbers are growing right now, there's no guarantee that we will survive a mass extinction indefinitely. Just as successful predators can bring about their own extinction by killing off their prey too efficiently, we could doom ourselves by destroying the ecosystems we depend upon for our survival. There are reasons to believe that damage they did to their local ecosystems played a role in the collapse of historical societies like the Maya and the Easter Islanders. (22) Most species are unable to dominate their environment completely enough to destroy it. But our domination is so complete that we could easily become victims of our own success.

New technologies also give us the power to hurt ourselves directly. Humans have harnessed enough atomic energy to create the man-made equivalent of an asteroid strike. The militaries of the world currently have more than 4,000 nuclear weapons deployed. (23) An exchange of just 100 of these weapons would—in addition to killing many millions of people directly—blast enough soot into the atmosphere to disrupt the global climate for a decade or more. Falling crop yields during the resulting "nuclear winter" could threaten billions with starvation. (24) And forthcoming advances in artificial intelligence, nanotechnology, genetic engineering, and geoengineering may make it even easier for small groups of people to bring about—whether deliberately or accidentally—our extinction.

Surviving the transformation into a species that has the power to remake both its planet and itself—and ultimately becoming a spacefaring species—will be a monumental challenge. We will need to use all our ingenuity to reduce the new dangers our ingenuity is creating. We cannot rely on luck to avoid a catastrophe. We need, as a species, to starting thinking seriously about how to survive.

Adapt or Perish

We will not ultimately be safe until begin to start to spread out beyond our own solar system. Figuring out how to move large numbers of people off the planet and into space will be a monumental task. Although the planet could theoretically remain inhabitable for hundreds of million of years, we may not survive long enough to witness the expansion of the sun if our entire species continues to live on a single planet in a single solar system. Living away from the surface of the planet will require developing a wide range of new technologies, from sustainable ecosystems to fusion power.

The more pressing technical challenge will be finding a clean way to power human society. The environmental cost of burning fossil fuels—as well as the intendant risk of disaster—is likely to only increase. Sooner or later we will use up the planet's store of easy chemical energy in any case. With solar power approaching grid parity around the world, this should be a manageable challenge. But we will have to develop better energy storage technology. And the transition away from our extensive fossil fuel infrastructure may take decades that we may not have to spare.

Advances in artificial intelligence, nanotechnology, genetic engineering and geoengineering—among many other things—should make solving these technical challenges much easier. But these same technologies could also to be dangerously disruptive. Each in careless or malicious hands could lead to catastrophe. Even some types of research in these areas have the potential to be dangerous. Each has the potential to transform both the Earth and humanity. Even if we escape extinction, we are likely to be changed dramatically in the process.

But the greatest challenges may be political. Overcoming the technical challenges may be easy in comparison to using our collective power as a species wisely. If humanity were a single person with all the knowledge and abilities of the entire human race, avoiding nuclear war, and environmental catastrophe would be relatively easy. But in fact we are billions of people with different experiences, different interests, and different visions for the future.

In a sense, the future is a collective action problem. Our species' prospects are effectively what economists call a "common good". Every person has a stake in our future. But no one person or country has the primary responsibility for the well-being of the human race. Most do not get much personal benefit from sacrificing to lower the risk of extinction. And all else being equal each would prefer that others bear the cost of action. Many powerful people and institutions in particular have a strong interest in keeping their investments from being stranded by social change. As Jason Matheny has said, "extinction risks are market failures". (25)

Nevertheless, our human diversity is a strength as well as weakness. It is easy for any of us to fantasize about what good we might be able to do if we were given complete decision-making authority for the human race. But as Edmund Burke observed after the French Revolution, idealist schemes are never as well thought out as we imagine. (26) No one knows all the facts or is completely aware of their own biases. Decision-makers almost inevitably end up serving their own interests. Only by working together and building consensus can we harness the wisdom of the crowds. In the end, survival will require the cooperation and insight of a broad cross-section of the human race.

First, we need to conduct more research into the risks we face so we can improve our decision-making. The science of human survival is still in its infancy. Some of the existential risks we face—like the danger of catastrophic climate change—are now being studied extensively. But others—like the danger posed by new technologies—receive much less attention. And much more work needs to be done to determine the most effective ways to survive and prevent a catastrophe.

Second, we need to improve governance of the common resources we depend on. That means building inclusive global institutions that can set and enforce rules about who can draw from those resources. And it means developing fair conflict resolution mechanisms that allow countries and groups to participate in the political process without resorting to destructive force.

Third, we need to watch for emerging threats from things like potentially hazardous asteroids and novel diseases. We need to agree on thoughtful guidelines for research—like "gain-of-function" studies that make viruses more virulent and transmissible—that could be dangerous. And we need to put together a global plan to respond to and survive any castastrophes that do occur.

We do not have to resolve all of our differences or agree on a single vision for the future. Instead of trying to bring about the perfect future, we should, as Bostrom has argued, focus on maximizing our chance of avoiding disaster. (27) That means making sure that our descendants have the best possible options to choose from. Because we know so little about what our best course will be—and because it is not ours to dictate to future generations—what matters more than what course we choose is how well we can steer our collective ship.

Conclusion

We can work together to safeguard our future. But governments will only agree on a common program if we—ordinary citizens around the world—demand one. Before evidence emerged that a massive bolide caused the most recent mass extinction, few scientists thought a global disaster large enough to threaten the human race was a real possibility. But the threats of nuclear war and runaway climate change have begun to awaken us to the danger. We now need to make our leaders take the danger seriously.

It is time that the human race took responsibility for its future. We have as a species become too smart and too powerful to continue to act carelessly. We should have a long, incredible future ahead of us before the universe comes to its end. But we have to make that future a reality. "A planet is the cradle of mind," rocket pioneer Konstantin Tsiolkovsky once wrote. "But one cannot live in the cradle forever." (28)

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