5

Apocalypse how?

Life is a tragedy to those who feel, 😞
but a comedy to those who think. 😊
—Horace Walpole

The probability of humankind’s long-term survival is encouragingly high, roughly 70%. This implies survival long enough to colonize the solar system and perhaps the galaxy either with *Homo sapiens* or some sort of conscious artificial creatures that we regard as our intellectual descendants (cyborgs, androids, whatever).

However, the high probability of survival does not imply smooth sailing. The chances are about 50–50 that some apocalyptic event will decimate mankind within the lifetime of today’s newborns. That will stop the frantic pace of technology and development and make the aftermath a very safe time in which the biosphere recovers from human devastation, although perhaps with a changed climate. Meanwhile, the present is a very dangerous time with almost 4% probability of extinction each decade. The probability of a lesser apocalypse is about 10% per decade.

The ultimate calamity, extinction, must reach the mountains of Tibet, the jungles of Amazonia, underground malls and subways of great cities, the Falkland Islands and the remotest islets in the South Pacific. It must be pervasive in the extreme, leaving so few survivors that they cannot find each other and assemble a tribe that has all the essentials for reproduction: a mate, perhaps a midwife, and enough people to comprise a viable breeding stock, perhaps eighty [39].

Nothing can save us from nature’s most potent disasters, the classic example being collision with a big asteroid. However, for other hazards, survival colonies reduce the probability of extinction. Remote outposts built for other purposes also serve as unintentional survival colonies.

Teams living in Antarctica comprise a survival colony. At McMurdo Station the few who stay through winter number about two hundred. They have contingency
McMurdo Station, Antarctica. Discovery Hut, Scott’s starting point on his first attempt to reach the South Pole in 1902, is in the foreground on the left, Observation Hill is on the right, and McMurdo is between the two. There are about 40 large buildings, many large fuel storage tanks, and countless rows of piled up cargo in McMurdo.

plans and supplies for long isolation. Smaller permanent bases bring the total to about a thousand. Some bases possess the means to escape unassisted before their supplies run out. However, they are not completely immune to global catastrophe. Travel during the summer might bring in an epidemic. An event that cools Earth (such as an asteroid strike or extreme volcanism) during the austral winter would likely kill them all [40].

Men outnumber women about two to one in these teams. If Antarctic teams are the sole survivors of some apocalyptic event, their numbers provide more than adequate genetic diversity for long-term survival of our species. In the first generation, polyandry would improve their gene pool and the men’s behavior.

The fact that remote outposts exist now is no guarantee they will be there when survival depends on them. Sooner or later these outposts will be abandoned, most likely after losing their funds to competing demands. This leaves humankind vulnerable to any hazard that would spare only the location of the abandoned outpost. Let us ask Gott’s predictor how long the Antarctic research stations will survive. Serious Antarctic studies began at a rather definite time, the International Geophysical Year of 1957, 52 years ago (from 2009), so Equations 3 in Section 1.4 tell us,

\[
\text{Duration of Antarctic crews } > 6 \text{ years with } 90\% \text{ confidence}
\]
\[
> 52 \text{ years with } 50\%.
\]

5.1 SCENARIOS FOR EXTINCTION

Population-dependent threats are all too obvious and worsening. Since 1950 world population has surged from 2.5 billion people (BP) to 6.3 BP, a factor of 2.5. New epidemics appear so often that we give them initials instead of names, such as AIDS
(Acquired Immune Deficiency Syndrome), SARS (Severe Acute Respiratory Syndrome), and BSE (Bovine Spongiform Encephalopathy). Man and nature may cooperate in our final demise. Nature creates the deadly disease, and then human activity spreads it. It is well known that dust carries microbes across oceans reaching the remotest islands and the highest peaks. Nature has always produced dust, but humans make more of it and add different sorts of contaminants.

Our mobility may spread disease before quarantine can be enforced. In the 14th century the horrific Black Death never threatened extinction, because it was confined to Eurasia. People were more mobile in 1918 when Spanish influenza hit. That disease spread worldwide and killed 20 to 40 million, about 2% of the world’s population. A comparable epidemic today would spread much faster and spare fewer areas if any. It is impossible to quarantine a continent in view of all the varied modes of transportation and the large number of travelers. Besides people taking legitimate business and personal trips, there are covert smugglers, illegal immigrants, and boat people.

Carbon dioxide may be another hazard. In about 2050 its atmospheric concentration will approach twice its preindustrial value. This concentration has been very high in the distant past, but humankind and agriculture were not yet present to interact and cause hazards that are not yet anticipated.

Safeguards against well-known hazards are already in place. We carefully monitor the atmospheric concentration of greenhouse gases, we continually update numerical models of climate change, and the Spaceguard program tracks those asteroids in orbits that may possibly collide with Earth. However, we should not forget that safeguards fail quite regularly. Since serious threats occur rarely, our guardians have plenty of time to grow lazy and complacent. The Federal Emergency Management Agency (FEMA), for example, was totally inept when Hurricane Katrina struck New Orleans. An airport security system was in operation on September 11, 2001 when terrorists hijacked four big passenger aircraft and used them for kamikaze attacks. The Securities and Exchange Commission (SEC) is supposed to protect investors from fraud. Yet Bernard Madoff, a respected financier on Wall Street, was able to run a Ponzi scheme that cost investors $50 billion despite financier Harry Markopolos claiming that he tried for nine years to alert the SEC. And so disasters continue.

The doomsday attack may well be deliberate. The culprit may be the proverbial mad scientist or a demented trillionaire who spares no expense. We should not forget that offense has a huge systemic advantage over defense. The attacker can spend a long time to find one optimum opportunity. By contrast, the defense must watch all possible vulnerable points all the time.

Before long, new hazards will emerge from the realms of science fiction and take their place on the list of real concerns. Robotics is a big concern, genetic engineering another. A more far-fetched hazard is the increasing number of high-power beams such as radar and lidar that are probing the sky and announcing our location to whatever may be out there.

#   #   #

In his book *Our Final Century* [2] Sir Martin Rees discusses the rapid arrival of new hazards in recent decades without focusing exclusively on complete extinction of
our species. John Leslie [12] provides an all-inclusive list of extinction hazards in his introduction to *The End of the World*. In the popular literature Corey S. Powell [41] provides a summary of specific threats. The following is a list of the extinction hazards borrowed from his section headings:

**Natural disasters**
1. Asteroid impact
2. Gamma-ray burst
3. Collapse of the vacuum
4. Rogue black holes
5. Giant solar flares
6. Reversal of Earth’s magnetic field
7. Flood–basalt volcanism
8. Global epidemic

**Human-triggered disasters**
9. Global warming
10. Ecosystem collapse
11. Biotech disaster [genetic engineering]
12. Particle accelerator mishap
13. Nanotechnology disaster [self-replicating microbes]
14. Environmental toxins

**Willful self-destruction**
15. Global war
16. Robots take over
17. Mass insanity

*A greater force is directed against us*
18. Alien invasion
19. Divine intervention
20. Someone wakes up and realizes it was all a dream

In number 17, mass insanity, Powell refers to worsening statistics for mental health. However, this heading could also refer to a mental state induced by a new wonder drug that almost everybody takes before its unexpected deadly side-effect appears. Perhaps 70% of humankind lose their minds, go on a murderous rampage, and kill the other 30%.

The results of Chapter 4 allow a major revision to this list. The disasters in which humans play no role, numbers one through seven, are negligible, simply because our species has been exposed to them for a very long time and has thus acquired a very long track record for survival. The same reasoning applies to 18, 19 and 20. Number 12 seems too far-fetched.

War, number 15, is not significant demographically unless it is part of some complex scenario involving other hazards. If nuclear war occurs, the blasts will
mostly be confined to the northern continents. From that origin nuclear winter would be bounded by the latitudinal bands that dominate air circulation. Even if the tropical Hadley cells merge, the temperate Ferrel cell from 30°S to 60°S would stay mostly intact. Inhabitants of Falkland Islands, Tasmania, New Zealand’s South Island, and Tierra del Fuego would survive. Philosopher Quentin Smith has independently made the same observation [42].

In no special order, the serious hazards that remain are the following:

- Global epidemic
- Nanotechnology disaster
- Global warming
- Environmental toxins
- Ecosystem collapse
- Robots take over
- Biotech disaster
- Mass insanity

These hazards are all so well known and widely publicized that there is no need for yet another review. Besides, the hazard that eventually kills us will probably not be any of those listed above, nor will it be monitored or well publicized. Rather it will be something bizarre that blindsides us because nobody has thought of it, or if they did, they never took it seriously. To stress this point, the following eight scenarios emphasize the offbeat and unexpected. Fictional details in some of them may help you visualize a sequence of events and decide whether it is truly plausible. In no special order the scenarios are the following:

1. Mutant phytoplankton
2. Coincidence and press/pulse
3. Latent killer
4. Pharmacology
5. Runaway greenhouse effect
6. Instability
7. Self-sufficient, self-replicating robotic species
8. Conspiracy

This set serves as a foil to the balanced discussions by Rees, Leslie, Powell, and others. The choice of eight examples is purely arbitrary. Their purpose is not orderly coverage but merely examples that indicate a range of possibilities. The actual number of such complex unorthodox scenarios is virtually infinite, hence the high risk.

1. **Mutant phytoplankton**  Trace gases in the atmosphere can have a big effect as demonstrated by chlorofluorocarbons decomposing the ozone layer. The source of that gas was artificial, and so governments were able, with difficulty, to control the emission. But what if the source were mutant plant life? Earth’s plants have
already changed our atmosphere in a big way: they gave us oxygen. The next change may be toxic to humans. If poison gas comes from a land species, we will identify the culprit and exterminate it at all cost before it spreads too far. Since the target is stationary, we would win that battle even against the most aggressive species. But what if the peril is phytoplankton or perhaps kelp or some other seaweed? We cannot treat the world’s oceans with herbicide, so that would be our doom.

Nature has warned us with the so-called red tides (back cover). They are not really tides but rather algal blooms in shallow seawater. The water turns reddish-brown with plankton, typically dinoflagellates (which means “terrifying flagellates”). The plankton poison shellfish, which in turn poison people who eat them. Occasionally victims die.

A related dinoflagellate is more vicious. *Pfiesteria piscicida* attacks with deadly nerve toxin. It was discovered by JoAnn Burkholder, a biologist at North Carolina State University [43]. In 1991 it killed as many as a billion fish in warm shallow estuaries nearby. After Burkholder sampled a toxic tank using gloves and the usual precautions, she suffered nausea, burning eyes, cramps and loss of memory. Five of her colleagues were seriously affected and suffered severe short-term memory loss. In one case, the victim had not been near the tanks. He was merely downstream in the ventilation system and had probably inhaled toxic aerosols.

Marine aerosols would probably not be a threat to people in the highest inland mountains such as the Himalayas, but toxic gas emission is a possibility. One estimate [44] states that living plants emit 400,000 tons of organic volatiles into the air, even some with metals in their molecular structure. Other estimates say millions of tons are emitted [45], the differences perhaps depending on what gases and vapors are included.

It is unlikely that a toxic-gas mutation can happen as a purely natural phenomenon. If that were possible, it most likely would have happened already, probably millions of years ago. Well, maybe it did. In the past 540 million years there have been five major events that killed more than half the animal species. Lesser mass extinctions that killed at least 10% bring the total to 26. Although a bolide strike has been implicated in the most recent event, the one that killed the dinosaurs 65 million years ago, other hazards may account for some of the other mass extinctions. A mutant species of phytoplankton is a remote possibility.

Chapter 4 showed that extinction risk from purely natural events is negligible compared to hazards that involve human activity. Genetic engineers and/or polluters may indeed create the deadly mutant by accident. Radioactive effluents certainly cause mutations, and one of them may be the eventual culprit. Once made, the mutant organism reproduces freely and propagates on its own throughout the oceans.

The only possible defense is risky and unlikely to happen, a survival habitat for the privileged few. It might be an airtight artificial biosphere something like Biosphere 2, the first attempt in Arizona, but bigger this time and with all the bugs worked out. The refugees must escape eventually before crucial supplies are exhausted, or equipment wears out. Perhaps there is a way the survivors can make
their descendants immune by vaccination, selective breeding, or whatever, but it all seems too complex to succeed on the first and only attempt.

It seems unlikely that any sophisticated survival habitat will be built and fully maintained prior to its need. Until the need is apparent, the project would suffer from severe lack of urgency and political will. It would be a prime target for budget-cutters who look for projects that produce no conspicuous benefit in the short-term. However, if we wait until the need arises, there will not be much time. Without many years of testing, the habitat will surely fail, as did Biosphere 2.

2. Coincidence and press/pulse In this scenario one mass killer leaves one set of survivors, another leaves a different set. Occurring together, they kill everybody. The dinosaurs’ demise may have been just such a double whammy: the bolide strike near Chicxulub, Yucatan, Mexico plus major volcanism at the Deccan Traps in west-central India.

The ultimate calamity will most likely be an improbable coincidence of multiple hazards or failures simply because we develop defenses only against single hazards. Defense against coincidences is impractical because there are too many possible combinations, each of which is very unlikely.

Some studies of past mass extinctions support a so-called press/pulse model [46]. Press denotes a long-term pressure on the ecosystem, and pulse a sudden catastrophe. The model makes good sense because two pulses are unlikely to coincide, and two

![Deccan traps in western India](image)

The word *traps* derives from the Swedish word *trappa* for stairway. Successive lava flows piled on top of one another in a manner that looks like stair steps.
presses probably leave survivors who manage to adapt. In the dinosaurs’ case volcanism might have been the long-term pressure because dust blocks sunlight and volcanic gases pollute the air. The bolide strike at Chicxulub, Yucatan is the prime suspect for the pulse.

As noted above, war by itself is not enough to cause extinction. However, while nuclear winter depopulates the Northern Hemisphere, a coincidental natural event might take out the South. Volcanism is a possibility. It may occur at one or both of the southern tips of the Pacific Ring of Fire in or near Chile and/or New Zealand.

As a third example, suppose climate-monitoring stations in Greenland and the southern Indian Ocean fail simultaneously in a way that masks an Orange Alert. By the time the trouble is fixed, it has become a Red Alert. That’s the pulse. Coincidentally there is long-term tension between industrial nations and the underdeveloped world. Leaders in four populous Third World nations assert themselves by refusing to respond to the Red Alert because that would be seen as cooperation with the industrial world. They claim the alert is a political ruse and refuse to shut down their national consumption of fossil fuel. Before the United Nations (U.N.) can enforce the Climate Treaty, it is too late. Earth follows the path of her sister Venus.

3. Latent killer  This fatal contagion has a very long incubation period, as do BSE and AIDS. By the time its symptoms appear, air travel will already have carried it to the tiniest populated islands and all the remote outposts. Well, maybe not every remote settlement, but perhaps a coincidence will strike those that remain. Wherever the epidemic strikes, it will infect everybody during its latency. When symptoms appear, it is already too late for quarantine. This is not too far-fetched: BSE has been known to lie dormant for decades without symptoms. Incidentally, if a microbe kills too quickly, its victims have little time to infect others. Thus, latency serves the microbe’s reproductive interest; in other words, natural selection reinforces this trait.

Although diseases kill individuals, they rarely kill their host species. That would be contrary to the microbe’s reproductive interest. Therefore, the killer probably will not evolve naturally. But genetic engineers can make it happen either by accident or on purpose. A lone mad scientist is not out of the question. In the words of Richard Posner, “Human extinction is becoming a feasible scientific project” [47].

4. Pharmacology  This hazard also depends on latency. Imagine that a wildly popular wonder drug has an unknown side-effect: those who take it slowly become sterile, and their offspring are born sterile. In our homogenized world, tourists, anthropologists, missionaries, photographers, and foreign-aid workers carry the drug to the remotest outposts. Nobody has any warning until middle age when grandchildren fail to appear. Nature has warned us with the drug diethylstilbestrol, better known as DES, which is now banned in the United States. It has produced adverse transgenerational effects in the reproductive tract. Thalidomide, which produced defective children, was another warning of this sort of hazard.
On a longer time scale, pharmacology weakens our species by breeding dependency (press). Worse, it tends to breed pathogens that mutate rapidly (as do influenza and HIV [Human Immunodeficiency Virus]). This is the pathogen’s survival trick by which it complicates or defeats medical treatment.

Although these hazards could cause the collapse of civilization, they are unlikely to cause extinction because there will always be some group that refuses to take the drug, perhaps a religious sect. To consummate extinction we must postulate something more violent. Maybe people taking the drug will go berserk and roam the land looking for victims to kill. Lurid fiction has zombies turning into murderous cannibals. As fantastic as it seems, we cannot entirely rule out the possibility that a drug might induce a murderous rampage.

5. Runaway greenhouse effect Our solar system has already demonstrated this hazard in the case of Venus, Earth’s near twin [48]. She has Earth’s size and a nearby orbit. Apart from slow rotation and dense atmosphere, Venus may have been much like Earth during infancy before her water evaporated into space. It is remotely possible that volcanism or a bolide strike could flip Earth to this lifeless state, but this hasn’t happened in the last billion years. Thus the probability of this natural event is insignificant, as Chapter 4 has shown. However, humankind may find a way to aggravate this natural hazard.

It is not clear how we could set off a cataclysmic event. It might involve methane (natural gas), CH₄, a powerful greenhouse gas. Vast undersea deposits of methane hydrate [49] will release methane if warmed and/or if its pressure is relieved. Perhaps our constant quest for hydrocarbon fuel will accidentally release a burp of methane, especially if the hydrate is already unstable as a result of ocean warming or falling sea level. Further warming might release more methane until it becomes a cataclysmic eruption. (Incidentally, methane hydrate is also known as methane clathrate, and the eruption is a clathrate gun. Never underestimate scientists’ ability to create jargon.)

6. Instability On the evening of November 9, 1965 an electric power failure blacked out parts of Ontario, Connecticut, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, and New Jersey. In some areas it lasted 12 hours. Twenty-five million people were affected. The cause was eventually traced to human error that happened days before, when a maintenance man incorrectly set a protective relay on a transmission line. In 1881 when Thomas Edison’s central power system electrified New York, he could not possibly have imagined such complex unstable connectivity over such a huge area.

Although that power failure was insignificant compared to extinction, it did demonstrate the downside of big complex systems with lots of interconnectivity. They work wonders while they work, but they also tend to have subtle instabilities that wreak havoc when least expected. Seven states and a province are a tiny fraction of the whole world, but if complexity multiplied that much in 84 years, think what it may be like in the next century or two. In particular, the explosive growth of the Internet makes our economy increasingly dependent on its proper functioning.
By itself, complexity probably has no means to deliver the *coup de grâce*, but it may be a contributing factor in some complex coincidence.

7. *Self-sufficient, self-replicating robotic species*  Self-replicating robots are not feasible today nor in the near future because they cannot fabricate the integrated-circuit chips they need to make their own brains. Billion-dollar facilities are required for that task. However, someday there may be artificial brains that grow by themselves when bathed in a special nutrient. The process may be something like either crystal growth, or biological growth of brain tissue in an embryo. The brains may be two-dimensional like integrated-circuit chips or three-dimensional like biological brains. A three-dimensional design will have a serious cooling problem, but perhaps that will be solved if coolant channels are an integral part of a crystal-like lattice.

Ultimately the robots will be capable of foraging for their own fuel and supplies and making their own spare parts. The danger is that a self-replicating species will proliferate, overrun the earth, and devour everything. Responsible nations will forbid these species by law. However, in a world with billions of people and nearly 200 nations, what is feasible usually happens somewhere. A group of rogue engineers funded by a rogue trillionaire may develop them in secret. Or, if not in secret, they can just do it quietly in a nation where it is legal. To keep it legal, the trillionaire puts national leaders on his payroll.

These robotic species will come in assorted shapes and sizes, one or more of
which may prosper unaided. There will be safeguards against runaway reproduction. For example, a bigger stronger species (not self-replicating) will be programmed to be its “natural enemy”. But then hackers may find a way to disable the safeguards. Even without hackers, mutations and mistakes occur, and when the bad one happens, the prolific species overruns Earth.

If the robots are tiny, they will spread worldwide, just as rats have done. They will hitch rides in luggage, boxes of freight and bilges. If the successful robots are too big to spread by accident, then the infestation can be confined to one continent until a human misanthrope smuggles them out. A sub-billionaire can spread the scourge to every habitable continent and island if she can hide her intentions from her hirelings and smugglers.

8. Conspiracy Several decades in the future, embryo selection will be available worldwide. Each embryo will be selected for its genetic perfection from a batch of a half dozen or more. Most industrial nations will offer embryo selection free of charge to all disadvantaged prospective parents. Besides the humanitarian aspects, this policy makes financial sense. The cost of selection is more than offset by the reduced need for social services and medical care later in life.

In this scenario a clandestine organization arises, the Secret Eugenics Society (SES). Most of its members began life as designer babies. Many are second-generation selectees. They observe that a majority of citizens worldwide reject genetic services and reproduce the old-fashioned way. SES members view this behavior as child abuse on a grand scale. Why would anybody want their children to have inferior health and intelligence? How can people justify using their mediocre eggs and sperm when selection is readily available? As members interact, they reinforce these views and develop growing contempt for the majority of humankind.

Eventually, the SES regards most of humanity as hopeless. Despite aid, underdeveloped countries remain underdeveloped generation after generation. Overpopulated countries remain overpopulated despite efforts to promote family planning. Subsistence farmers continue to strip the land, kill off species, and exhaust natural resources. “And for what?” the eugenicists ask each other. If impoverished lives had a modicum of quality or any purpose in the big picture, then many SES members would feel a moral compunction to help them, or at least to let them live. But now the Secret Eugenics Society has grown weary of it. They now regard the masses not as real people but rather as an infestation to be exterminated.

By a big majority, the SES decides that the most merciful solution and the only hope for global happiness is to cull humanity. “And why not?” they ask one another. People cull herds of goats, elephants and other animals when their numbers threaten their habitat. Why shouldn’t excess humanity fall in the same category? All those people must someday die anyhow, so to SES members it seems reasonable to hasten the inevitable if that is what it takes to make a better world. The SES plans a surprise attack to kill all humanity except for several thousand privileged survivors, which of course include their own membership.

Is this scenario absurdly far-fetched? Probably not. Attitudes and morality change; what was outrageous a few decades ago is routine now. Why should this
trend stop? Before 1973 abortion was illegal throughout the United States. During the 1950s college dormitories for women had curfews and were guarded like fortresses against sexually aroused men. Go back a few more decades and alcoholic drinks were forbidden in the United States, a period known as Prohibition, 1920 to 1933. Well into the 19th century slavery was common, and men fought duels. No one can predict the next change in morality.

The end of the world may happen as follows: The Secret Eugenics Society conducts studies, which show that biological weapons are the best choice. The Society can make weapons by genetic engineering, which has become routine and inexpensive. Genetic engineering is on a roll, much like the computer revolution of the 1980s, 1990s, and 2000s. The SES has skilled research biologists and genetic engineers among its members, plus money to hire many more, most of whom are kept unaware of the project’s true goal. The SES carefully selects and breeds pathogens to be as lethal and contagious as possible to humans while sparing most plants and livestock. They also develop a vaccine to protect the designated survivors. The pathogen’s ability to reproduce is designed to fail after one year, long enough to exterminate humanity plus a few months to spare.

Committees draw up a detailed plan. The big expenses include research and development and a stockpile of weapons. All together they cost hundreds of billions of dollars. But money is not a serious problem; in recent decades private fortunes have been growing at an unprecedented pace. Nearly all SES members are millionaires, a few are billionaires, and one of them is among the first trillionaires.

The SES develops aerosol bombs to dispense the pathogens. The bombs are to be hidden in dark remote corners of public buildings, subways, and the like. Very few people would see them, and the few who do would be deterred by their false labels: “Do not disturb, Property of the Department of Air Quality Control.” The bombs are to be planted worldwide with signs in hundreds of languages.

The big problem is testing the plan. The SES sets up an “industrial biotech plant” on an isolated Indonesian island. It has an “accident” and everybody dies except a test group who were vaccinated. But that is only one test; several more are needed. Years and continents must separate the next test from the first so that the world does not suspect a conspiracy. The second test occurs on an island in the Canadian Arctic with a mix of Inuit and Caucasians. The test succeeds, meaning that vaccinated people survive and the others die. But this time a worker escapes and spreads an epidemic among the sparsely populated villages. Information leaks, hired assassins kill those who know too much, bribes are paid, and the SES barely manages to contain the damage.

The membership grows impatient. On a close vote, they decide to forego further testing—big mistake. The next extermination is worldwide. The pathogens kill everybody who was not vaccinated. However, in the Amazon jungle the pathogen does not expire after several months as it is supposed to. It finds a host where it thrives, reproduces, migrates, and mutates (shades of Jurassic Park). Soon the vaccine is ineffective, those chosen to survive die like the others, which completes the extinction of humankind.
5.2 WILD CARDS

Wild cards can be either our downfall or salvation.

*India and China* These nations have two billion people and sizzling economies (prior to the global downturn in 2008). At present they show little interest in big long-term issues like survivability and global warming, but then we cannot expect them to think that way until their living standard improves. This is happening, but so is their consumption and their impact on the biosphere. Will they become world leaders in conservation, survival habitats and related projects? Or will they opt to be uninhibited consumers? Nobody knows. Perhaps our species’ survival is at their mercy.

*Outrageous private wealth* Forbes magazine publishes an annual report on the 400 richest Americans. In 2006 for the first time, all 400 were billionaires. In 2004 there were 313 billionaires, compared to 262 in 2003. The five Walton heirs (Wal-Mart stores) have $90 billion among them, and Bill Gates (Microsoft) has $53 billion. At the rate private fortunes are accruing, there will be trillionaires before long. Any one trillionaire would be able to buy weapons of mass destruction. She might possess enough wealth to purchase a nation, rewrite its laws, and take its seat in the United Nations, perhaps in the Security Council. Are all these trillionaires sane? What about their heirs? Does the Federal Bureau of Investigation (FBI) or any intelligence agency keep tabs on them?

Several people have committed horrendous, senseless crimes and claimed that they acted on orders from God. Trillionaires are not immune to such delusions. If and when a trillionaire imagines God’s command to end the human race, he may have the will and the power to succeed.

John E. du Pont gave us a small demonstration [50]. He is the great-great-grandson of E. I. du Pont, founder of the chemical company. As one of many heirs, John’s fortune totaled a couple of hundred million. He is seriously deranged and sometimes has claimed to be the Dalai Lama (among others). In 1996 he shot and killed wrestler David Schultz for no apparent reason. A jury convicted du Pont of third-degree murder. Okay, so he killed only one, far short of 6.5 billion, but his crime and mental state warn us that the wealthy can have murderous delusions like anybody else. They have the money to play out their delusions, and they are less likely than others to be under supervision.

We think of megafortunes as good capitalism—an incentive to perform, a just reward for a job well done. True, to a point, but gigafortunes far exceed that point, simply because a thrifty shopper can live her whole life in splendid luxury for only a few hundred million. After that, the money is just a thrill that feeds a dangerous craving for power and enriches heirs of unknown sanity. Perhaps governments whose tax laws allow such accumulation should be considered corrupt. In 1965 chief executives of U.S. corporations were paid 24 times the wages of the average worker. By 1989 that ratio had crept up to 71. In 2005 it was 262, an increase exceeding an
order of magnitude in only forty years. To quote Francis Bacon: “Money is like muck, not good except it be spread [51].”

Ironically a billionaire or trillionaire may save us when government fails. There is no hope of making human survival a viable political issue since it lacks urgency and emotional appeal. How many politicians are capable of understanding this treatise? What fraction of their constituents? But hope is not lost. The possibility remains that one of those vast fortunes can save humanity. Wealthy landowners in some countries have protected private forests that peasants would raze were the land equitably divided. Billionaire Gordon Moore (of Moore’s law) is a major contributor to Conservation International, a group protecting land that would otherwise be plundered. Albert Gore, Nobel Laureate, is a crusader to stop global warming.

Here is a modest proposal to save the world that an ordinary billionaire can sponsor: Help nature take back the tropics. From the dawn of our species until the mid-20th century, the tropics were sparsely populated. They were a reliable buffer against the excesses of humankind. The tropics absorbed carbon dioxide, stored carbon, released oxygen and water vapor, retained nutrients, and preserved the genes of millions of unidentified species of unknown (but probably great) future value. Then “progress” came to the tropics with steel tools, insecticides, fungicides, and medicine. The population exploded, and with it the demand for timber and raw materials. Now the great tropical buffer is dwindling.

Perhaps a wealthy preservationist’s most effective strategy is to aggravate the tropical conditions that discouraged development in the past. Insects and vermin are high on the list. One possible project would breed and/or import harder more virulent pests, something aggressive and resistant to insecticides, repellents, and the like. Genetic engineering might play a role. Unlike two-legged forest rangers, the six-legged kind are far more numerous, self-replicating, and respect neither property lines nor national boundaries. Best of all, they work without pay.

Homesteaders would suffer terribly from this preservation project. Depending on the date and the areas affected, hundreds of millions might be displaced, but the billionaire sponsor cares little; she is dedicated to her greater goal. Moreover, she does care about the primates that the homesteaders abuse. In the case of Africa, she cares about gorillas and chimpanzees, and in the case of Amazonia, she cares about indigenous people. She views her project as long overdue redress for a half century of abuse and encroachment on their lands. She also realizes that the indigenes are humanity’s fallback population, which should never be assimilated for reasons discussed in Section 5.7 under homogenization.

An alternative project would plant land mines in the main roads leading into the forests and jungles. This might work where the terrain offers plenty of foliage to conceal implanting teams and their equipment. Roads are the bane of preservation. Main arteries branch into modest roads, which in turn branch into dirt roads and driveways until vast areas are open to development, exploitation, and poaching. A billionaire preservationist can probably acquire sophisticated mines and implanting equipment normally reserved for the military. These mines can be activated or deactivated by remote control. If observation posts are feasible, mines can be inactive
Deforestation in Amazonia as seen from satellite. Small roads branching from big ones make this typical fishbone pattern (Wikipedia, public domain).

while sweepers are present, active as soon as they leave. Minesweeping operations are likely to fail for other reasons. The mines are difficult to detect against the natural background of rocks, roots, and irregular terrain. Neither magnetic detection nor acoustic echolocation is likely to work. The detonator’s trigger can detect either pressure or magnetic material such as steel. The latter is attractive because it would take out bulldozers and lumber trucks while sparing pedestrians and carts drawn by animals.

Robotics When a species expires, it usually succumbs to predators or to competition from another species that has moved into its territory and/or ecological niche. Within the biological realm humankind has no such challenge, but in a larger scope that includes robotics and artificial intelligence, we shall soon manufacture our own competition.

Sometime this century we shall see a revolution in robotics similar to the recent one in personal computers. (Perhaps that revolution will produce the first trillionaire.) What guarantees this is a most amazing example of runaway technological growth widely known as Moore’s law. In 1965 Gordon Moore noted that the density of transistors on a computer chip had doubled every year. The time slipped to a year and a half, then to two. Sometimes the law takes on a broader interpretation as a doubling of computational power. For rough estimation over a long term, two years is a valid doubling time. That amounts to a thousandfold increase every 20 years, and a millionfold increase during the forty years from 1968 to 2008. Other components have also maintained the pace. Especially noteworthy is the capacity of the hard drive. It went from a few megabytes in 1980 to a terabyte in 2008 by doubling every 1.5 years.

Obviously a physical limit exists, and so the growth must level off at some point like a logistic curve. Moore’s law will fail someday when the technology of transistor
packing hits a hard physical limit, certainly before we reach one molecule per transistor. However, it has already survived predictions of its demise. Each time some new technique comes to its rescue. Ultimately, components with periodic structures will be made by self-assembly, which means that the microscopic elements arrange themselves in an orderly structure much as molecules do during crystallization. If we give Moore’s law a broad interpretation that encompasses derivative technologies, then this quasi-exponential trend could continue until it contributes to the end of our world.

All this progress has occurred on the two-dimensional surface of the silicon chip; the third dimension has yet to be exploited. Stacking integrated circuits vertically will create a serious cooling problem, but that is not a fundamental limitation; engineers will eventually solve it. We can reasonably expect another thousandfold increase during the next 30 years, only a little more than a human generation.

As the capability of digital hardware grows exponentially, one might think that the pace of artificial intelligence will be held in check by the time and intellect required for programmers to write the computer code. Not so. That process will also grow exponentially by means of genetic algorithms, a most amazing new technology. Computer programs exist today whose developers, the human ones, have no idea how they work. Because of limited education and intellect, humans may not be capable of knowing how they work! The actual software development happens inside a big computer equipped with a genetic algorithm (GA) that develops the program through an evolutionary process.

It begins with a seed program that does something vaguely like the desired program. Then the GA makes small random adjustments in the program’s code and tests the result using known examples. (Suppose the problem is to factor enormous integers. GA would create test examples by multiplying big prime numbers to obtain integers to be factored.) Next, GA grades the altered program rather like a teacher grading a pupil. It keeps the programs with the highest scores and proceeds to the next generation with another set of adjustments. The process continues until a near-perfect program emerges. All of this evolution runs automatically at high speed inside the Central Processing Unit (CPU) of a supercomputer at rates trillions of times faster than biological evolution.

So far this description applies to asexual algorithms. Sexual ones involve two or more evolving programs that occasionally swap bits of code by analogy to biology. Distinctions between man and machine dwindle as fertilization *in silico* takes its place alongside fertilization *in vitro*. Robot manufacturers will compete using genetic algorithms to make their androids ever smarter. These algorithms will advance robotics software far beyond anything human programmers (or androids) can comprehend, much less compose as ordinary computer code [52].

#    #    #

When advanced robots arrive, people will quickly grow addicted to cheap, skilled slave labor. Pundits and politicians will urge caution and safeguards to no avail. They cannot restrain the demand for ever-smarter models. Some nations will outlaw manufacture or at least limit their permissible intelligence, but then another nation
takes over the market and reaps the profits. Smuggling will be low risk because the robots can cross national borders on their own by walking, hitching rides, snorkeling across rivers, or whatever works. Their body shapes and camouflage coloring can be designed for self-smuggling. The juggernaut is unstoppable.

The serious threat is human hackers. They may deliberately breed a hostile strain of androids, which then infects normal ones with its virus. To do this, the hackers must obtain a genetic algorithm and pervert it, probably early in the robotic age before safeguards become sophisticated. And their efforts may be sponsored by a billionaire who thinks he hears orders from God.

Excluding hackers, it seems unlikely that androids will turn against us as they do in some movies. The engineers who develop them will be so concerned about hostility that they will build in safeguards at every level of their behavioral programs, in effect giving the robots powerful instincts to nurture humans. It is unlikely that the androids will violate such numerous and basic instincts. They cannot turn hostile in a single accidental mutation. Computer code for hostility is too complex; that would be like the proverbial monkey accidentally typing Shakespeare’s works.

A series of mutations could gradually undermine the original safeguards and produce hostility, but only if some compelling Darwinian advantage reinforces the trend. Fortunately there is none. Androids do not eat human flesh nor compete for cropland or scarce resources. All the gentle androids need is minerals to make body parts and plenty of sunshine for their solar batteries. As for lebensraum they can design themselves to be content in the desert, on platforms at sea, or in the Arctic.

Nobody truly understands consciousness. The one who comes closest may be neuroscientist Gerald Edelman, Nobel laureate. He said, “Someday scientists will make a conscious artifact” [53]. He and mathematician Eugene Izhikevitch have already made a numerical simulation of a brain, which, to their delight, exhibits intrinsic activity. In other words, it is thinking on its own even when it has no assigned task or sensory input.

In the very long term, androids will become conscious for the same reasons humans did, whatever those reasons may be. Lazy humans may let them run their own genetic algorithms, at which point they control their own destiny and become a species practicing unlimited, unregulated, open-ended evolution. In the words of Richard Posner, “Human beings may turn out to be the twenty-first century’s chimpanzees” [47].

Bill Joy fears the technology he helped create. Maybe he’s right, but to me it seems more likely that robots will be our salvation. The same programmers who create safeguards against hostility are unlikely to protect human rights such as freedom, dignity, self-determination, justice, equality, and the unrestricted right to reproduce. The programmers simply do not think about these issues in the context of their daytime jobs. Even if they do, they will have great difficulty translating them into computer code. In summary, the androids have powerful instincts to nurture humans, but these instincts are unencumbered by concerns for human rights. Androids will feel free to impose a harsh discipline that saves us from ourselves while violating many of our so-called human rights.
World Simulations A detailed unimaginative approach to survivability would make a huge numerical model of our entire world and run thousands of simulations of our future, each with slightly different inputs and random events. Statistics of the outcomes would then indicate the probabilities of survival at various levels of confidence. If world simulation seems far-fetched, then imagine living in 1975 and somebody predicts that in thirty years most middle-class homes will have an appliance that searches most of the world’s knowledge in less than a second.

If current trends continue, computer capability will have increased many thousandfold in fifty years, which may be enough to enable the simulation. It will require at least three major modules: the physical Earth, human behavior, and the economy.

Existing computer programs simulate huge physical systems, for example world climate models. One component is a representation of oceans, a three-dimensional grid that specifies temperature, pressure, current, salinity, carbon dioxide concentration and contaminants within each volumetric cell. Similar representations describe the land and atmosphere.

Numerical models of the world economy date back to 1970 when the Club of Rome made a big simulation that included natural resources, population, money, industrial output, consumption, birth rates, food, environmental pollution, and much more. They called their report The Limits to Growth [54].

The big missing piece is simulation of human behavior to the level of individual personalities. Complexity theory tells us that tiny differences in the initial conditions (perhaps small childhood events) cause a huge divergence in the outcome. Therefore, any single run (execution) of the program will be virtually meaningless. However, the simulation programs will make hundreds or thousands of runs with slightly different initial conditions from one to the next. Then the full set of outputs will give the investigators a sense of the range of plausible responses they can expect from each simulated individual.

With this tool a diplomat can prepare for negotiations with her foreign counterpart by first negotiating with his avatar. After the real meeting she can revise the virtual personality and rehearse for their next encounter. Likewise, a candidate for public office can simulate a public debate with her opponent to prepare for the real one.

A world simulation cannot possibly treat eight billion people as individuals. However, it can lump ordinary people into groups with generic personalities: the membership of each labor union, immigrants from Mexico, the Caltech physics faculty, Hutu farmers in Rwanda, and so forth. But world leaders, corporate leaders, renowned scientists, and other influential and extraordinary individuals each merit their own unique virtual personality and behavior pattern. When the world model runs a short-term forecast, it will use personalities of named individuals. However, long-term forecasts must assume personalities for unknown future leaders. For any single run each personality is drawn from a statistical ensemble that covers the range of traits found among leaders of that nation, organization, or ethnic group.

Again the single run means very little. What counts is the range of possibilities established by a very large number of runs. Using a so-called Monte Carlo algorithm,
the world model will run thousands of simulations in which parameters are varied within their range of uncertainty, especially the random personalities of future leaders. This builds a statistical database of plausible futures from which events can be predicted with varying degrees of confidence.

To be realistic, the world model must have imagination and “think outside the box”. It must occasionally inject imponderables such as tipping points, paradigm shifts, and the unexpected geniuses and inventions that cause them. For example, in August 2001, no list of terrorist weapons included box cutters. Hence, a simulation could not predict the terrorist attack on September 11, but it might yield comparable disasters that indicate a level of risk and general areas for concern.

However, imagination can go too far by injecting too many extraordinary events. Certain parameters must be adjusted to realistic values: the frequency of tipping points, paradigm shifts, and revolutionary inventions, the percent variation in initial conditions, and similar quantities. This is a significant obstacle.

A possible solution would calibrate these parameters against historical data. Pretend to live in an earlier time and then run the program to “predict” events similar to those that have actually happened. This method is limited because history does not include extinctions and near-extinctions among the test cases. Moreover, it is doubtful that extant historical records provide enough details to initialize the simulation.

A more practical approach would extract summary data from the simulations and compare them to an analytic formula such as our Equation 16. It is not likely that a seriously flawed simulation would conform to the formula. This test is analogous to Benford’s law discussed in Section 1.5. It gives the statistics of the leading digits in a big set of numbers that are measurements of something. Benford’s law has trapped embezzlers and tax evaders who have cooked their books with fictitious numbers that do not obey the law. In a similar manner an appropriate analytic formula may expose invalid results from a set of Monte Carlo simulations.

No simulation can replace analytic models for three reasons. The first is time; we cannot afford to wait fifty years for the model to operate reliably. Our species or civilization could collapse in the meantime. The second is complexity; it is hard for independent evaluators to digest all the inputs and intricacies and then make a valid assessment. The third is the calibration discussed above. The analytic model and the simulation are complementary. The latter provides the details with many surprising and important trends. The former provides the reality check. No matter how sophisticated simulations become, we’d better keep analytical models of survivability as reality checks. No doubt there will be successors to my model that will be more detailed and accurate but still within the analytic genre.

When the world model and the analytic model work together, this pair stands a good chance of producing valid forewarnings. Whether the public pays attention is anybody’s guess. Scientists running the model would use their results to make a candid list of urgent reforms. It may include harsh measures that offend almost everybody: restrain the economy, levy heavy taxes on fossil fuels and other natural resources, impose compulsory birth control, and the like. The public reaction to such a report would itself be an interesting subject for a simulation.
One can imagine the repercussions: Special interests hire scientists willing to downplay or ridicule the world model. Celebrities like the late Dr. Michael Crichton will declare themselves instant experts and enumerate all the prior predictions of doom that have failed. They will find lots of them since each simulated future is merely a possibility, not a certainty. The real scientists will be branded as alarmists trying to inflate their own importance. The public is helpless because the simulation’s flowchart alone is too complex for any individual to grasp. Few people have time to read it, much less verify the algorithms and statistical inputs.

Bulky data offer opportunities to insinuate biases consciously or not. An old mainstay, selection bias, emphasizes one class of data and downplays or ignores another. Potentially friendly critics know this game and remain skeptical. Most of them put the problem aside for another day, which somehow never comes. By contrast, hostile critics are motivated to sift through the data and inevitably find some that are suspect and a few inputs that have been questioned or discredited. (Think of creationists attacking Darwinism.) In the end the simulations will have little impact on our way of life regardless of their true potential. Still, we must try.

So, will the simulation’s existence enhance or jeopardize our survival? It could go either way. After a simulation averts a few ordinary disasters, people may have a false sense of security. We press on with an expanding economy and ever-higher technology confident that our computer program will warn us when we begin living too close to the edge. Then the fatal one hits, something neither the machine nor its human supervisors had ever imagined.

5.3 OVERRATED NATURAL HAZARDS

Our sun behaved alarmingly from 1645 to 1715, the so-called Maunder Minimum when sunspots almost disappeared. This occurred during the four centuries of the Little Ice Age in Earth’s Northern Hemisphere, which suggests a common cause. However, the sun recovered and displayed normal spots for the next three centuries, so our solar rotisserie seems secure for centuries to come. We now know more solar and stellar physics and see no evidence that the sun will misbehave, nor will a nearby star explode during the centuries in question. As they searched for sunspots, one wonders whether Edward Walter Maunder and his colleagues felt much anxiety for the world’s future, especially since they lived during the Little Ice Age.

Volcanism can spew enough ash into the stratosphere to shade Earth and cause widespread famine. This happened in April 1815 when Mount Tambora in Indonesia erupted. It canceled the summer of 1816 in the Northern Hemisphere causing hardship in Europe and China and famine in New England [55]. Curiously the ash had little effect during the summer of 1815, which began two months after the eruption. Nor did it cancel summer in the Southern Hemisphere even though the volcano is situated at 8° south latitude. This was probably because the huge southern oceans comprise a heat reservoir like none other on Earth. (Incidentally, the so-called Year without a Summer spoiled Mary Shelley’s vacation in Switzerland, so she passed the time by writing her novel *Frankenstein.*)
Geologists find evidence of catastrophic eruptions of far greater size that occurred at intervals of a few hundred thousand years. On that time scale our species will have likely expired from another cause.

Our survival for 2,000 centuries is a consequence of adaptation to killer plagues, famine, and other natural hazards of ancient times. By contrast, our exposure to man-made risks began only about a half century ago, which is shorter by a factor of 4,000. Based on this contrast Chapter 4 shows mathematically that natural hazards are insignificant compared to man-made hazards. But few people are familiar with this analysis, and even for those who are, the abstract argument lacks impact and drama. People are understandably in awe of nature’s power—hurricanes, tsunamis, droughts, fire, and so on—and so they assume that nature is at least as threatening as humankind.

Concern about bolide strikes is almost a fad, especially since the comet Shoemaker-Levy collided with Jupiter, thus drawing attention to the possibility. A loose international effort called the Spaceguard Foundation detects and tracks asteroids and other threatening objects that might possibly collide with Earth. Effective defense requires years of warning and careful planning. Objects with diameters bigger than a few kilometers will be tracked decades in advance of a possible collision. The threshold for extinction size is about 10 km in diameter, the probable size of the dinosaur killer. A lesser bolide might surprise us, but at worst it could depopulate only a modest-sized continent.

Many hazardous objects follow very predictable orbits and can be deflected harmlessly by any one of several techniques. A review in Scientific American describes half a dozen defenses [56]. For example, smashing a big spacecraft into the object at about the midpoint of its trajectory would nudge it into a harmless orbit. Exploding a nuclear bomb has been considered. In some cases a sustained gentle push or pull would suffice. If we dust the object with white pigment, it increases solar radiation pressure, which may provide enough gentle push. A feasible pull might be gravitational attraction to a nearby spacecraft of appropriate mass. This last scheme is totally independent of the physical characteristics of the object, such as its composition and spin. Thus the gravity scheme might be important in cases where we know nothing about the object’s mechanical characteristics.

The most deadly objects, some tens of kilometers in diameter, are simply too massive to nudge. Fortunately they are also extremely rare, hence not in the same league with man-made hazards.

One exceptional hazard is a comet passing very close to the sun. Extreme heat boils gases off the comet’s surface, which propels it slightly in the manner of a rocket jet. We have no way to accurately estimate the jet’s thrust because the comet’s shape, chemistry and physics are largely unknown. Thus, as it emerges from behind the sun, its orbit is unpredictable to the accuracy required to forestall a collision. While the comet is close to the sun, it is difficult to observe from the ground. Eventually we track it and compute its new trajectory, but by then there is little time to react.

However, all these bolide scenarios are details. The bottom line is that humanity has an extremely long record of survival in the presence of these hazards. Hence,
bolides are overrated compared to hazards we have survived for merely half a century or less.

5.4 TRIAGE

Medical aid is usually inadequate in the aftermath of a great disaster or battle. To allocate scarce resources to best advantage, medics practice triage, which classifies the injured into three groups. Treatment is withheld from those who will survive without it, and also from those who will die regardless. Only the third group gets full attention, the ones who require treatment to survive.

There is so much misery in the world today that triage should be the guideline for philanthropy, but alas it seldom is. Consider, for example, the battle against AIDS in underdeveloped countries. If many cases can be prevented for the price of treating one, then prevention should get priority, while those already afflicted should be regarded as dead soldiers.

Discussion of prevention often arouses emotional distractions because it involves condoms. Machismo is one impediment. Another is the accusation by Third World leaders that western philanthropy has a hidden agenda to depopulate their countries. Let us set these issues aside and focus on triage purely as cost effectiveness of treatment versus prevention.
Recent price reductions in underdeveloped countries have brought the price of treatment per person down to about a dollar a day; however, this is still very expensive for anyone living on two dollars per day. Treatment must be perpetual because there is presently no cure for AIDS. As for prevention, a comparable effort to hold the price down will provide protection for about ten cents per day, one tenth the price of treatment. This makes an ideal case for triage: those already infected should be ignored, except for pregnant women with AIDS, who should be treated to save the baby.

A recent television report showed two ex-presidents, Bill Clinton and his good friend George Bush, Sr., endorsing an AIDS treatment program. They appeared with a stricken child in a Third World country. She was one of the few getting medical treatment as a result of the program. It was a heartwarming photo-op, the kind politicians love. Well, they are ex-politicians now, but old habits die hard.

The camera could not show a scene in the future where ten AIDS victims lie dying, those who could have been saved by spending the same money for prevention. Nor could the camera show the likely death of that same child at a future time when the drug delivery system breaks down in her village, a likely occurrence. Meanwhile, her presidential benefactors have moved on to other projects and will never know of her fate.

Surely Bush and Clinton understand the triage equation. So what was going on? Well, medical aid is held in high esteem, much higher than condom distribution. Moreover, some of the better places for real progress are in sordid waterfront bars and truck stops where prostitutes hang out—not great photo-ops for politicians. President Bush, Jr. maintained the same inept policy by spending $15 billion on AIDS relief, mostly in Africa, through his Pepfar program (President’s Emergency Plan for AIDS Relief).

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The issues in this treatise add a new dimension to philanthropic choices as shown in the Venn diagram, Figure 28. Philanthropy typically ignores the set on the left and scatters donations throughout the set on the right. In view of threats to the human race, it would make sense to concentrate most aid in the intersection.

An altruist might decide sadly but reasonably to abandon lifesaving efforts in overpopulated countries, because the long-term benefit is marginal. The people saved (and their future children) occupy space and consume scarce resources that others need, many of whom will die as a consequence. The net benefit of lifesaving may be positive; certainly those saved and their families appreciate their benefactors, trust them, and become influenced by western ways. However, the net gain may be too marginal compared to worthy causes in the intersection of the two sets, for example family planning in overpopulated countries.

Two lists of the top philanthropists [57] tell what causes they support. It is heartwarming to read about billions of dollars going to scholarships, poverty prevention, hospitals, schools, museums, and conservation. It was nice of Denny Sanford to pledge $5 million to the Crazy Horse Memorial Foundation, which is carving
a mountain to make a giant sculpture of the famous Lakota Sioux. But very few philanthropists seem aware that humankind is at risk, and that they can do something to help. An exception is Ted Turner, who funds projects for the environment and population and the Nuclear Threat Initiative. Also, the Bill and Melinda Gates Foundation gave $8.8 million to an organization that in my opinion does the absolute most good per dollar in the intersection of sets in the Venn diagram (Figure 28). And we must remember Nobel laureate Albert Gore for his dedication to global warming, even though he is not among the top fifty philanthropists.

5.5 REFLECTIONS ON THIS STUDY

Most studies that address the big questions of economics and ecology have no simple formulation like Gott’s survival predictor, Equation 2 in Section 1.4, and so analysts resort to huge numerical simulations with myriad judgment calls. A classic example is the Club of Rome’s study of Limits to Growth [54, 58]. A drawback of big models is that analysts (like most of us) are often partial to some outcome. Consciously or not they may bias their assumptions to produce a desired result. After publication, another analyst comes along with the opposite predilection. Her model and assumptions reach the opposite conclusion. The matter degenerates into conflicting schools of thought with no clear resolution, while the bewildered public has no time to delve into the bowels of the models and challenge the myriad details.

The results of this treatise support my proclivity for restraint as opposed to unfettered growth and development. However, unlike big numerical models, the predictor—Equation 16—is so simple that it gives opponents only two places to attack, and they are out in plain sight for all to judge. You can keep your daytime job and still find time enough to challenge this formula. The first vulnerable spot is the choice of cum-risk, \( Z = M^{(\omega+1)} = (X - X_0)^{\omega+1} \), essentially the choice of parameters \( X_0 \) and \( \omega \). The equation for the current (2009) risk rate \( \Lambda \), which appears in Section 4.6, is proportional to \((\omega + 1)/M_p\). My own attempts to evaluate this ratio by
various means span no more than 15% change, but this range follows from my own mindset. Your mindset might bring the variation up to 30%.

The second uncertain quantity is \( W(q) \), the relative weights of natural and man-made hazards, which is plotted in Figure 23. Details appear in Appendix L. A revised \( W(q) \) can lean in either direction: a shift toward natural hazards (small \( q \)) is optimistic for human survival; a shift toward man-made hazards (big \( q \)) is pessimistic. In Appendix L (Equations L-3 and L-5) we use a very natural expression for \( W(q) \), which involves a square root. When we change it to a cube root, which is somewhat contrived (L-4 and L-6), it increases the current hazard rate by 33% for species survivability, but only 7% for civilization. This change appears as dashed curves in Figures 23, 24, and 25. Combining the two vulnerable spots in the analysis might indicate errors as great as 50% in some of our results.

# # #

Opponents of my analysis will include optimists like the late Julian Simon [4], also the late Michael Crichton [5, 60]. People ensconced in comfortable ruts resist ideas that would require change. Dr. Crichton reviewed various predictions of doom that have failed, and suggested that all such predictions are invalid. He thought “inside the box”, which contains a finite list of known hazards and the means for coping with them. Outside “the box” all sorts of unforeseen threats are lurking in our chaotic world. For example, the weapons of September 11, 2001 were box cutters and hijacked aircraft. Our complex biosphere has many possibilities for runaway positive feedback, some of which have never been identified. New hazards bombard us with increasing frequency until we eventually fail to anticipate the crucial combination in time to adapt.

The new anxieties—climate change, population explosion, exhaustion of raw materials, robotics, and pollution—arise from our evolved instincts that have successfully kept humankind going for 2,000 centuries. Crichton should not have disparaged them. He used his novels to express prophetic opinions. He failed in 1992 [59] by warning America about economic domination by predatory Japan. Now he has failed again with a novel [60] that portrays environmentalists as the bad guys. People should read his novels for entertainment, nothing more.

## 5.6 PROSPECTS FOR A SAFER WORLD

Sir Martin Rees [2] has wagered $1,000 that “by the year 2020 a single instance of bio-error or bio-terror will have killed a million people.” He writes that he fervently hopes to lose that bet. Humane and politically correct people are supposed to share that sentiment, and yet, as we saw in Chapter 4, a near-extinction event is required to save our species. Is there no humane way out of this dilemma?

Population reduction would solve everything. Census extrapolation for world population peaks at nine or ten billion in about 2090. From there the decline may continue, perhaps to 4 billion (the world population in 1974), or it may falter and let the population creep up to 12 billion. The latter seems more likely. Optimists say that
the big population surge is ending; the long-awaited “demographic transition” is
catching on [61]. True in the near future, but this is simplistic extrapolation with no
appreciation for tipping points.

In the long run, fertility decline is probably just a hiatus. We’re seeing the result
of the contraceptive revolution. By enabling sex without pregnancy, it defeats
nature’s strongest reproductive strategy. But nature has other tricks in reserve. They will
not be apparent for a while, because it takes several generations of natural selection to
make them conspicuous.

A friend of mine planned to have three children, but the third was a set of triplets.
His two girls and three boys comprised a full house! His many grandchildren will
propagate the predisposition for multiple births, especially multiples in the second or
third pregnancy. Twins from the first pregnancy do little to inflate family size because
the parents simply quit at that point. But when multiple births happen later, they do
inflate family size as happened to my friend.

Other pronatalistic incentives include provision for old age, and a simple love of
children—lots of them. Natural selection will reinforce nature’s backup tricks until
one of them restores the population explosion.

Any one pronatalist group acting alone can overpopulate the entire world. Most of these traditional societies and religions will mellow out and join the
mainstream. Catholic Italy and Spain have birthrates well below replacement. Even
the communal Hutterites have dropped their fertility from about ten to about five or
six, which is still alarming [62]. But to permanently stabilize population, every last
one of these groups must change, and it is hard to believe this could happen voluntarily.

The United States and Canada have unwise population policies. They admit
almost anybody—many claiming to be refugees—who then reproduce freely. People
like me are to blame. Both my housekeeper and my gardener are immigrants, each
with four children. I should fire them, but I like them personally—their children too.
It is one thing to be an armchair pundit, quite another to practice what you preach.
Multiply my personal fault by a billion or two, and you have the makings of
extinction.

Optimists have faith in benign social programs: education, contraception, and
incentives for sterilization. These work for a while, but in the last analysis they are
just a form of selective breeding. The surest way to breed stubborn pronatalists is
to dissuade everybody else from reproducing [63]. As cooperators die off, they vacate
land and resources, which the pronatalists gladly take for their big families. Hum-
nists seem to ignore basic rate equations for exponential processes that engineers use
routinely.

 Somewhere in our galaxy a few humanoid species may have broken out of their
home planets and expanded to other habitats or other stars. These winners must have
made a concerted effort. Perhaps narrow escapes from extinction have focused them
on a goal and spurred them to action, or perhaps their world governments imposed
the goal by force.
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We earthlings dislike coercive world government; our leading nations and the U.N. are committed to reproductive freedom and self-determination, which I am sure most of my readers also support. But this benign ethic was forged by goodhearted people with the best of motives who never saw Figure 27. Let Gott’s predictor tell us about the survivability of this ethic. The start date was fuzzy; let us say 1960. Before that time, colonialism, racism, and various other forms of suppression were commonplace. So let us put age 48 years into Equations 3 and find,

duration of benign ethic > 5 years with 90% confidence;
> 48 years with 50%.

The next ethic may be almost anything: good or evil, safe or risky. Hopefully a population homogenized by intermarriage will reduce tensions among groups. However, we may get imperialism redux, ethnic cleansing, subsidized joy pills doped with contraceptives, harsh state-imposed limits on family size as in China, or reproductive quotas for various ethnic groups. Nobody knows.

#   #   #

We tend to rank perils based on emotion rather than reason. In the United States we celebrate Halloween (October 31) by letting 36 million children put on costumes and extort candy from neighbors, including strangers. A few decades ago there was a big scare that people were putting needles, pins, razor blades, and sometimes poison in the candy. Many parents forbade their children to eat anything that was not a commercial brand in its original wrapper with no sign of tampering. The poison stories all turned out to be hoaxes. There were only about a dozen instances of very minor injury from sharp objects.

Many of these same parents take their children in the car while driving on routine errands, a far greater risk. Moreover, these children are subject to greater risk simply by being earthlings in the 21st century. A cataclysm that wipes out civilization will kill vast numbers of them, and in Chapter 4 we found that hazard rate to be about 1% per year.

During humanity’s 2,000 centuries, people evolved a strong concern for survival of their own tribes, maybe even nations, but nothing as vast as their whole species. Now, for lack of such an instinct, there is no sense of urgency or political will for a trillion-dollar international project to save humanity.

I am no different. During a productive phase of this survivability project, I was offered a lucrative consulting job. Of course, I took it. Humanity be damned, here was a chance to make money! It is the same old Darwinian priority: first take care of self and family. Abstract thinking about the world at large has low priority because it has never before been a survival issue. It is a mere intellectual exercise rather than a powerful instinct.

Saving one person brings out powerful instincts in primitive parts of the brain. In prehistoric times the one saved was usually a fellow tribesman carrying many of the same genes as his rescuer. But today, saving humanity is a small intellectual idea somewhere among the brain’s most recent updates. Perhaps Josef Stalin was thinking
of this when he remarked, “A single death is a tragedy; a million deaths are a statistic” [64].

And so the short answer to the big question is, No. There is no way out of our dilemma. An apocalyptic event, perhaps a near-extinction, is prerequisite for long-term human survival, and that’s just the way it is. Meanwhile, let’s be jolly, enjoy some gallows humor, and let children accept candy from strangers.

5.7 SYSTEMIC STRENGTHS AND WEAKNESSES

The probability analysis in Chapter 4 applies to a hypothetical ensemble of humanoid species scattered about the galaxy, each member of which has passed through a phase similar to the one we earthlings are in now. Within this ensemble we have no idea what percentile of longevity we fall in. We differ from those other humanoids in ways that make us more or less survivable than typical members. Let us speculate on some of those variations.

This comparison will be too pessimistic because we cannot imagine the strange irrational thoughts and actions that may plague extraterrestrial humanoids. Like us they carry obsolete baggage from their prehistoric times including instincts that served their ancestors well but are superfluous or even a liability in a civilized environment. By contrast, it is much easier to identify our own irrational behavior. In this sense comparing earthlings to extraterrestrials resembles the comparison between ourselves and our adversaries (us versus them) in such events as war and business competition. We tacitly assume that our adversary is more rational, capable and knowledgeable than we ourselves, which usually proves to be untrue in the aftermath when all the facts come out.

Intellectual extremes  One way to have a fairly safe society is to forbid all firearms. Another way is to require everybody to carry one. The middling condition is the most dangerous, which partially explains why the United States has so much crime. Similarly, an ignorant species is incapable of self-extinction. A genius species will protect itself from the hazards it creates. The most vulnerable species is the one with a broad spread of intellect, and this is what we have, especially in the United States.

Creative geniuses gave us nuclear power, lasers, fiber-optic communications, integrated circuits, computers, the Internet, search engines, genetic engineering, and robotics. These ingenious inventors usually manage their creations responsibly when they retain control of them. Some of them do become entrepreneurs and retain some measure of control of their inventions; Gordon Moore comes to mind. However, patents expire, competitors appear, and control slips away. Genius happily moves on to create more dangerous toys while control of the current ones devolves to business people and politicians, including those with inferior intellect and selfish motives. Then the cycle repeats. Perhaps other humanoid species have devised a better system of governance that avoids this hazard. If so, their futures may be more secure than ours.
Homogenization  It is important that isolated tribes be left alone to live as they always have. Something in their diet, culture, surroundings, customs, or genetic code may give them immunity to the extinction hazard that will kill the rest of us. These tribespeople are humanity’s backup population. Contact brings them drugs, new diet, microbes, and manufactured goods (cargo). One of those imports might somehow cancel their immunity and make them as vulnerable as the rest of us. Hence, it is vital that they be neither persecuted nor assimilated.

Misguided altruism  Mosquitoes and other pests protect much of the remaining wetlands and jungle in the overpopulated Third World, but then well-meaning aid workers exterminate the six-legged defenders out of compassion for the burgeoning human population. In the battle between nature and humanity, we should favor nature, not for nature’s sake but for humanity’s sake. Nature often tries to restrain humanity and keep us more survivable, but then goodhearted people thwart her efforts for misguided short-term altruism.

Neoclassical economics  A few economists are green [65, 66]. The late Kenneth Ewart Boulding was the most notable with metaphors of cowboy economy (reckless, exploitative) and a spaceman economy (constrained by the limited reservoirs of his spaceship) [67]. Unfortunately, most mainstream (neoclassical) economists are committed to growth and regard sustainability as a fad. Then there are globalization folks, who help the underdeveloped world to develop because this will create more markets for goods from the First World, as though we didn’t already have enough.

Adaptation  The event that killed the dinosaurs was something they experienced for the first time. Had there been many precursors that killed some fraction while others survived, then that bit of selective breeding would have enabled more species to survive the big hit. We might have descended from dinosaurs and might still exhibit vestiges of the reptilian line, perhaps eggs, scales, or something else.

As far as we know, our species has never in its 2,000 centuries been exposed to an apocalyptic event of that magnitude. That leaves us much more vulnerable than other extraterrestrials who have survived one and recorded it in their history. However, there is a curious twist: even without their historical motivation, we somehow developed an interest in the subject. What sort of evolutionary selection acted on our ancestors to make me want to write this treatise and you want to read it?

Curiosity is a factor. It had obvious survival benefit when our ancestors investigated strange footprints near the tribal campsite. Curiosity extended to scary things that proved harmless like eclipses and rainbows. It produced practical inventions with great survival value. Now we carry this trait to extremes by sending expensive spacecraft to observe not only earth-like bodies but also obscure ones that tell us nothing of any practical value. To my knowledge nobody has explained how we evolved such extreme curiosity. Yet it may save our species by causing us to investigate extinction scenarios that are completely beyond our experience and history.

Somewhere a humanoid species may have as much high technology as we do, but no instinctive drive to think beyond practical applications, no desire to ask questions
about the big picture, things like species survival. Those types are more vulnerable than we are.

*Solutions to social problems* It would seem natural to find sustainable social solutions for social problems. Instead we evade social change by adapting hazardous technical solutions:

- Our government could create incentives for people to donate organs for transplant, but instead we breed special pigs to supply scarce organs, a procedure called xenotransplantation. Obviously this is an opportunity for xenogenic diseases to jump from pig to man. Such a disease may be mild in pigs and fatal to humans, just as simian immunodeficiency syndrome (SIDS) is mild compared to AIDS.
- Cities could be made safe and livable, but instead people emigrate to suburbs and commute daily to the city thus wasting time and money and needlessly generating carbon dioxide.
- At rush hour our freeways are jammed with full-sized cars, the great majority of which carry only the driver. So we widen freeways and build more of them. A creative social solution would make hitchhiking safe, desirable, and a social obligation for those who own cars, just as tipping waiting staff after good service is a social obligation. For safety, an ID system could keep records of who traveled with whom. It is quite possible to manage these data in the age of computers and cell phones.

*Mental disconnect* I have given three lectures on human survivability to scholarly groups with varied specialties. After presenting my calculated results I noted that the survival risks are comparable to ordinary perils that insurance companies underwrite. All three audiences calmly accepted that and then asked good intellectual questions about my analysis. Ironically there is a whole class of questions that nobody asked—not one, not even close; questions with intense personal concern like the following:

- How can we initiate political action to make a safer world? Do you think any existing organization will take up the cause?
- What are the chances that death will be quick and relatively painless?
- My son and his bride plan to have children. Should I discourage them?

Perhaps my audiences didn’t believe me and tuned out. I tested them with the joke slide in Figure 29. I tried to say, “Since survival risks are comparable to insured risks, somebody ought to sell extinction insurance. However, I’m the only person with actuarial tables, so I must take on that burden. Now if any of you brought your checkbooks ...”. But milliseconds after the slide appeared, laughter drowned out those words. So they were attentive, and the question remains: Why no expression of intense personal concern? No doubt these same people would be troubled if they accidentally let an insurance policy expire.
My audiences reacted as though I deserved credit for solving an amusing mathematical puzzle. Perhaps it went straight to one cerebral hemisphere where intellect resides but never reached the powerful emotions and motivators in the other side. Apparently the topic trips a circuit breaker in the corpus callosum and shuts down the connection.

Between lectures I discovered a much better way to formulate the cum-risk $Z$ discussed in Section 4.2. This made my analysis more accurate and convincing, so I was elated. Oops, I forgot to be sad because the risk is three times my previous estimate, which jeopardizes my own grandchildren! Quite clearly I have the same mental block as the folks in my audiences.

If other species in our galactic ensemble have no such mental block, then they may be more survivable than we.

5.8 SECOND CHANCE?

If a great calamity destroys civilization, the survivors will undoubtedly rebuild. No matter how primitive they may be, they will discover our artifacts, repair or replicate many of them, and proceed toward urbanization, industrial revolution and eventually science and technology.

But what about extinction? Will Earth get a second chance to evolve a humanoid species that develops civilization, industry, and scientific curiosity? Evolution would take many millions of years compared to only a few centuries to replace civilization. Could we be just such a replacement, the second rather than the first species to occupy the humanoid ecological niche? Not likely, paleontologists would surely have discovered ruins or some sort of evidence if a predecessor had existed.

Another fact guarantees our status as first. Our ancestors found native metals, almost pure stuff that is ready to use with little or no metallurgy. We have now exhausted all such handy resources and must obtain metals from ores, mostly sulfides and oxides. Had there been a prior humanoid species, they would have exhausted the native stuff, and our ancestors would have found none.
In particular, our ancestors found native copper and fashioned it into useful artifacts. Sometimes they found nuggets in creek beds or in pits in the ground, and sometimes irregular chunks of copper embedded in rock. On rare occasions they found metallic gold, silver, and platinum. Other metals, such as zinc, tin, and nickel, were scarce in the pure native form but abundant as ores. Native non-metals, especially sulfur, have been found in abundance, also metalloids, which include arsenic, bismuth, and antimony. Our ancestors would have found nothing so convenient had they not been first.

So, what if anything will take over the humanoid niche after we expire? Perhaps some rodent will survive the extinction event and eventually develop hands, start walking upright, develop a big brain, and ultimately move into the humanoid niche. This evolution can proceed to the level of industry based on stone, wood, leather, and other abundant resources. They will invent the windmill, waterwheel, and such. But then their evolution hits an insurmountable barrier for lack of readily accessible resources such as native metals and rich ores. Without them there is nothing to spark their curiosity and give them a vision of a world with things more interesting than wood, leather, and stone.

#  #  #

Perhaps the first human coppersmith became wealthy, took two wives, and begot many children, some of whom inherited his inventive skills. At that point in the long complex Darwinian process, one strand turned a corner toward evolution of modern man.

Another ancient man discovered how to exploit oil he found leaking from cracks in the ground. Yet another became the first smelter. He built a fireplace from unusual rocks. During a particularly hot fire, molten metal oozed from the rocks where it came in contact with embers. In this reaction hot carbon reduced a sulfide or oxide ore leaving a puddle of metal, probably lead since other ores require higher temperature than a basic fireplace achieves.

Our replacement species will not have such educational experiences, nor will they find such handy resources. The nascent humanoids that replace us will be deprived of the stepping-stones they need to go on. With hardship they may be physically capable of finding the buried low-grade ores and deep pools of oil that we use today. However, no tribe living at a subsistence level would allocate the time and effort for such a project without a clear objective and a good prospect of success. Besides, at their state of development, they do not understand such concepts as research and
long-term investment. An essential piece is missing, a teacher who could persuade them that the effort would be worthwhile.

Without a quick payoff, maybe one generation, it is hard to imagine how Darwinian selection could begin to reinforce the inventive skills required for an industrial revolution, much less hi-tech. Instead, competing needs would drive their evolution toward other benefits such as physical strength, warrior and hunter skills, and resistance to disease.

Perhaps another planet can produce more than one humanoid species if their resources for industry and hi-tech are as abundant as wood, leather and stone. But Earth can bear only one.

5.9 SURVIVAL HABITAT

Before our time expires, we may send colonists to a survival habitat. Instead of outer space, it is far cheaper to use an isolated or sheltered place on Earth and far easier to rescue anyone in trouble. But where? John Leslie [68] thinks we should build human survival colonies in artificial biospheres. He deplores the lack of any such project, and I agree.

However, the safest and most affordable habitat may be unfit for humans, but quite suitable for our sentient robotic successors. Their bodies can be designed especially for the new environment, either on post-human Earth or in outer space. Prof. Hans Moravec at Carnegie Mellon University would be comfortable with that. He regards our robotic successors as our Mind Children [69].

A colony on the sea floor next to a hydrothermal vent [70] might possibly become self-sufficient. (My Google inquiry turned up the current Aquarius program [71], but nothing that attempts to wean itself from the world above.) That secluded neighborhood should survive almost any calamity on the surface. Geothermal power is available for general needs and for making oxygen from seawater. A temperature differential from about 400°C in the vent to 2°C ambient is enough for a Carnot engine to run at 60% efficiency. Among the strange organisms attracted to the vents, some are probably edible, but to my knowledge, no one has yet done the taste test. Available power might support light industry but probably nothing heavy.

Besides formidable technical problems, there is a psychological obstacle to building a survival habitat, namely severe lack of urgency. Short-term concerns always take priority over those with a time scale of centuries—right up to the day disaster strikes. During 2,000 centuries of human life we have evolved a sense of urgency to deal with short-term hazards before they get out of hand: smoke in the distance; neighbors encroaching on tribal lands, and that sort of thing. But we have no such instinct for a threat that lurks in the background for a century or more. If this inadequacy is typical of humanoid species throughout the galaxy, it suggests an answer to Enrico Fermi’s famous question: “Where are they?” They died because they were always too preoccupied to anticipate long-term consequences.

Once a colony escapes Earth’s gravity at great expense, it makes little sense to trap it again in the gravity of another planet unless that planet has water or other
resources more important than any we have found yet in the solar system. Hence, the best scheme for a space habitat may be O’Neill’s cylinder [72]. The living space is the interior of a cylinder, which spins to make artificial gravity. Both gravity and climate are adjustable for comfort. The cylinder can begin life in Earth orbit where help is near. If and when it evolves into a permanent colony completely weaned from Earth, then the cylinder can migrate into solar orbit. Eventually the colony can mine the asteroid belt for material to expand or replicate more cylinders.

Sir Martin Rees [2] questions the feasibility of O’Neill’s cylinder because it is vulnerable to sabotage, but that problem may be soluble. A saboteur needs privacy both to prepare his attack and to conceal his emotional state. Hence, privacy should be strictly limited to brief bodily functions (including sex). This is not an unnatural state. Primitive tribes had little privacy. Nor do sailors in the United States Navy, where officers inspect both workspaces and personal lockers. Violent incidents occur occasionally, especially with disgruntled drunken sailors, but rarely if ever has anyone threatened the ship. If anything could drive a mariner berserk, it would be claustrophobic life on a submarine, and yet carefully selected submariners adapt to patrols that last two months. (I spent one day submerged—the most I could possibly tolerate.)

NASA and other space agencies and space enthusiasts everywhere seem to overlook an important experiment: Establish self-sufficient colonies in harsh locations here on Earth. The idea is not to choose a site that simulates a particular destination in the solar system, but rather to develop intuition and experience in the problems of self-sufficiency. Hydrothermal vents mentioned above seem ideal. Other possibilities include Antarctica, the central Greenland ice sheet, and/or a harsh desert. Compared to space stations and planets, these all have huge advantages of familiar gravity, protection from space radiation, and breathable air at normal pressure. These colonies would provide a baseline for evaluating questions about launch weight (initial supplies), shelter, temperature control, food and other necessities, and in general, the difficulties of achieving self-sufficiency. They also serve as survival colonies without calling them that. Preparation for “space colonization” makes a much sexier pitch for funds than “survival colony”, and the price is a bargain compared to other projects in the manned space program.

We should not wait too long to build a space habitat, because the window of opportunity will close (as Gott noted). Let us apply GSP to the duration of the space age. So far it has lasted (from Sputnik, 1957) \( T_p = 52 \) years, the same as Antarctic studies, hence,

\[
\text{future of the space age} > 6 \text{ years with 90\% confidence} \\
> 52 \text{ years with 50\%}
\]

Space exploration may end with humans stranded on Earth just as the Rapa Nui (the people of Easter Island) were stranded when Captain Cook visited in 1774. Prior to that contact, Dutch admiral Roggeveen had found a hardy people in 1722. Sometime between those dates civil war and ecological collapse had apparently decimated both the population and the island’s resources [73]. They had toppled and desecrated
their stone statues, just punishment for gods who failed them. The trees were gone, also their seeds, and they had no material to build seaworthy vessels for escape.

Maybe Rapa Nui is a microcosm for humanity. If we spend all our resources on wars and extravagant living, then we may not have enough left to build the giant spaceships required to launch a viable colony. We may be marooned like the Rapa Nui. If this fate is normal for humanoids throughout the galaxy, it may resolve Fermi’s paradox.

Richard Gott wants us to colonize Mars and then move on to planets throughout the galaxy [74]. He argues fervently that humans need a second planet (or other base) to insure survival of our species [75]. But he should know better! He famously chides people who think they are very special [76]. Yet humans would be very special indeed if we become the first earthly species out of millions to colonize another planet. Instead we should strive for a less special goal that is more attainable, to be the progenitors of the first species to colonize the galaxy—our robotic descendants, the androids.

We (or they) can design their bodies to be spaceworthy, able to thrive in a hard vacuum without water or oxygen. And they can be designed to hibernate throughout centuries of interstellar travel. It is far more feasible to design the colonists’ body to thrive on a particular planet than it is to terraform the entire planet to accommodate our demanding maladapted bodies. There is a good chance that we will not be able to afford spaceships for humans but can afford them for androids. Look around any superstore and compare the number of things that humans need to the number that androids need. Then think about sending all that stuff to Mars for a few hundred thousand dollars per pound.

We may simply be living in the wrong times for big high-tech engineering projects. Manned spaceflight to the Moon and beyond has been on hold since the last Apollo mission in 1972. More than half the missions to Mars have failed. The space shuttle has been disappointing, and we have not built the proposed space elevator (lift). (This would employ a cable car riding up and down a cable that dangles from a space station above synchronous orbit to a point on Earth’s surface.)

Our cities are not covered by geodesic domes that would be useful as skyhooks. Nuclear electric power is on hold. We have explored only tiny samples of the oceans’ floors and the insides of mountains. Boreholes to Earth’s mantle are challenging, and earthquakes still cannot be predicted. By contrast, the microelectronics and software needed to make android brains has been succeeding beyond our wildest dreams of a few decades ago. It seems clear where we should place our bets.

It would be a shame to populate a galaxy with our own pitiful, frail bodies, which require special care and feeding, major water supplies, crops, and so forth. Comfort and pleasure cost far more. Rather than gamble on a long shot, we should gracefully accept our limitations and take pride in our robotic descendants as they go forth to colonize the galaxy.

If we humans ever journey into the galaxy, we may travel as frozen embryos in the care of robo-nannies. This makes good ethical sense. If a mission fails, then the only human loss is a batch of embryos, not sentient adults who have endured a long journey only to perish disappointed. As for sentient androids on a failed mission, they
can be reinsilicated here on Earth using backup copies of their brains and memories. When a mission succeeds, the androids will go out in the poisonous air and do all the building and exploring while their human pets live in a comfortable zoo with climate control. It will be a “brave new world” with little role for human courage and prowess.