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LIVING WITH THE RAVAGES OF FOUR INDUSTRIAL REVOLUTIONS

The greatest threat to our planet is the belief that someone else will save it.

— Robert Swan, the first person to walk to both poles and the force behind the South Pole Energy Challenge—the first expedition of its kind—a 600-mile journey to the South Pole with his son, surviving solely using renewable energy

First, the good news: we're living in an unprecedented time in human history, where technology is advancing so fast that it is, or will soon be, capable of solving all the world's major problems. Now, some of you may be thinking, *Nonsense! Technology and industry are the cause of most of the world's problems!* And you'd be right about that. But that doesn't make my statement wrong. They say ignorance of history makes one doomed to

repeat it, and never more so than in the case of technology. If we're not careful, the danger of repeating the damage caused by early tech is very real, so let's briefly revisit technology's history. You see, 200,000 years ago, the humans that walked on Earth were anatomically similar to you and me, but for the first 130,000 years, we lived like animals. Then, about 70,000 years ago, something happened. No one knows what caused the change, but it's now known as the cognitive revolution or great leap. Archeologists tell us there was an explosion of art, tools, and human migration. Anthropologists tell us humans discovered speech and invented language.[6] Ever since then, each time we've discovered a new way to connect, communicate, and collaborate, our world has fundamentally changed. Just look at the differences in human society brought on by learning to talk, then write, then do mathematics, followed by the social upheaval brought on by inventions such as the printing press, radio, TV, internet, World Wide Web, social media, now generative AI, and soon, agentic AI. Our advancements have put us humans on an exponential trajectory of growth.

The effect of humans on the planet really heated up when, in the late 1700s, we enjoyed the first industrial revolution featuring the invention of the steam engine, weaving loom, and cotton gin. At that time, humans first experienced the miracle of rapid transportation and mass-production and thought the world was getting better in every way. However, as we began to burn fossil fuels in earnest, pollution came along with the progress. This was, in many ways, the beginning of humanity learning to live with that disturbing dichotomy.

It would take approximately another hundred years before the planet's next industrial revolution in the late 1800s, where electricity came into common usage and assembly lines further automated production. People in the Victorian age were in awe of the fact that their homes were lit up well past sundown and thought technology really had reached its peak! But society now needed large, central power stations, pollution increased as industry and automobiles flourished, and dangerous electrical wires snaked across cities and towns, meanwhile people stopped living by the natural rhythms of the sun, which changed society forever. Humans lived with the ups and downs of this technology for about another hundred years.

Finally, in the late 20th Century, around 1970, we built microprocessors, which led to the common use of electronics and enhanced our ability to automate life and business. Boy, did we think we had it all figured out, then! Telephones were small and cheap enough for individuals to have in their homes, and by the early eighties, computers were, too. Cars became safer, more sophisticated, and affordable, further enhancing personal freedom. During this time, we also developed innumerable chemical compounds for mass use in agriculture and industry, maximizing production at every level. At first, we had no idea the irreparable harm some of these substances caused to the planet, and when we finally gained awareness of the devastation our technological progress had caused, there wasn't much anyone could do about it. At this point in human evolution, going backward to a pre-industrial era was out of the question. But with this third

industrial revolution, technology itself had reached a stage where it enabled its own rapid development, so it didn't take another 100 years for us to get to Industrial Revolution 4.0. In fact, it took half that time.[7]

As I write this around fifty years after the advent of the microprocessor, we're well into the planet's fourth industrial revolution, where the power of a laptop computer has been harnessed to a motherboard the size of a salt crystal;[8] where cellular phones, "smart" systems, and the internet dominate our technological landscape; and where social media has created societies as big as countries with no physical location, enabling anyone from any social class to share information of any kind with the world at large. The technological developments of the last fifty years have, in fact, turned the very idea of social revolution on its head.

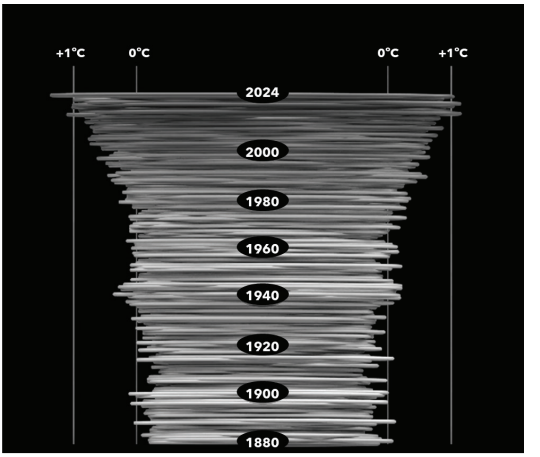
Instead of offering better transportation options, this era enables people to leave home less as they conduct business meetings, see doctors, and even run political campaigns via video instead of in person. Instead of offering a new set of jobs, this era enables self-employment through crowdsourcing such as home-share and ride-share apps. Instead of fighting for better physical working conditions, this era simply enables many to work from home. Meanwhile, much of the work formerly done by humans is now handled by ChatGPT, other generative AI, and various robotic applications,[9] which, in some ways, means this era requires a better-educated population that can handle more managerial-level jobs, but education is easier to get than ever, online. Progress is no longer measured by how we maximize the use of electricity,

petroleum, and steel. Indeed, today, data is the new oil; artificial intelligence, the new electricity; and robotics, the new steel. Future companies will either embrace data, AI, and robotics or cease to exist.

Because of the rapid pace of technology, there will be more wealth created in the next ten years than was created in the last one hundred. In fact, according to ARK Investors,[10] the estimated economic impact in the next decade will dwarf the economic activity generated over the last century from well-known industries like telecommunications, automotive, electricity, computers, and the internet. This new wealth will come from blockchain technology, genomic sequencing, robotics, energy storage, and artificial intelligence. This is no surprise, as all wealth, from the beginning of time, has come from innovation – doing something different that creates value. Innovation itself comes from a combination of knowledge, curiosity, imagination, persistence, luck, and the application of the scientific method. Humanity has simply gotten so much better at these skills that technology now even enables us to predict its own progress. We know the next technological revolution won't take another hundred years. In fact, it will probably begin fewer than fifty years from now.

Those of us alive today may very well see the world completely transform, yet again, within our lifetimes. To this point, the former vice chairman of General Motors has gone on record saying that by 2035 nobody will own or operate a vehicle.[11] We'll simply hail self-driving taxis to take us everywhere. Another futuristic company called Neuralink has already developed brain-computer interface technology

where electrodes are implanted into the brains of quadriplegics to enable them to operate computers with only their thoughts.[12] At the same time, a start-up called Atomic Machines has developed technology that reorganizes matter at the atomic level, enabling rapid manufacture of any object of any size in record time. What's more, genetic disease will soon be a thing of the past, as the CRISPR-Cas9 genome editing tool will soon allow scientists to alter any organism's DNA to cure diseases such as inherited blindness[13] and sickle cell anemia.[14] Indeed, emerging technology is set to improve human health in so many ways that children born this year will likely live to be more than one hundred, but only if they have a planet to live on and societies to live within. After all, our planet is still suffering from the ravages of four industrial revolutions.



This chart shows data from NASA[15] illustrating how the surface temperature of Earth has changed from 1880 to 2024. And it's still climbing. In fact, Princeton University,[16] The Royal Society,[17] and NASA[18] have all issued reports announcing that even if we immediately stop all fossil fuel use (which ain't happening, let's face it) the CO_2 already in the Earth's atmosphere would continue to warm the planet for hundreds if not thousands of years. So, to stop global warming and preserve the earth before it ceases to be hospitable to human life, we have to figure out ways to *remove* CO_2 from the atmosphere. Just fifty years ago, such an idea would have been laughable, but with the technology we have now, surely there is a way. What's more, with the weaponry and strife between nations currently existing on the planet, there's a better-than-average chance humanity will actually destroy itself before global warming finishes the job. One company, Climeworks uses direct air capture technology to remove CO_2 from the atmosphere, storing it underground through mineralization.[19]

Over time, technology has proven to be both a blessing and a curse, and this is still the case, as it has created a world that now changes so drastically, so often, that life today has been described as VUCA: characterized by high Volatility, Uncertainty, Complexity, and Ambiguity. Keeping up with the way technology constantly updates our tools (and changes society in the process) has practically become a part-time job we each have to do in addition to making a living. It's yet another aspect of technology's blessing/curse dichotomy and the reason technology will either make us or break us,

as a species. What's more, because of the speed of change, whatever happens will happen *in your lifetime*.

Defining Humanity-centric Innovation

As a parent, I think it's safe to say that I'm not alone in dreaming that my children's children's children will tell stories about great-grandpa's life and the times in which he lived. You could say my greatest ambition is to be a good ancestor. But will I be? Will our progeny look back and admire my generation (or yours?) for seizing the opportunity technology presented to save a dying planet? Or will tired parents be barely able to choke out their stories through a smoggy haze to children wilting in the latest heat wave, hiding in a bunker from a violent post-apocalyptic society, trying to achieve sustenance on polluted water and unclean food? In fact, asking, "Will we be considered good ancestors," as posed by Roman Krznaric,[20] is a great way to underscore our obligation, indeed our mandate, to save this planet for the generations to come and even to ensure those future generations exist at all. I often wonder: will history textbooks one day describe the eight billion people alive today as those who ushered in a new Renaissance? Or the next Dark Age?

When people act to clean up our oceans, grow chemical-free food, reduce CO_2 emissions, and curb the flow of pollution, they often speak of "saving the planet," which is wonderful, but I think it's important to note this language is the wrong way around. After all, for the most part, planet Earth is only suffering because we human beings are on it.

We're the ones who created the Great Pacific Garbage Patch, which contains two trillion pieces of plastic and is twice the size of Texas. We're the ones who have been dumping planet-altering CO_2 into the atmosphere for centuries, fueling global warming and raising sea levels so rapidly that some island nations are already losing land to the ocean—and, in the not-so-distant future, may vanish entirely. We're the ones who developed the nuclear weaponry that made us aware of a looming phenomenon called "mutually assured destruction." If we humans die out because our societies and atmosphere are no longer conducive to human life, trust me, the rest of the planet will recover.

The earth has been here for four and a half billion years and will likely remain a lush, green oasis for billions more, although humans may not be around to enjoy it. After all, without humans here to cause trouble, the forests, in a couple thousand years will grow trees right up through our buildings' concrete foundations and twine vines around our defunct power stations. Animals will evolve, thrive, and continue to live by instinct, even if radiation gives them three heads each. Fish will eventually evolve to function even better with plastic in their systems, and they'll repopulate the oceans. For proof, look at Chernobyl, where a defunct nuclear power plant makes the place famously toxic to humans but hasn't stopped a woodland from growing over the town and deer from grazing next to the faulty containment vessels.[21] Rest assured, *the planet* only needs saving insofar as it is the container for human life. In fact, if Mother Earth could talk, she would probably say, "The sooner I'm rid of you pesky humans,

the better!" Humanity itself is the thing we're striving to save, but first rescuing our planet is the path to that goal. We need to save the planet to save our species!

Become a New Kind of Billionaire

Isn't it incredible to realize that, unlike all previous industrial revolutions, this fourth industrial revolution (which, as I write this book, is just getting started) finally provides us with the tools to improve all the harm we've done to this planet throughout the centuries-long process of developing the tools themselves? For instance, now we have blockchain technology that ensures secure, transparent, hack-free information-sharing across worldwide networks. We can do genomic sequencing, which is leading to genomic medicine, where certain disease markers could be permanently edited out of individuals' DNA. We have even fulfilled, to some degree, the fantasy presented by The Jetsons cartoon so long ago: we have advanced robots that can do everything from vacuum our floors to calculate algorithms that run entire digital societies. What's more, we have access to a new system called additive manufacturing that can (or will soon be able to) 3D-print everything from tiny objects measured in nanometers to a full-sized house in record time.[22] We have long-range batteries that not only enable us to drive electric cars but potentially will provide portable energy solutions for every city, village, and rural outpost in the world. And, of course, we have artificial intelligence (AI), which reduces human error, processes data in record time, and does the

dirty work in regions too risky for humans. What's more, part of AI's job is to constantly improve itself, so the more we use it, the better it gets.

But these technological tools are so powerful that, if we don't use them right, they also have the potential to exacerbate our existing problems. The greenhouse effect is only one of the types of environmental damage that needs to be reversed. On top of that, the cells of almost every living organism on Earth now contain micro- and nano-plastics. Studies show fish exposed to such microplastics experience a variety of toxic effects including structural damage to the intestine, liver, gills, and brain as well as reduced fertility in subsequent generations.[23] Unfortunately, micro-plastic toxicology studies on humans are still in their infancy, so we still don't know what these plastics are doing to us. The only thing we can be sure of right now is empirical evidence points to nothing but negative effects. Yet, today's technology gives us the power to find a way to stop and reverse these and many more indicators of man-made planetary failure. But will we?

As Carl Sagan observed, "Extinction is the rule. Survival is the exception."[24] In our current era, it's imperative that we harness modern innovations to restore and preserve our planet. Historically, our pursuit of profit has led to environmental challenges; however, that same drive for advancement can now be redirected towards sustainable solutions. By channeling our collective ambition and creativity, we have the opportunity to repair past damages and build a more resilient world for future generations. Many on this planet still aspire to use and abuse every resource imaginable in a

rush to become millionaires or billionaires. Hear me out as I encourage you to do the same, but with a twist. What if we stop defining a "billionaire" as someone who accumulates a billion dollars and instead define it as someone who helps a billion people? Now, that's a goal worth pursuing! Most folks, in all different walks of life, believe their work may help tens or hundreds or even thousands of people in their lifetimes, but consider that if you work for real change, systemic change, in some crucial aspect of the world, you'll be helping future generations, too. If you help fundamentally alter our current unsustainable systems into long-term sustainable ones, then, over the years, long past your own lifetime, the tens, hundreds, or thousands of people you initially helped will grow exponentially. You'll help a billion people. Yes, you.

The key to becoming this new kind of billionaire is in choosing or altering your career today so that it's oriented toward making deep-level change. If you're currently manufacturing widgets that have little use in the world besides generating profit, wouldn't it be more satisfying to manufacture something that solves a big-picture problem for a long-term effect? If you make your living by providing a service that simply puts a band-aid on problems, wouldn't it be more satisfying to work for long-lasting change in the same industry? Even if it's just a change in how people think or how they conduct one small aspect of their lives, if you make it your mission to create fundamental, positive change in whatever aspect of the world you control, you could become a "billionaire" with the legacy you leave behind. I call this "planting a tree whose shade you'll never enjoy."

It has always been my habit to think long-term in that way. In fact, I find it the key to job satisfaction in every way. The days of short-sighted "working for the weekend" really need to come to an end. This suggestion begs the question, *What are the world's most crucial problems, and how do I choose one to focus on, so I can help a billion people?*

In the late eighties, when I first started my chemical-engineering career, I asked myself the same question. Then, I read about the Brundtland Commission, which had been conducting studies on this topic for three years. Its 1987 Brundtland Report entitled "Our Common Future," quoted the Great Law of the Iroquois Confederacy:

"In our every deliberation, we must consider the impact of our decisions on the next seven generations."

This report highlighted the fact that members of high-income countries like the United States use such a disproportionate number of resources that if everyone in the world were to live like us, we'd need an additional 2.6 Earths to support us all.[25] The impact of the report was that we can no longer talk of economic and environmental policy in separate compartments. It introduced "sustainable development" as a bridge concept connecting economics, ecology, and ethics. Its leaders stated, "To get real action, the ownership of the concept of sustainable development must extend to all sectoral agencies and, most importantly, to key private-sector stake holders."[26]

In essence: Don't wait for the government to force you to act sustainably; take it upon yourself. Many nations took this report very seriously, and one of the eventual results was

that the United Nations established a Commission on Sustainable Development that defined seventeen Sustainable Development Goals (SDGs) for the planet. This list provides an excellent guideline for anyone seeking direction as to how to make a difference for humanity and the planet. In brief, it follows:

17 United Nations Sustainable Development Goals[27]

1. End poverty
2. End hunger
3. Provide good health and well-being for all
4. Give access to quality education
5. Achieve gender equity
6. Ensure clean drinking water and hygienic sanitation
7. Construct systems providing affordable, reliable, sustainable and modern energy for all
8. Enable all populations to have decent work leading to economic growth
9. Build resilient infrastructure while fostering innovation
10. Reduce inequality in socioeconomic status
11. Make all cities and settlements safe and sustainable
12. Consume and produce responsibly
13. Take urgent action to combat climate change
14. Conserve the sea and use it sustainably

15. Protect terrestrial ecosystems and sustainably manage forests
16. Promote peaceful and inclusive societies with justice for all
17. Revitalize a global partnership for sustainable development

I hope you can find an SDG above that inspires you or dovetails with your existing skills. Shortly after I read the Brundtland Report,[28] number six became close to my heart quite quickly, inspiring me to build my career, as much as possible, around achieving various aspects of this goal and guiding the corporations I worked for to participate as well. If you truly contemplate this list and ask yourself which aspect of world sustainability feels both significant and possible for you to work towards, you've already begun the process of becoming a modern-day billionaire. With this new "billionaire mindset," your efforts toward innovating a sustainable future will progress quickly from hype to hope to something really happening.

The Be-Your-Own-Boss Mindset

In the traditional 20th century model of employment, institutions hired individuals to achieve the purpose of that institution. Employees worked for bosses and performed to the best of their ability, no matter whether they were Rosie the Riveter or Albert Einstein. This still takes place today, and workers' job satisfaction tends to depend upon the quality

of the management that directs them to produce whatever they produce for their company. I have worked for many such companies, managed others, and been managed by those higher placed than myself, so while my work model has been, on the surface, traditional, hierarchical, and subordinate to corporate interests, I never thought of it that way, which made a huge difference in my job satisfaction. In my heart, I've always seen myself as my own boss, with the company as a partner in achieving our shared vision, rather than the other way around. I entered the workforce knowing I wanted to make a difference in society, change peoples' lives for the better, and fulfill my childhood dream of using science and technology to build a better world. From my very first job, I've seen each company I work for as a valuable part of my journey, helping me grow and move closer to my ultimate goal. In the companies I worked for, whenever I was given a choice as to which projects I wanted to work on, I'd choose something around sustainability, like engineering systems for clean water or developing projects for world sanitation or women's equality. When I felt one company wasn't helping me fulfill my own goals, I sought work at a different company whose vision was closer to my own. I always asked myself, "how do I get the company working for me?" as a means to achieve my humanity-centric ambition. I think this is more of a 21st century way of thinking. After all, nowadays we must take personal responsibility to ensure that the work we do advances the cause of saving humanity from the possibility of extinction.

You don't have to be the CEO of a corporation to make

that resolution, you just have to be the CEO of your life, create a vision statement that drives you forward, and (as much as possible) don't compromise in the achievement of that vision through your employment, where you use the resources your company allocates toward those goals. I've personally observed that many members of Gen Z are highly ethically driven and can't be motivated by money alone. I think as we move further into the 21st century, we'll see more and more individuals "hiring" institutions to achieve their own ethical goals. Companies that have no sustainability initiatives or outreach to underserved communities are going to find themselves understaffed as qualified workers take employment elsewhere, or create their own companies.

During the current era in my own career, which I suppose would traditionally be called retirement, I've chosen to start my own business that promotes sustainable initiatives all over the world. I call it my renaissance, not my retirement. After years in the corporate sector, I'm finally living my dream to the fullest. But many brilliant younger engineers these days don't see any reason to wait to become self employed when they have so much skill, access to nearly infinite technology, and are living in the midst of what many call an AI revolution. Nowadays, in many cases, it literally makes more sense to start one's own business than to get a job working for others. What better way to begin helping a billion people? In fact, dozens of such start-ups are so successful, they have been valued at $1 billion before going public.

Sam Altman, CEO of OpenAI, has given startups like these his stamp of approval, further speculating that with AI

taking over repetitive-task and data-analysis jobs, he expects to soon see the first "one-person unicorn," or billion-dollar company operated solely by its founder.[29]In my youth, the world's greatest technological tools were only available to major corporations that had massive financial resources, but today, nearly anyone with the skill to use them (or the desire to learn) can get any kind of advanced tech on a laptop. This fact alone disrupts traditional business models and will soon democratize the entire entrepreneurial landscape. I think it's even safe to say the days of having to pay your dues to corporate America are over.

Also a vestige of the past are typical e-commerce business models and other such startups without a social conscience. Just in tech for the money? These days, you'll find a lot less investment capital coming your way. Renewable energy, carbon capture, plastic recycling, HVAC efficiency, and fighting the new rash of wildfires around the world are the types of sustainable innovation topics winning prizes, gaining investors, making the news, and garnering profit, too. Both Simon Stiell, executive secretary of the UN Framework Convention on Climate Change, and UN Secretary-General António Manuel de Oliveira Guterres[30] agree. They have asserted that humanity is on a "highway to climate hell," and since we still don't have the technology to cool the atmosphere quickly enough to save the human race, we must put ourselves in the hands of today's youth via paradigm-shifting startups.

Such startups operate by leveraging tech, innovation, and minds brimming with creativity, drive, optimism, and admittedly a touch of sheer desperation. For such revolutionaries,

data is a new source of value that must be mined with the enthusiasm of a startup founder in Silicon Valley. Accordingly, all boundaries must be opened, and no source of this precious resource can remain taboo. Importantly, everyone from UN officials to tech moguls have stopped calling on charities and non-profits to do this kind of data-based, humanity-centric innovation. You see, where sustainability-minded folks used to want to "stick it to the man" and work outside the corporate sphere, things have changed. Now, making a profit is no longer synonymous with exploiting people and resources. Quite the opposite, in fact.

In a way, the global polycrisis has done the world a favor by excising that victimhood tendency a lot of young folks (well, most of us at some point in our lives) used to carry around. Once upon a time, it was, "If only my boss would tell me what to do, I'd do it!" but now the prevailing attitude among educated and capable folks like you is, "Someone must solve this problem. Why not me?" This is an especially powerful statement when it becomes clear you can now make a living, often a very good living, pursuing humanity-centric innovation. To be completely fair, over time, Non-Governmental Organizations (NGOs) and nonprofits have played crucial roles in making an impact on nearly all the UN SDGs, but without significant profit, they just can't scale up enough to help more than a small sector of any population at a time. But with the planet now in the midst of its fourth industrial revolution, we don't have time to play small ball anymore. Go big or go home.

2

THE FUTURE OF SUSTAINABILITY IS BUSINESS

Whether you believe you can do a thing or not, you are right.

— Henry Ford, an industrialist and pioneer in making automobiles affordable for middle-class Americans

As a lifelong technologist and businessperson who has always had sustainability top-of-mind, I believe in the power of profitable business to make a difference, but I also know it must be part (or most) of the business' stated vision, not just a recreational side project. There is no shame in building a profitable brand around providing clean water to underserved populations, manufacturing earthquake-proof housing, empowering women and girls in developing nations, or cleaning plastic out of the ocean.