Chapter 1
The Context of Investing

1.1 COVID-19: Evolutionary Dress Rehearsal or Autocratic Regression?

During the final stages of writing this book, COVID-19 was declared a global pandemic\(^1\) and is now forcing us to question existing systems. Governments around the world took action, much of it unprecedented, to contain the virus—including closing borders, enforcing social distancing, and imposing lockdowns and other restrictions on movement. It is only 2020 and already we are on the fourth pandemic of the century: COVID-19 was preceded by SARS in 2001–2004; H1N1, known colloquially as the swine flu, in 2009; and Ebola in 2014–2016. All four were zoonotic—that is, they were transmitted from animals to humans. Such diseases are more common than you might imagine, which is the reason why Bill Gates has warned us for many years, most eloquently in a 2015 TED talk,\(^2\) about our collective vulnerability in the face of a pandemic.\(^3\) Few listened, as was demonstrated by the general lack of preparation in the face of the COVID-19 outbreak.

The American Centers for Disease Control and Prevention (CDC) estimates that 75% of new diseases that infect humans are spread via animals. The prevalence of such diseases seems likely to increase given that a combination of natural disasters and irresponsible human behaviors is inflicting ongoing damage to the quality and quantity of wild animals’ habitats, and forcing animals into urban areas. As both climate change and the global population continue to grow, so too do the extent and scope of the crisis.\(^4\) I suspect that all goes without saying. One related danger that is frequently overlooked, however, is that how we respond nationally and internationally to this and similar crises could determine the future of democracy.

\(^1\)An earlier version of this section was published on medium.com, see Bozesan (31 March 2020).
\(^2\)https://tinyurl.com/t8lcmc6
\(^3\)https://www.gatesnotes.com/Health/Pandemic-Innovation
\(^4\)https://tinyurl.com/u2uupjm and https://tinyurl.com/uy48874
Is Democracy in Danger?
Alex Gladstein, Chief Strategy Officer at the Human Rights Foundation, argues that open democracies are more likely to respond in a competent manner to COVID-19 than are authoritarian regimes (such as those in Iran, North Korea, or Syria) whose actions are directed by the interests of the ruling classes rather than public well-being. And while he believes that the delayed response to the pandemic by the Trump administration in the United States and the Johnson government in the United Kingdom is a sign of incompetence rather than a failed democracy, democracies could indeed fail if they do not take this opportunity to prove themselves more competent than authoritarian regimes. For example, let us take a look at restrictions on freedom of movement, a literally foreign concept in many Western democracies.

Times of crisis such as pandemics may require temporary restrictions on freedom of movement: witness the introduction of social distancing and lockdowns in democracies across the globe in 2020. As responsible citizens, we can accept such temporary aberrations because they are for the greater good—but we must protect democracy by making sure those restrictions do not extend beyond the lifetime of the crisis that triggered them.

The USA PATRIOT Act passed after the 9/11 terrorist attacks is only one example of restrictions that have been imposed with good intentions at the time but are still active. In Hungary, where democracy has long been a fragile concept, extraordinary measures were implemented to grant Prime Minister Viktor Orbán “sweeping powers” to deal with the COVID-19 crisis. Most significantly, there are no clauses in the legislation that granted these “sweeping powers” to spell out when and how they will come to an end. No matter where we are, as soon as life returns to normal, we must insist on regaining our civil liberties, even if we have to take to the streets in protest. Of course, because we live in a technologically advanced era, those civil liberties extend to our digital lives. If data have been collected for scientific purposes, for example, they must have an expiration date and be anonymized; they must not be used against citizens; and there must be democratic accountability attached to their harvesting, use, and storage.

Exponential Tech: A Threat or a Blessing?
The current situation almost encapsulates the inherently contradictory nature of life in the exponential tech age. And the initial response, or lack thereof, in some countries including the United Kingdom and parts of the United States, could be seen as an assault on Enlightenment. Social media quickly turned into a breeding ground for COVID-19 fake news and misinformation on the one hand, and a source of life-saving information on the other, with hashtags such as #FlattenTheCurve and #StayHomeAndSaveLives on Twitter going viral and subsequently helping to educate people on the importance of respecting social distancing and other scientifically

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5https://tinyurl.com/urzk5dd
6https://tinyurl.com/j8b5tt8 and https://tinyurl.com/uc5mtn5
7https://tinyurl.com/rgxhp9
robust measures crucial for survival. In Italy, where more than 6000 people died of the virus in a single month, respirator valves were 3D-printed after a hospital in Brescia reported that the lives of hundreds of people were at risk because they had run out. Italian engineers Cristian Fracassi and Alessandro Romaioli asked the manufacturer to provide the blueprints of the valves so they could print replicas on their start-up company’s 3D printer, but their request was denied. Undaunted, the engineers looked at the design of the original valve and developed three prototypes of these life-saving devices in only a couple of hours. They transformed a common snorkeling mask into an emergency respiratory mask and printed 100 devices within 24 h for less than €1 (just over US$1.00 at time of writing) per piece (compared with the regular price per valve of around €11,000) and had saved the lives of at least 10 patients by late March 2020. At the time of writing, the researchers were working for free, and this could have been an amazing example of people before profits were it not for the patent owner and manufacturer of the valve threatening to sue because of patent infringement. This highlights the question of ethics and morals when it comes to the value of a human life compared with the financial gain derived from a patent.

As the call for social distancing increased and more people were required to self-isolate or self-quarantine, organizations encouraged many workers to work from home. This would not have been possible before the Internet age, and we can now fully appreciate the importance of digitalization (in fact, of all the 6Ds, which we will discuss later), including the necessity for high-quality global Internet access, which means that social distancing does not have to mean social isolation. We have now seen in real terms how exponentially growing technologies (discussed below) and platforms (Netflix, Amazon Prime Video, Slack, Google Suite, Alibaba’s Ding Talk, or Microsoft Office 365) can be applied to maintain some semblance of normality during a crisis. While we cannot know what the long-term economic effects will be, the short-term pain is being at least partially eased in some sectors by remote working, access to free online learning options, and even remote graduation. Some gyms and yoga studies are looking after their clients’ physical and mental wellbeing by offering online classes, often by donation so that they continue to look after their instructors as well. Videoconferencing tools such as Skype and Zoom have played a significant role in the current need to live virtually, and Zoom even experienced a financial boost, as their stock more than doubled after January 2020. AI is also playing a central role in the management of this crisis. In an IEEE Spectrum article, Megan Scudelari discusses how five companies are currently using deep learning models to find new drugs that might successfully treat
COVID-19. These companies have opened their platforms to allow scientists around the world to leverage their collective intelligence to expedite the development of antiviral drugs and a vaccine.

The need for self-sufficiency at home has never been more apparent, and I am positive that this experience will encourage the construction of sustainable housing and zero-energy buildings, and the retrofitting of existing homes with renewable technologies in the near future. From solar panels to solar tiles, power walls, energy storage, home automation, and even vertical farming at home, to name only a few initiatives, the necessary technologies are available and could be successfully and effectively applied with proper legislation and government support. One exponential technology that is currently still a work in progress but that will ultimately prove its value in any future time of social distancing is autonomous service robots powered by neural networks that can be used to remotely deliver food, medication, and other supplies to people in quarantine. For now, though, food delivery companies such as Deliveroo and Glovo have switched to contactless delivery. To date, many large organizations have displayed a people-first mindset. Online retail platforms such as Amazon and Kijiji canceled the accounts of people who had bought up essential supplies to sell for inflated prices online. And many supermarkets not only imposed limits on the number of items customers could buy at any one time but also had designated hours (usually the first business hour of the day) for seniors and high-risk members of the community. Some also offered free delivery. But let us not get ahead of ourselves.

Systemic Evolution or the Collapse of Civilization?
As I write these words, things are still changing—sometimes by the hour. By the time this book goes to print, the pandemic may have peaked, and life may be returning to normal for most people. But there will be consequences, both long-term and short-term. The implications are not only medical and biological, or social, cultural, and political—they are not even only economic. If pandemics really are increasing in frequency and impact—and remember, we are on our fourth pandemic of the twenty-first century and it is only 2020—they are also fundamentally existential. We can see the current situation as an opportunity to evolve to the next stage of human civilization and not only prevent the collapse of democratic societies but evolve them, or we can regress to nationalism, populism, and dictatorship either through incompetence or out of fear. We will see how resilient the various forms of government and governance are and how we can make them more resilient in the future. Thus far, individual governments around the world are taking historic measures to stop the spread of the pandemic and to prop up the economy during

14Scudelari (19 March 2020).
15https://tinyurl.com/s82h9ff
16https://tinyurl.com/tc67bn6
its reign. Unfortunately, there is little to no collective activity to help countries such as Iran, North Korea, or Syria.\textsuperscript{17}

Current responses are only highlighting how helpless and disunited we are in the face of COVID-19 which, like climate change, does not respect national borders.

\textbf{Can the European Union Become a Beacon of Light in the Darkness?}

Systemic change is nonnegotiable if we want to protect democracy. Yanis Varoufakis, a former economic minister of Greece, is convinced that “Europe is unprepared for the COVID-19 recession,”\textsuperscript{18} and that current stimulus packages will do little to counteract it. He is comparing the current stimulus packages with those issued in 2008 in response to the financial crisis that provided liquidity to an already bankrupted financial system without changing it at its core—such packages were essentially fiscal enablers. In his view, the COVID-19 crisis is only resurrecting the problem, and so he is calling for systemic changes. First, he called for solidarity to be a priority for the European Union, which has never been weaker than now. “Europe is only as healthy as its sickest resident and only as strong as its most bankrupted nation,” and the price the EU will pay for a lack of united action threatens to be the “disintegration of the union itself,”\textsuperscript{19} which would bring its own terrible consequences. Varoufakis has led the Democracy in Europe Movement 2025 toward proposing the following 3-point plan for addressing the COVID-19 depression and creating more resilient systems in the process\textsuperscript{20}:

- Issue €1 trillion Eurobond by the European Central Bank (ECB).
- Inject a €2000 European Solidarity Cash Payment (UBI-like).
- Introduce a European Green Recovery and Investment Program to ensure the future of jobs, public health, public education, and the green transition (while getting rid of the old trickle-down recovery packages that did not work in the past).

This would require a democratically elected European government, a treasury that raises taxes to ensure the repayment of the Eurobonds in a timely fashion, and a green recovery agency. New systems will have to replace fossil fuel-based, free-market economies that are not sustainable in the long term with wellbeing economies fueled by zero-greenhouse gas emissions and ensure that small and medium enterprises, which create a large percentage of common prosperity in most nations, maintain their diversity, creativity, innovation, and resilience through massive amounts of capital made available to them. This capital must serve the greater good, be patient (long-term), be properly de-risked, and enable the development of integrally sustainable companies (see Chap. 3). But we can only achieve what we measure. This is why we must move beyond traditional GDP (for profit-only) criteria.

\begin{itemize}
  \item \textsuperscript{17}https://tinyurl.com/v2ojcmg
  \item \textsuperscript{18}https://tinyurl.com/saa7hmw
  \item \textsuperscript{19}Yanis Varoufakis, minute 0:47–1:16. Viewed at https://www.youtube.com/watch?v=jm97g0RqYGM
  \item \textsuperscript{20}https://tinyurl.com/yd62jjjf
for success and include integral sustainability metrics such as the parity of people, planet, and prosperity.

I am confident we can collectively learn from our COVID-19 experience and apply the lessons learned to protect ourselves and our planet. At an individual level, if we are healthy and have been lucky enough to either not be affected by the virus or have overcome it, we have an opportunity to grow beyond ourselves and become a source of support for those in need and to avoid fear from becoming a hidden pandemic. Times of crisis remind us that we cannot control the outside world, we cannot control what other people do, we cannot control the weather—and we certainly cannot control a virus. But we can control our psychological state, what we think, how we behave, and who we become in a crisis. We have choices. We can move into a state of desperation, panic-buying, and depriving our friends and neighbors of the basic supplies they need, or we can become an inspiration and a force for good for ourselves and others. We can grow emotionally and be there for those in need, or we can regress, feel sorry for ourselves, and become a burden, in every sense of the word, to those around us. Our mindset will determine whether we choose misery or happiness, and only we can define that mindset for ourselves (see Chap. 2).

1.2 A Challenged World

My past had convinced me that Soviet-type communism did not work (see box Confessions: From Communism to Capitalism), but once I was living in the West, I had a new question to ponder: Does capitalism really work better?

Often disguised as democracy and claiming to be built on values such as individual freedom, brotherhood and equality, and the promise of abundance for all, capitalism can easily fool us into believing that it is the better path to follow, that it offers more opportunities to thrive and escape unacceptable circumstances. Yet, capitalism, in its current global manifestation, is holding the whole world hostage not only through staggering and ever-increasing levels of inequality but also through short-term profit maximization, the latter of which has in turn sparked human-caused planetary crises of unprecedented proportions.22 In its 2020 global risk report,23 the World Economic Forum highlights five areas of major concern:

- **Environmental fragilities** caused by climate action failure, human-made environmental and natural disasters, extreme weather, and accelerated loss of biodiversity whereby “the rate of extinction is tens to hundreds of times higher than the average over the past ten million years” (p. 7). Climate change is hitting us harder

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21Diamandis and Kottler (2012), Pinker (2011 & 2018).
22See, for example, Stiglitz (2010) & Stiglitz (May 2011); Vollmann (2018a) & (2018b), von Weizsäcker and Wijkman (2018).
23World Economic Forum (2020).
and faster than expected, with the last 5 years being the warmest on record and pointing toward a 3 °C increase by the end of this century and planetary emergencies of unprecedented proportions.

- **Technological instabilities** due to the breakdown of information infrastructure, cyberattacks, adverse technological advances, and data fraud or theft undoing the remarkable economic and social benefits initially created by technological digitalization.
- **Societal and political strains** caused by pandemics and other infectious diseases, food and water crises, involuntary migration, and failure to pursue appropriate urban planning and ensure social instability.
- **Geopolitical tensions** caused by weapons of mass destruction, terrorist attacks, state collapse, interstate conflicts, global governance failure, and national governance failure.
- **Economic vulnerabilities** due to financial failure and fiscal crises caused by deflation and/or unmanageable inflation, asset bubbles, unemployment, energy price shocks, illicit trade, and failure to build critical infrastructure.

The post-COVID-19 era will be different from its predecessor, just as it ought to be. The data from the pre-COVID-19 era showed quite clearly that we had an outdated, unsustainable economic system. Despite its weaknesses, however, it was supported by a majority of investors, financiers, and businesspeople. For example, an investors’ poll published in December 2019 by the Global Sustainable Investment Alliance shows that “only 16% of total respondents are already reporting in line with” (p. 8) climate-related financial risk disclosures in their mainstream financial reports. The reason for that seems to stem from the fear of impacting economic growth, and even many academics such as William Nordhaus, recipient of the 2018 Nobel Prize in economic sciences, continue to be outspoken advocates of traditional economic growth. Tax havens such as the Cayman Islands and Panama have encouraged indiscriminate economic growth at the expense of nature, people, and Earth’s resources, which has contributed to the growth of destructive business practices. We are so enamored with growth that we did everything possible to prevent the underlying financial systems from going bankrupt during and after the 2007/2008 financial crisis. The stimulus packages, quantitative easing, issued in response to it continued to provide enormous liquidity to the bankrupted banks just to keep the illusion of growth alive. In **Tax Havens and Global Environmental Degradation**, Victor Galaz et al. establish a clear link between tax havens, deforestation—for example, 68% of all scrutinized foreign capital was associated with the deforestation of the Amazon—and illegal fishing—for example, 70% of ships associated with illegal fishing were registered in tax haven countries. They, therefore, posit that lost tax revenue ought to be considered an indirect subsidy to

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24Global Sustainable Investment Alliance (December 2019).
25See, for example, https://www.nobelprize.org/prizes/economic-sciences/2018/nordhaus/facts/ and https://news.yale.edu/2018/10/08/cheers-and-roses-undergrads-yales-latest-nobel-laureate
26Galaz et al. (2018).
economic activities with disastrous environmental, and eventually tragic social, consequences, and that the elimination of tax heavens be added to the UN’s sustainability agenda.

Confessions: From Communism to Capitalism
During my childhood in Romania, hunger, cold, misery, and shortages of just about anything you can imagine were part of my daily life. My crooked toes and feet are a daily reminder of those difficult times. My feet grew as fast as any child’s feet grow, but my parents could afford to buy me shoes only once a year. For that, they borrowed money, which they paid back during the following 12 months. But deprivation was not shared equally: while I went short of food, some of my classmates ate strawberries in the middle of winter; while we had an outhouse in the backyard, no bathroom or running water, and a coal oven for heating, a lucky few families enjoyed both indoor toilets and bathrooms, complete with running water and central heating. As far back as I remember, I was determined to escape poverty and enjoy strawberries whenever I felt like them. I realized early on that to do this, I would have to use my brain, the only thing I had that gave me any kind of advantage over my strawberry-eating schoolmates. This way of thinking also happened to reflect the party line, in which I deeply believed, although my parents gradually became disillusioned by it. My father was born in 1934 to hardworking but poverty-stricken farmers in Transylvania, in northern Romania. Like me, my father was a communist in his youth and thus a great believer in equality, freedom, and social justice; and like so many other idealists, he eagerly adopted Karl Marx’s now-infamous idea that the class struggle inevitably leads to the dictatorship of the proletariat, which in itself represents only a transition to a classless society without the exploitation of people by people. As a young adult, he was a devoted party secretary, determined to make the theory work for the underprivileged, whom he represented. The Hungarian uprising of 1956 gave him his first hint that he may have been deceived. A few years later, he knew for sure that nothing had changed for the better. In fact, things were worse than ever. For people like him, poverty was a fact of life. He became disillusioned, although he recognized the danger to which this exposed him. Until we emigrated to West Germany, he faced the constant threat of rotting in prison like so many of his idealist friends, but even so, he continued fighting—not so much communism but human foolishness. He was too much of a warrior to give in, and he used the system to fight the system, but he remained mired in poverty. He believed in revolution, equality, ethics, and other communist ideals, and he never tired of fighting corruption, bigotry, and ignorance. However, while the conformists were doing rather well, we as a family were dirt poor. Things improved a little when my mother began working as a baker—not because of the extra money (although that certainly

(continued)
helped) but because, like so many other decent people in corrupt societies, she turned her back on her principles and began stealing food from work. And so, for the 11 years leading up to our emigration to West Germany, we did not starve.

My parents may have been completely disillusioned by communism, but they were smart enough to not put me or themselves in danger by disclosing their political opinions. Thus, I toed the party line and became a great believer in the communist ideology. I never questioned the system, for it never occurred to me there could be anything to question. I was living under a regime that encouraged education and learning; provided outstanding free education in sciences and free healthcare; and promoted equality between men and women, as well as perseverance and the prospect of achievement through hard work independent of any religious indoctrination. I learned to believe in my own abilities and what I could achieve through my intellectual skills alone. My hopes for a better future were high, and I worked hard to try to make them a reality. I truly believed that if I worked hard and studied, I would eventually escape poverty. This belief that I could achieve virtually anything if I only worked hard enough would become a guiding force for the rest of my life. And I did get out of poverty—but not in Romania. I only escaped poverty because we left the so-called “communist” society (Karl Marx would turn in his grave if he could see what people made of his philosophy)—and all it offered, negative and positive—to move to the capitalist West, which had been presented to me for so long as the ideological root of all evil. Our emigration to West Germany in 1974 improved not only our material circumstances but also my view of the world. Once I was in the West, the brainwashing I had experienced while living under communism became obvious to me, and I decided that I would never again become a member of any political, or religious, organization. I would never again be blindsided by any type of dogma. Letting go of the “communist” doctrine was easy for me because I had seen for myself that it did not work—unless working meant keeping millions of people oppressed, poor, and miserable, in which case it was very effective. Thirty years after the fall of the Berlin Wall, as I look at current realities, I wonder, does capitalism truly work better?

If we are not to self-destruct as a species, taking down the planet as we go, we must face the fact that the time has come for a radical transformation in our attitudes to life. But we must act carefully, responding rather than reacting so that we do not simply swap one harmful ideology for another. To do that, we must understand the full complexity of the greater context in which we operate, including its hidden determinants. At the center of those hidden determinants is mindset, human psychology, and trust in both the individual and the collective. The current Edelman Trust Barometer, for example, shows an epochal lack of trust in “the four societal
institutions that the study measures—government, business, NGOs and media.”

Therefore, as we analyze the context in which capital, investing, and businesses operate, we need to stand guard at the door of our minds and make sure that we do not fall into the traps of either exaggerated pessimism dominated by “progressophobia” or inflated, naïve confidence. Wise optimism should be our guiding light.

1.2.1 Planetary Emergencies

The COVID-19 pandemic has amplified our economic vulnerabilities and demonstrated that they stem not only from the increased volatility in the financial markets but also from the fact that they lack sustainability, solidarity, social and ecological orientation; disregard our global interdependence; are decoupled from nature and the real economy; and are measured by a single factor: GDP. Additional contributing factors to economic vulnerability are (1) the global debt, which at around 225% of GDP is significantly higher than before the 2008 global financial crisis and which is increasing daily as governments are forced to mitigate the COVID-19 crisis, and (2) the constriction of global financial circumstances, which is imposing burdens on countries that built up dollar-based liabilities while interest rates were low. While these factors pose serious threats to the world economy when paired with geopolitical and societal tensions, it is significant to note that the picture changes significantly if we analyze how these risks have changed over the past 10 years. In 2009, the top risks were seen to be mostly economic in nature (the collapse of asset prices, retrenchment from globalization, fossil fuel price spikes, fiscal crises), followed by chronic disease, pandemics, and gaps in global governance. In 2020, however, the top existential threats are:

- **Ongoing climate emergency**, manifested by extreme weather events, natural disasters including unexpected pandemics such as COVID-19, critical sea level rises, water crises, and the failure to mitigate and adapt to climate change
- **Nuclear threat**, including weapons of mass destruction, exacerbated by the withdrawal from and termination of the INF Treaty by the United States followed by Russia
- **Unsafe AI and cyber criminality**, including data fraud, data theft, and cyber attacks

In Call to Action from the Planetary Emergency Partnership, an open letter to global leaders, the Club of Rome warns decision-makers that “how leaders decide to

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27 See, for example, the Edelman Trust Barometer (2019) at https://tinyurl.com/t9kutqv
28 Pinker (2018, p. 39).
29 World Economic Forum (2020, Figure IV, p. 8).
30 https://tinyurl.com/ua45n9d
stimulate the economy in response to the corona crisis will either amplify global threats or mitigate them, so they need to choose wisely.\footnote{31} As a collective, we may be tempted to do anything we can to mitigate the fallout from the pandemic so we can get back to business as usual as fast as possible. But we have a real opportunity now to transform our systems (economics, financial, governance, education, etc.) and make them more sustainable.\footnote{32} This means that those who care most about their economic future must address existential threats.

### 1.2.2 The Speed of Change

The current warnings about climate change are not new, but they have become increasingly relevant. The COVID-19 crisis showed us in no uncertain terms that if we are to overcome climate change challenges, our leaders must trust in science and recognize the value of foresight, prevention strategies, and wide-scale disaster preparation. One of the first—and certainly the most remarkable—forewarnings came via The Limits to Growth,\footnote{33} the groundbreaking 1972 report to the Club of Rome. It sold more than 9 million copies and put the impact of exponential economic and population growth on a finite planet on the world agenda thanks to the shocking wake-up call it sounded. It alerted the public to the potentially disastrous results of ongoing resource depletion, uncontrolled population and food production growth, as well as a growing carbon footprint. The environmental consequences would be dire and the social implications massive if business were to continue as usual. Unfortunately, few people truly accepted or took to heart, let alone acted upon, the recommendations of the report—and look where we are now. William Nordhaus was far from alone in his nonresponse to the warnings, and I believe that he and his ilk must accept much responsibility for our current precarious situation.

The MIT researchers who wrote The Limits to Growth modeled its now-famous 12 scenarios using the WORLD3 system dynamics of their eminent professor of engineering Jay Forrester. They created a model for the computer simulation of physical growth, including interactions between population growth, industrial growth, food production, and ecological limits on a finite planet. The scenarios in the report represented the options global society could choose to take between 1970 and 2100. Some were optimistic and indicated where the potential collapse could be averted through a deliberate reduction in population as well as systematic CO\textsubscript{2} footprint reduction per person. Others were pessimistic and simulated pollution crises, demonstrating what could—and in fact, as we now know, did—go wrong due to resource depletion, excessive pollution, and an increased decline in well-being through population explosion, a growing human footprint, and resource scarcity. Although the report did not predict which of the 12 scenarios was most

\footnote{31}https://tinyurl.com/rl2ty86
\footnote{32}https://tinyurl.com/saa7hmw
\footnote{33}Meadows et al. (1972).
likely to happen, it encouraged sustainable development within planetary bound-
aries. It was also perceived as unnecessarily alarmist. It was heavily criticized by
some economists, and in 1992, economist Wilfred Beckerman even observed that
"the best—and probably the only—way to attain a decent environment in most
countries is to become rich."\(^{35}\)

In 2008, Paul Krugman, a Nobel Prize laureate in economics, even disparaged the
group’s endeavors as “hard-science arrogance” and Jay Forrester’s system dynamics
model “a classic case of garbage-in-garbage-out: [insinuating that] Forrester didn’t
know anything about the empirical evidence on economic growth or the history of
past modeling efforts.”\(^{36}\) Economists, in general, were offended by the report and
held firm to the belief that something that must not happen will not happen. Their
resistance emphasizes, however, the ubiquitous tension between the current climate
emergency and the “crucial roles played by exploration and discovery, technological
progress, and substitution.”\(^{37}\)

My own involvement in climate emergency action began in 2003 at the Alliance
for a New Humanity conference in Puerto Rico, which my husband, Tom, and I
co-sponsored. The keynote speaker was Vice President Al Gore, and for several days
we had the opportunity to discuss in depth his concerns about climate change. At that
time, I was already a big fan of Gore, having listened to his 1992 audiobook, *Earth in
the Balance: Ecology and the Human Spirit*.\(^{38}\) I believed he genuinely cared about
people and the future of our planet. During the first conference dinner, Gore shared
with us how he was desperately trying to get important countries including Russia
and the United States to ratify the Kyoto Protocol, and what we could all do to
support his efforts. That was when it became obvious to me that we investors had to
redirect our investments, resources, focus, and activities toward averting human-
caused climate change, AKA the biggest threat to Earth and humanity in recent
history. I realized that we could and should balance our ongoing needs as investors
with the long-term needs of the planet. The two motivations were not mutually
exclusive. In fact, by switching our investing behaviors, we could make a positive
difference to the health and future of the planet. However, Tom and I were in the
minority at that point.

"The Kyoto Protocol is an international treaty which extends the 1992 United
Nations Framework Convention on Climate Change (UNFCCC) that commits
state parties to reduce greenhouse gas emissions, based on the scientific
consensus that (part one) global warming is occurring and (part two) it is

\(^{34}\)See, for example, Beckerman (1972); Nordhaus (1973); Nordhaus et al. (1973).

\(^{35}\)Beckerman (1992, p. 482).

\(^{36}\)https://krugman.blogs.nytimes.com/2008/04/22/limits-to-growth-and-related-stuff/

\(^{37}\)Nordhaus (1992, p. 45).

\(^{38}\)Gore (1992).
1.2.3 Accepting the Challenge

The 2006 Academy Award conferred on Gore’s documentary, *An Inconvenient Truth*, brought climate change into the mainstream and pushed home the point that the time for procrastinating is over. Like *The Limits to Growth*, *An Inconvenient Truth* was heavily criticized and accused of exaggerating the problem and being gloomy and disempowering. When the 2007 Nobel Peace Prize was jointly awarded to the Intergovernmental Panel on Climate Change (IPCC) and Gore for their research on and dissemination of knowledge about human-made climate change, we heard yet another wake-up call. Or we ought to have. Instead, business continued—indeed, continues—as usual, with little significant action having been taken to date by regulators, governments, or industry. The result: global CO₂ emissions continue to rise unimpeded. According to data provided by the Copernicus Climate Change Service of the European Centre for Medium-Range Weather Forecasts, the global average temperature for June 2019 was the highest since records began.40

Of course, reducing CO₂ emissions is a fraught business, but perhaps if we understand why nations are reluctant to even discuss such reductions, we will be better placed to understand how we could make changes. Figure 1.1 illustrates why negotiations between nations about reducing CO₂ emissions are so difficult.

Every year, the International Energy Agency (IEA) publishes its statistics on worldwide CO₂ emissions in an attempt to show clearly why the global community must reduce the total amount of CO₂ being released into the atmosphere.41 But *who should do the reducing?* CO₂ emissions present a particular global challenge, for they do not halt at the border of the country emitting them, and there is no world government to legislate on behalf of the planet to reduce them. We, therefore, depend on each individual national government to do the right thing and advocate for our planet.

To identify the source of emissions, my husband, Tom, developed a variwide chart (Fig. 1.1) that uses 2017 data (published in 2019) from the International Energy Agency.42 The vertical axis shows CO₂ emissions per capita and the horizontal axis population data per country or continent. While emissions vary widely from one

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39Viewed July 5, 2019 at https://en.wikipedia.org/wiki/Kyoto_Protocol
40https://climate.copernicus.eu/record-breaking-temperatures-june
41See, for example, IPCC (2020).
42International Energy Agency (2018).
**Fig. 1.1** 2017 worldwide CO$_2$ emissions per capita and country. (Source: Schulz (2019))
region to the next, the world average is 4.35 metric tons per capita. Most industrialized nations range between 4 and 15 metric tons of CO₂ emissions per capita. The total CO₂ emissions of a region are represented through a rectangular area. The height of each rectangle is proportional to the CO₂ emissions per capita and the width is proportional to the population of the represented region. The regions are sorted by CO₂ emissions per capita, from highest to lowest, and are a mix of countries and continents.

When you look at this chart, it becomes evident that Earth will not be able to absorb additional greenhouse gas emissions to make room for developing nations to “catch up” by increasing their per capita emissions to match the current average. Yes, developed countries are responsible for the current misery, but the fate of Earth will essentially be decided by what occurs in developing nations from this point on. The future of life depends on their not building an economy based on fossil fuels at any cost and instead “leapfrogging” the use of renewable energy sources, thus joining those awakened souls and climate activists behind the Paris Agreement on Climate Change43 and the adoption of Agenda 2030 with its Sustainable Development Goals (SDGs) in 2015.44 Nevertheless, there continues to be not only little obvious appreciation of the sense of urgency but also insufficient commitment or regulatory action to address the current climate emergency. In fact, in 2017, one of the world’s greatest polluters per capita, the United States (see Fig. 1.1) decided to withdraw from the Paris Agreement,45 with President Trump stating that “the concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive.”46 Some people watching the temporary drop in global emissions due to COVID-19 lockdowns and reduced economic activity may be tempted to believe that no additional climate action may be needed in the aftermath of the pandemic. This belief could not be further from the truth. Climate change is the result of 100 years of global emissions into the atmosphere; it is not going to be turned around in only a few weeks.47

Investors and entrepreneurs are very pragmatic, and in order to assess whether or not something is sustainable within planetary boundaries, we need not only a definition of sustainability within planetary boundaries but also metrics to help measure and deliver the outcome. One of the first definitions of sustainable development was published in Our Common Future, a 1987 report by the United Nations World Commission on Environment and Development.48 Known as the Brundtland Report, in honor of former Norwegian Prime Minister Gro Harlem Brundtland, who chaired the commission at the time, it defined “sustainable development as the development that meets the needs of the present without compromising the ability
of future generations to meet their own needs.” Since then, we have made much progress through the ratification of Agenda 2030 of the UN in 2015 with its 17 Sustainable Development Goals\(^49\) and 230 individual indicators.\(^50\) However, we are still a long way away from being able to provide a clear and implementable blueprint for investors, business people, and other stakeholders. This is particularly significant because the UN SDGs are inspirational goals that at times contradict each other. For example, if we keep focusing on goal number 1—end poverty in all its forms everywhere—and try to implement it regardless of other considerations, we will continue to burn fossil fuels to lift people out of poverty, and thus violate goal number 13—take urgent action to combat climate change and its impacts. This is why we must ensure the UN SDGs are implemented within planetary boundaries, the constraints dictated by our planet’s operating system.

“The planetary boundaries concept presents a set of nine planetary boundaries (Fig. 1.2) within which humanity can continue to develop and thrive for generations to come.”\(^51\) The nine factors covered by them concern the regulation of the stability of Earth’s operating system and include, for example, biosphere integrity, freshwater use, ocean acidification, ozone depletion, and climate change.

Humanity is continuing to operate in a twentieth-century type of business-as-usual scenario—the very scenario that took us into in the yellow zones in the first place. If we are to ensure a safe operating environment and also implement the Paris Agreement, we must get back into the green zones. Unfortunately, we are currently hurtling toward breaking through the orange boundary, which could have irreversible consequences.\(^52\) As discussed at length by Ernst von Weizsäcker and Anders Wijkman in *Come On!*,\(^53\) their 2018 report to the Club of Rome, current financial, economic, and governance systems are not sustainable in terms of the above requirements. Most governments promote gross domestic product (GDP) to enhance job creation, safeguard tax revenue, and increase overall prosperity whereby prosperity is defined in a narrow, local, and mostly financial-only sense at the expense of both the UN’s SDGs and our planetary boundaries.\(^54\) The price for this short termist approach to prosperity will be paid by future generations through subsidies for fossil fuels such as coal, tar sands, and natural gas, as well as nuclear energy.\(^55\) The result

\(^{49}\)https://sustainabledevelopment.un.org/

\(^{50}\)https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf

\(^{51}\)https://www.stockholmresilience.org/research/planetary-boundaries.html

\(^{52}\)Randers et al. (2018); Rockström et al. (2009).

\(^{53}\)Von Weizsäcker and Wijkman (2018).

\(^{54}\)Pinker (2011); Stiglitz et al. (2018).

\(^{55}\)Vollmann (2018a) & (2018b).
will be not only climate devastation and record biodiversity loss\textsuperscript{56} but also global inequality of unprecedented proportions.\textsuperscript{57} Since November 2007, the European Commission, European Parliament, Club of Rome, OECD, WWF, and several other major organizations have been collaborating in an attempt to change this outdated approach to measurement criteria, albeit without much global success to date.\textsuperscript{58} In terms of accounting practices, the same approach is taken in corporate accounting, which is not required to take into account environmental degradation,

\textsuperscript{56}Martin (2015).
\textsuperscript{57}Dorling (2014); Stiglitz (2011).
\textsuperscript{58}Stiglitz et al. (2018).
social, or governance issues. Thus, the sole measurement criterion on which we currently rely is short-term profit at the expense of long-term financial sustainability, as well as the security of people and the planet.

However, there is hope. The European Commission recently defined a 10-step action plan aimed at implementing sustainable finance with the intention of transforming the EU economy in order to meet the goals of the Paris Agreement and Agenda 2030. This long-term strategy intends to achieve carbon neutrality by 2050 and is accompanied by several key pieces of documentation:

- Financing a Sustainable European Economy: Taxonomy Technical Report, published in June 2019 by the Technical Expert Group (TEG) on Sustainable Finance
- Sustainability-related Disclosures
- Climate Benchmarks and ESG Disclosures

As investors who care about the future and want to win “the race of our lives” against the destruction of our planet, we need to keep a close eye on these developments and begin to change our own investment practices to:

- Move beyond a short-term, financial, profit-only approach by making long-term investments in companies that renounce short-term profitability and quarterly benchmarking, and assess the degree to which companies weaken their long-term investments by not including UN SDG criteria in their strategies and tactics.
- Build robust measurement criteria that include integrated UN SDG metrics within planetary boundaries that drive sustainable performance and demonstrate reliably the value of nonfinancial information. The investment products currently available rarely go beyond the negative screening of particular sectors. We must, therefore, develop more attractive investment mandates, benchmarks, portfolio turnovers, and performance fees and metrics.
- Eliminate investments in extremely complex investment structures with increasing complexity of products and services that encourage speculative trading and are disconnected from the comforts, needs, and expectations of the primary beneficiaries.
- Simplify investments and eliminate intermediary agents and money managers with expensive lifestyles that make them dependent on high earnings—and can lead to their taking inappropriately high risks.
- Stop investing in financial products whose incentive structures are predominantly influenced by short-term financial performance, market indices, benchmarks, market share, personal security, success, and reputation, as well as short-term regulatory compliance. Such incentives encourage unsustainable behaviors in the participating agents and can lead to a lack of alignment of goals, a culture of fear, growing self-interest, and high levels of remuneration linked to short-term profits.

59https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en
60See, for example, https://tinyurl.com/y2qq6syw, https://tinyurl.com/rkz92zx, and https://tinyurl.com/tfkv6cd
• Seek out or develop your own portfolio structures and strategic asset allocation by exploring new approaches that ensure sustainable investments.
• Encourage the development of sustainable financial markets by contributing to the development of better risk-management tools, especially for the “too big to fail” organizations. Work with regulators for the introduction of better regulatory systems that help implement Agenda 2030 within planetary boundaries to serve the interests of long-term investors.
• Support transparency and corporate disclosure by investing in companies that already have—or want to introduce—voluntary and regulatory disclosure practices for all information pertaining to long-term value creation.
• Help finance the development of circular and full-spectrum economies, thus facilitating the aggregation of the necessary capital to address the Paris Agreement and Agenda 2030.

The implementation of these measures is a gargantuan task, and so it inevitably leaves unanswered many questions pertaining to proper measurements, regulations, and capital. But we know that we have to act soon—and we cannot risk waiting for governments or regulators to act on our behalf. So, what to do?

In Jorgen Randers’s opinion, capitalism in its current form cannot provide the necessary paradigm shift, because it is designed to allocate money to what is profitable in the short term and not to what society and/or the planet need in the long term.61 Furthermore, several experts are united in their opinion that democratic parliaments are unlikely to pass new regulations in time to save us out of fear of losing voters who could presumably be against solutions that require, for example, higher taxes and more expensive gasoline and/or electricity in the short term.62 Thus, democratic bodies are not only barely meeting the needs of the current generation but also compromising the ability of future generations to meet their needs. Democratic governments appear rather overwhelmed by the complexity of the problems—the prevalence of short-term thinking, profit-only orientation, outdated measurement criteria, old dogmas, lack of understanding of exponential growth, inertia, and lack of a unified political will. Moreover, because of the lack of legislative incentives and proper measurement criteria, the private sector is moving too slowly toward a sustainable financial and economic system.

My question is: What can we as individual investors do to avert the worst within the 10-year window of opportunity given by the Paris Agreement and Agenda 2030? Before diving deeper into possible solutions from an investors’ perspective, let us take a look at another global context in which we are currently operating, one that will continue to influence and disrupt our lives more than anything else in the history of humanity: exponentially growing technologies.

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61Randers et al. (2018); Randers (2012).
62See, for example, Gore (2006, 2011); Krugman (2012); Randers et al. (2018); Randers (2012); Sachs (2008).
1.3 Exponentially Growing Technologies

1.3.1 Evolution of Evolution

Despite the current assortment of challenges, humanity as a whole is on average better off today than 50 years ago.\(^6\) We live in some of the most peaceful, progressive, and exciting times in human history,\(^6,2\) and, despite the unprecedented population growth,\(^6,4\) life expectancy keeps increasing,\(^6,6\) the average standard of living is improving,\(^6,7\) and famine has largely been conquered.\(^6,8\) Today, people have a greater chance of digging their graves with their own teeth through unhealthy lifestyle choices that lead to noncommunicable, lifestyle-related diseases or dying through suicide or of old age than from starvation, terrorism, war, or communicable diseases.\(^6,9\) Poverty has been reduced from 94% at the dawn of the First Industrial Revolution around 1820 to 9.6% in 2015,\(^7,0\) the average global income has increased tenfold,\(^7,1\) and global child mortality rates have fallen from 18.2% in 1960 to 4.3% in 2015. According to Max Roser, “over the last 200 years people in all countries in the world achieved impressive progress in health that lead to increases in life expectancy.”\(^7,2\) In South Korea, for example, life expectancy at birth grew from an average of 25 years in 1800 to above 80 in 2012, surpassing even German and the United States life expectancy.

Literacy rates have also increased—from 12% in 1820 to 87% in 2014\(^7,3\)—and most countries in the world now have democracy as their form of government—in 1799, there were no democratically governed nations; in 2019, 96 out of 167 countries with more than 0.5 million inhabitants were democracies.\(^7,4\) It is a relatively undisputed fact that this could only have been accomplished through technology, exploitation of fossil fuels, and modern agriculture practices that enabled the production of significantly more food per hectare of land. This productivity increase both reduced the amount of agricultural land necessary to feed populations (on a per capita basis) and the number of people working in agriculture and freed the labor force to move into manufacturing and other types of employment.\(^7,5\) As a result, the

\(^6\)Rosling et al. (2018, pp. 27–39).
\(^6,2\)Roser (2018), & (2018e).
\(^6,4\)Roser and Ortiz-Ospina (2017a/2013) & 2017b/2013).
\(^6,6\)Roser (2018a) & (2018c).
\(^6,7\)Roser (2018b); Roser and Ortiz-Ospina (2018)
\(^6,8\)Ritchie and Roser (2018).
\(^6,9\)http://ghdx.healthdata.org/gbd-results-tool
\(^7,0\)Roser and Ortiz-Ospina (2017a/2013a).
\(^7,1\)Roser (2018b). Viewed 5 July 2019 at https://ourworldindata.org/economic-growth
\(^7,2\)Roser (2018a), https://tinyurl.com/y7lq78m2
\(^7,3\)Roser and Ortiz-Ospina (2018).
\(^7,4\)Roser (2018d); https://www.pewresearch.org/fact-tank/2019/05/14/more-than-half-of-countries-are-democratic/
\(^7,5\)Roser and Ritchie (2018a, b).
number and severity of famines have been significantly reduced,\textsuperscript{76} as have food costs.\textsuperscript{77} Today, the majority of people in the world have a standard of living that is comparable to that of people in the West in the 1950s.\textsuperscript{78} None of this progress would have been possible without human curiosity, ingenuity, determination, a willingness to grow beyond oneself, a sense of wonder and purpose—and, of course, ongoing developments in technology.

Whether we call the current era the Second Machine Age, as Eric Brynjolfsson and Andrew McAfee from the MIT Center for Digital Business do,\textsuperscript{79} the Third Industrial Revolution, the term preferred by Jeremy Rifkin,\textsuperscript{80} or even the Fourth Industrial Revolution, as Klaus Schwab, founder of the World Economic Forum,\textsuperscript{81} will have it, research shows that we are living in an era of massive transformations driven by double exponentially growing technologies.\textsuperscript{82} But what does this really mean for us as individuals, investors, business people, and people who care?

\subsection*{1.3.2 The Role of Exponentials}

After seeing Mosaic, the groundbreaking Internet browser, Tom and I returned from California to Germany in 1994, ready to ride the Internet wave. We knew that it was taking off because the growth of the Internet was exponential (Fig. 1.3), as was the exponential growth of the underlying computation power, which had become both affordable and powerful enough to enable such applications such as the Internet. But the Internet is just one manifestation of the exponential tech boom.

Our plan was to start a technology transfer business to help companies build their Internet presence using Java-based application servers, and so we founded Infobahn International in Munich, Germany. However, 12 months down the road, we had a rude awakening: the few businesspeople in Germany who had even heard of the Internet had no interest in building an Internet presence. We experienced not only ignorance of its existence and potential, but also actual hostility toward it. Most people to whom we talked felt that the Internet had come out of nowhere. They did not understand the extraordinary opportunity it was offering because it was a paradigm changer challenging the entire business-as-usual attitude. No one seemed to know quite how to classify it. For example, the banks we asked for funding referred us to movie subsidy and film financing organizations. For me, the most disturbing fact was that even high-tech executives who should have known better did

\textsuperscript{76}Hasell and Roser (2018).
\textsuperscript{77}Roser and Ritchie (2018a, b).
\textsuperscript{78}Rosling et al. (2018, pp. 27–39).
\textsuperscript{79}Brynjolfsson and McAfee (2014)
\textsuperscript{80}Rifkin (2011).
\textsuperscript{81}Schwab (2016).
\textsuperscript{82}Kurzweil (2005, p. 67).
not get it. I remember vividly how the head of Oracle Germany, my indirect boss at the time, went against founder Larry Ellison’s directive to begin selling Oracle’s products online, stating during an internal company meeting, I heard him say: “solange ich bei Oracle bin, ist Internet kein Thema” (“as long as I am at Oracle [Germany], Internet is a non-issue”). As a consequence, I quit Oracle and focused on growing Infobahn International, while Tom co-founded Cybernet to give companies access to and push the adoption of the Internet. In our fundraising efforts, we repeatedly showed the immense Internet infrastructure implementation curves—represented logarithmically in a linear fashion in Fig. 1.3—dating back to 1969. Like every exponential curve, in the beginning, it looked and felt linear.

As a species, we have been conditioned to think linearly and locally because for millennia we lived our lives mostly in a limited geographic area, lived on average a relatively short time, and performed mostly the same jobs in the same ways as our ancestors did. Our lives were fairly predictable. It was only through accelerated technology growth that our linear and local way of thinking began to be challenged.

Throughout the history of humankind, technological progress evolved not only slowly but also exponentially (see the orange curve in Fig. 1.4). The COVID-19 pandemic provided a real-life example of how difficult it is for most people (world leaders are no exception) to wrap their minds around exponential curves—not least because the past few years have seen an increasing misuse of the word “exponential” to mean “lots” or even “accordingly” (as in, “if we need more staff, the costs will increase exponentially”), so there is a general fuzziness about what the concept and the related curves all mean. In times of crisis, this is particularly problematic, as it
means that people—governments as well as the general public—do not see the doublings coming and thus do not respond either adequately or in a timely fashion. This also partially explains why many governments have a hard time reacting to advice from the science community on what measures are required to save people’s lives. The numbers and growth are difficult to process and therefore difficult to believe.

Within the context of exponential growth, Ray Kurzweil and others in the exponential tech movement use the term “intuitive linear” to refer to the habitual human pattern of thinking locally and linearly without actually defining the term “intuition.”83 From the perspective of the continuum of consciousness and the nature of the mind, which we will briefly discuss within the context of Integral Theory in Chap. 2, researchers such as psychiatrist Arthur Deikman differentiate between lower-order intuition, which might apply within the context of linear/habitual thinking, and “higher intuition as a direct knowing of non-dual realities,” which allows for human perceptions to extend beyond the boundaries of time and space.84 Therefore, I recommend avoiding the term “intuition” unless its intended meaning is clearly defined.

John von Neumann, inventor of the von Neumann machine, one of the first computer architectures, recognized the impact of exponential growth and its acceleration of technology toward singularity—a term we will discuss later—as early as the 1950s.85 Humanity is now at that seminal point of technological evolution where its exponential growth is becoming explosive and massively disruptive. Thus, if we want not only to survive but also to thrive in the twenty-first century, we must learn to think, and most important to act, exponentially and globally.

83Kurzweil (2005, p. 11).
84Deikman (1998).
85Oxtoby et al. (May 1958).
The Fun Game of Exponentials
To see just how few of us truly understand exponentials, try this game with your children or friends. Ask them what they would prefer: a dollar a day for the next 30 days or a penny on the first day, two pennies on the second, four on the third, and so on until the end of the 30 days. Their answer will tell you if they have the foresight to see the difference between $30 for the first choice and $10 million for the second.

I speak frequently at a variety of events, and in my presentations, I sometimes ask people if they understand exponential growth as a premise for surviving and thriving in this century. Without exception, there are people who roll their eyes, bored by my question, and I get it. Yet, when I have a chance to speak to them afterward, nine times out of ten I realize that they did not internalize exponentials, or if they did, they did not do so in mathematical terms. They seem oblivious to how rapidly exponential tech is going to change their own lives in the coming decades. It is difficult for most people to see that we are doubling the rate of technological progress every decade, which means that we can expect to see in 25 years—at today’s rate—the same technological achievements that previously took us 100 years to make.86 For example, assuming 1 step = 1 meter, 30 linear steps would take us 30 meters. Thirty exponential steps, however, would take us 1 meter for the first, 2 meters for the second, 4 meters for the third, and so on. By the time we had completed 30 exponential steps, we would have walked 1,073,741,824 meters. That is 26 times around the earth! Every exponential step is double the length of the preceding one. This is why exponential growth is so deceptive. No matter how fast a linear curve grows (see the green line in Fig. 1.4) it can never catch up with an exponential one once it has passed its deceptive phase at the knee of the curve. It becomes disruptive—and this is what we are currently experiencing in many areas of our global lives, from climate change through exponential growth of CO₂ emissions, to population growth or even exponential technology growth. As with the COVID-19 response, the sooner we understand this phenomenon, the sooner we can turn this challenge into an opportunity for us all by addressing climate change and creating collective abundance within planetary boundaries. This is the caveat: We must ensure that exponential tech growth is guided to respect the limits of the physical context of Earth.

If we do not observe the planetary boundaries, that growth threatens to destroy us, because it will exacerbate our current challenges. We must leverage our intelligence now to avoid making things worse—something we have not managed to date. Will we be able to use the double exponential growth in technology to address our challenges? Or, to paraphrase Ray Kurzweil: How can an intelligence create an intelligence more intelligent than itself within planetary boundaries?87 To get closer

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86Kurzweil (2005, p. 11).
87Kurzweil asks on p. 46 of The Age of Spiritual Machines (1999), “Can an intelligence create an intelligence more intelligent than itself?”
to an answer, let us continue to develop our understanding of exponentials and their potentially positive implications for our future. The following story might add to your understanding of the impact of exponentials—but if you are already bored with this, you may want to skip the next two paragraphs and go straight to the game you could play with your friends to see how well they understand exponentials.

The King and the Sage

According to an ancient legend, an Indian king who was a renowned chess lover often challenged visitors to his land to a game of chess. One day, the king challenged a traveling sage to a game and offered him any reward of his choice, should he win. The sage modestly asked only for a few grains of rice that should be counted in the following manner: Place a single grain of rice on the first chess square and double the number of grains on every subsequent square. The king agreed. When he lost the game, the king, a man of his word, ordered a sack of rice to be delivered so he could pay his dues. Then he had the rice grains placed according to the agreement: 1 grain on the first square, 2 on the second, 4 on the third, 8 on the fourth, and so on. The rice payment, as you can see, was based on exponential growth, and the king quickly realized that he was unable to pay his debt. On the 30th square, he would have had to put 1,000,000,000 grains of rice, and finally, on the 64th square, he would have had to place more than 18,000,000,000,000,000,000 grains of rice. The total debt equaled 210 billion tons of rice, enough to cover today’s India with a one-meter-thick layer of rice.

We must never lose sight of the power of doubling: one doubling leads to 2 items, 10 doublings to 1,000 items, 20 to 1 million, and 30 to 1 billion. While we might still be able to make sense of the billion, the doublings on the second half of the chessboard result in almost inconceivable figures!

The story of the chessboard sums up why it is important to understand not only how technology has evolved throughout the history of humankind but, more importantly, how it will continue to drive progress with a double exponential acceleration. The key to this progress is the underlying force of evolution (see below). For now, let us focus on the exterior aspects of “evolution as a process of creating patterns of increasing order” that goes through various stages and will ultimately function as a premise for the universe “to Wake Up” as Ray Kurzweil would say.

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88 Kurzweil (2005, p. 14).
89 Kurzweil (2005, p. 21).
1.3.3 Stages of Evolution

In Life 3.0: Being Human in the Age of Artificial Intelligence, MIT professor Max Tegmark defined life broadly as a “process that can retain its complexity and replicate.” While physicists still do not know what caused the Big Bang—or even if that really did trigger the beginning of our universe—there is a relatively strong consensus on what has occurred since the Big Bang. Understanding what occurred is extremely relevant in the context of this book because it helps us:

• Grasp the meaning of the exponentially growing complexity in which we live
• Prepare for this complexity
• Influence our future in the universe

So, please join me in the “most important conversation of our time” as I unveil Kurzweil’s six epochs of evolution and Tegmark’s three lives.

Epoch 1: Physics and Chemistry of evolution, as Kurzweil named it, occurred when the first atomic structures were built during the first few hundred thousand years after the Big Bang due to electrons that became trapped gravitating around nuclei made of protons and neutrons. In his view, “evolution works through indirection [because] it creates a capability and then uses that capability to evolve the next stage.”

Epoch 2: Biology and DNA. Three and a half billion years ago, the first signs of life appeared when the first prokaryotic life structures developed after molecules were “born” through atoms that came together to build much more stable structures. They were simple life-forms that kept reproducing and evolving to build more complex biological systems, such as eukaryotic cells, that contained DNA and RNA molecules as information-storing structures and mechanisms, as well as cell membranes and nucleus membranes, mitochondria, and so on that enabled them to store energy and process information more efficiently. This was the first indication of how evolution rewards the ever-growing complexity of life. A billion years later, multicellular life-forms developed and began cooperating in large numbers to build multicellular organisms. Tegmark calls this Life 1.0 (biological stage) and says that it occurred as the “self-replicating information processing system whose information (software) determines both its behavior and the blueprints for its hardware.” Note the distinction Tegmark makes between hardware (atoms and molecules) and software (DNA and RNA as the blueprint for atoms and molecules). It will be useful to you when we move on to exponentially growing information technology.

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90Tegmark (2017, p. 48).
91Tegmark (2017, p. 22).
92Tegmark (2017, pp. 22–48).
93Kurzweil (2005, p. 15).
Epoch 3: *Brains* evolution began when early life-forms began to recognize patterns that were stored as information in specialized neural cells that enabled the building of intelligent life forms, from fish to *Homo sapiens*. Sticking with computer terminology, Tegmark sees this as the onset of Life 2.0 (cultural stage), when the hardware—atoms, molecules, cells, and organisms—has evolved somewhat without explicit influence from their participants, but—and this the crucial difference—the “software is largely designed”\(^{94}\) through neural patterns, or learning. Humans are an example of Life 2.0 because we can create abstract models and redesign our world in our brains before transforming the world around us. This sets us apart from bacteria, for example, which are still in the Life 1.0 stage.

Epoch 4: *Technology* is the apogee of the ability of humans to influence the world through intelligence. For example, it took biological evolution 2 billion years from the creation of the first life-form to move on to the creation of the next paradigm, cells.\(^{95}\) The technological evolution, however, needed only 14 years to move from the invention of the first personal computer,\(^{96}\) in 1975, to the creation of the next paradigm, the World Wide Web.\(^{97}\) Biological evolution ultimately led to extraordinary technological evolution, and we are just at the beginning of its exponential acceleration.

Epoch 5: *The Merger of Human Technology with Human Intelligence*. This epoch has already started and will continue to lead us toward the predicted singularity “with biological evolution leading directly to human-directed development”\(^{98}\) and beyond. It is expected to eventually enable us to transcend the limitations of our biology, including our brains, through technology. For many of us, our smartphones have already become our “extended memory,” our access to others, our business, our knowledge base. The expectation is that we will continue to enhance our human intelligence by exploiting the potential offered by that very intelligence.\(^{99}\) However, we must learn to control our negative human tendencies, especially through the evolution of AI and the development of Life 3.0 (technological stage), as Tegmark called it. This is expected to occur within the next 100 years, with the expectation being that life will design not only its hardware but also its software.

Epoch 6: *The Universe Wakes Up*. In a far-off future, “intelligence, derived from its biological origins in human brains and its technological origins in human ingenuity, will begin to saturate the matter and energy”\(^{100}\) and could circumvent the speed of light as a limiting factor on the transference of information to help the universe Wake

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\(^{94}\)Tegmark (2017, p. 26).

\(^{95}\)Kurzweil (2005, p. 15).

\(^{96}\)https://en.wikipedia.org/wiki/History_of_personal_computers

\(^{97}\)https://webfoundation.org/about/vision/history-of-the-web/

\(^{98}\)Kurzweil (2005, p. 17)

\(^{99}\)Brynjolfsson and McAfee (2014); Kelly (2016).

\(^{100}\)Kurzweil (2005, p. 21).
Up by evolving into “exquisitely sublime forms of intelligence.” This is, of course, very speculative at this point, and we will leave it at that for now, keeping in mind that double exponential growth applies not only to the exterior, the physical part, of the world but also to the interior, the consciousness and the unconsciousness part of being.

We humans have set ourselves up to become increasingly intelligent as we merge with technology to the point where we will combine biological thinking with technological “thinking.” But have we already arrived at the end of our biological evolution? Or are we not even close? Only the future will tell. As an AI-trained investor, I agree with Tegmark that we cannot completely eliminate the thought that humans may eventually build human-level artificial general intelligence (AGI) or even superintelligence—a discussion we will have later. Tegmark goes beyond the possibility of superintelligence creation, stating, “Since we humans have managed to dominate Earth’s other life forms by outsmarting them, it’s plausible that we could be similarly outsmarted and dominated by superintelligence”—a statement to which I would add the hope that we manage to avoid self-caused extinction in the process.

If we cannot decide for sure that superintelligence is unlikely, we had better get very smart very soon, understand it deeply, and begin taking safety precautions to prevent undesirable outcomes. This is why Tegmark founded the Future of Life Institute together with other concerned scientists including the late Stephen Hawking, Ray Kurzweil, and Dennis Hassabis, and serial entrepreneur Elon Musk. The institute came up with 23 Asilomar AI Principles. These have been adopted by thousands of AI researchers, concerned scientists, and business and industry people, including Tom and me. Safety engineering for AI means preparing by envisioning what could go wrong to make sure we get it right. This is why I am also involved with the augmented intelligence efforts of the institute.

1.3.4 Stages of Technology Acceleration

Within the context of technological evolution (Fig. 1.5), the majority of people generally think of Moore’s Law, named after Intel’s founder Geoffrey Moore by his friend Carver Mead, of Cal Tech.

But Moore’s Law refers to integrated circuits only and is the fifth in a lineup of technological evolutions after the mechanical calculators of the 1890s, Alan Turing’s relays, the vacuum tube, and transistor-based computers. The twentieth century was

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101 Bostrom (2014).
102 Tegmark (2017, p. 135).
103 https://futureoflife.org/ai-principles/
104 https://futureoflife.org/augmented-intelligence-summit-2019-2/
105 Moore (1965).
one of the cruelest centuries in human history, with two world wars and tens of millions of casualties, not to mention numerous other, more localized conflicts, but it was also one of the most radical in terms of human achievement. The data relating to the exponential technology growth represented in Fig. 1.5 show only progress; there is no hint of that progress being negatively affected by concurrent existential threats.

Kurzweil calls this type of evolution the Law of Accelerating Returns: the returns, such as the speed, massive cost reduction, or supremacy, of the evolutionary process, which explode exponentially over time. Within this context, it is important to note that Moore’s Law and the Law of Accelerated Returns are brilliantly recognized evidence of a technological reality that describes certain regularities,

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106 Kurzweil (7 March 2001) & (2005, p. 35).
directions, and patterns of evolution in the digitalization era. They are not the same types of laws we find in physics, for example, such as Newtonian laws or the laws of thermodynamics, which described how our world works until they were challenged by new laws such as quantum mechanics or Einstein’s theory of relativity. What we can expect, however, is that the next S-curve in Fig. 1.6 representing the next paradigm in technology has already started, but because it is deceptively flat at the beginning of the “S,” it would barely be on our radar. The curve will undergo a rapid phase of adoption and improvement, in which the tech that the curve represents becomes more powerful while the price of that technology drops. When the technology matures, it reaches its apogee, the curve begins to flatten out, and the next paradigm emerges. I cannot emphasize enough the importance of these S-curves in terms of reflecting the reality of fast-paced technology adoption. Due to the exponential nature of the curves and our human inability to interpret them properly, mainstream analysts have constantly misunderstood them and consequently did not forecast technology evolution accurately. They relied on their traditional linear forecasts, which do not fully capture exponential speed. The adoption of cell phones and the proliferation of photovoltaic solar panels are two everyday real-life examples that challenged the authority of linear forecasting.

When all the paradigms are stacked on top of each other as in Fig. 1.6, we can clearly see that the rate of technological advancement occurs at an accelerated pace alongside an exponential curve. This explains how our physical world is amplified by the digital world, which itself is colliding with, for example, artificial intelligence, blockchain, robotics, Internet of Things (IoT), neurotechnology, nanotechnology, bioinformatics, advanced material, robotics, quantum computing, and 3D printing. One exponential growth that is mentioned less often, but is not less relevant, occurred even faster than that of computation: growth in telecommunication technology for data transmission. Its explosive advance—due to accelerating developments in improved optical switches, electromagnetic technologies, and fiber optics—made the proliferation of today’s applications possible. Overall, I agree with Peter Diamandis that “tomorrow’s speed of change will make today look like
we’re crawling,” because evolution applies positive feedback in such a manner that more evolved forms from a previous stage of development are used to create the next stage. Thus, the next stage both transcends and includes the previous stage and the exponential growth progresses over time in such a manner that the rate of exponential growth itself grows exponentially. So, if you feel that the world is accelerating and getting more complex every day, or that you are struggling to keep up, never mind catch up, with the avalanche of information or emails, or the explosion of technological advances from autonomous cars to genetic engineering, 3D printing, or robotics, you are right. Why? Because the rate of exponential growth itself grows exponentially and the way in which it acts upon us means we can no longer see it. Furthermore, we are only at the beginning of these exponential curves, and the speed of progress will only increase if nothing happens to interrupt it. As we saw earlier, both the biological evolution and the technological evolution are examples of exponentially accelerating processes whereby the technological evolution has evolved to support the biological evolution. The key to technological evolution has been, and continues to be, the ongoing aggregation of humanity’s collective intelligence over millennia. The importance of grasping the full significance of the double exponential growth in technology therefore cannot be overstated, for it has the potential to help us overcome our global great challenges if properly leveraged and steered in the right direction. The nature of evolution will eventually flatten out Moore’s Law, but Kurzweil’s Law of Accelerating Returns forecasts the emergence of the next paradigm that will continue to drive exponential growth.

To understand this at a deeper level, let us take the time to look at it step by step and see (1) how accelerated computation brought us to where we are today and (2) how we can prepare for tomorrow.

Exponential investors, entrepreneurs, and other progressive stakeholders use the 6Ds of acceleration as a technological road map to predict future technologies and when and how to capitalize on the opportunities giving them an advantage over those who do not understand the implications of those new technologies. The 6Ds were popularized by Peter Diamandis and Steve Kotler in their book *Bold: How to Go Big, Create wealth, and Impact the World,* as a roadmap to show what can happen when an exponential technology is born and to help prepare for it, because technology never goes back and it provides opportunities to impact the lives of millions of people:

1. *Digitalization* is the logical consequence of the Law of Accelerating Returns. It enables technology to turn every product or service into “1’s and 0’s.” For example, music CDs followed analog vinyl albums and turned them into digital and thus, for most people, much better-quality music. From IBM to Google to Amazon, data center construction is mushrooming, yet those of us who invest in sustainable data centers clearly see how it is still normal in the construction

107 https://tinyurl.com/rnbcc27
108 Diamandis and Kotler (2015).
industry to work with pen and paper, and that the industry as a whole is having a hard time adapting to digitalization or adopting new technologies to scale production. A *Harvard Business Review* article from April 2016 noted that construction came second only to agriculture, out of 22 sectors covered in the article, in terms of being a late adopter of digitalization.\(^{109}\) This reluctance to embrace digitalization is not sustainable from a business perspective. Once something becomes digitalized, it becomes subject to exponential growth and the Law of Accelerating Returns. Thus, it becomes easily and ubiquitously accessible. We will see later how entire professions from legal clerks to radiologists will be transformed, even eliminated, through AI systems that are much faster and more accurate than humans. Now ask yourself: How are you digitalizing your investment processes and businesses?

2. Deception: As illustrated in the king and the sage story and in Fig. 1.4, in the early stages of digitalization, the process of doubling is deceptive, for we barely register its impact until we get to the second half of the metaphorical chessboard. And in Fig. 1.3, we saw how, at the dawn of the Internet boom, people in Germany did not see the same potential in the Internet that my husband and I saw. And look at CDs. They were sold for more than 10 years until the music industry began taking notice, at which point they finally became profitable. The German automobile industry, which still builds mainly combustion engines, is a contemporary example of the impact of deception. It was not until Tesla threatened the big players in that market, from Mercedes to BMW to Audi/VW, that they began to react. Rumor has it that the Quandt family built the electric cars i3 and i8 on their own, despite extreme internal opposition from their own company, BMW. Now ask yourself: What trends do you not see that may disrupt your investments and businesses?

One of my personal experiences of deception comes from the summer of 1985 when Tom and I were exchange students at Stanford. At that time, Ken Olsen, founder of Digital Equipment Corporation (DEC, the second-largest computer company worldwide at the time after IBM), decided not to productize the RISC-based (Reduced Instruction Set Computing) workstations that were leading-edge technology at the time and had been developed in his own company at DEC’s Western Research Lab in Palo Alto, by a team led by Stanford Professor Forrest Baskett. Olsen was so blinded (“deceived”) by his own old, proprietary hardware VAX and PDP/11 and operating system VAX/VMS that he refused to productize the modern RISC computer technology using Unix, the new operating system.

I remember as if it were yesterday how the RISC developers left the conference room weeping about the management decision from the east

\(^{109}\)https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digital-and-why
coast where DEC was headquartered. In our view, that incident was one of many similar ones that marked the beginning of the end for DEC. Within days, most RISC developers had left DEC and started their own companies, with Forrest Basket who co-founded Silicon Graphics being one of the most prominent. The rest is history.

3. **Disruption:** When the Internet became mainstream through the World Wide Web as technology that allowed us to share large amounts of data faster and cheaper, old business models were massively disrupted. The iPhone is the best example of this disruption, and not only in the context of the phone industry but also the camera, music, computer, and GPS industries, to name but four. But as we saw earlier, disruption is not a new phenomenon. Ken Olsen did not only not productize at the time the RISC computing technology; he also repeated his mistake with the PC and even AI, despite DEC being a market leader in the sector at the time with their Expert Systems. Olsen is also credited as having said, “There is no reason for any individual to have a computer in his home.”

Eventually, DEC was acquired first by Compaq, a workstation newcomer, and then by Hewlett-Packard. DEC had everything those companies needed to lead the world of computing at the time, but Olsen was somewhat deceived by his previous successes. I worked in his organization, so I knew that he did not listen to those who saw the need for change—that is, until DEC was literally disrupted. This simple example shows that disruption must be recognized and acted upon early to prevent destruction rather than disruption. According to research by McKinsey & Company, digitalization is high on the agendas of top CEOs and boards in order to prevent disruption that could lead to massive reductions in corporate profits globally from 10% of global GDP right now to less than 8% in 2025, offsetting the gains of the past three decades. But the question remains: How to implement an exponential jump in a global world with a linear and local mindset? Digital transformation means not only technology adoption and transformation but also a psychological mind shift, as well as behavioral change and adaptive processes (see below). Now ask yourself: What trends are there that will disrupt your investments and businesses? How might you or your life change when a certain product or service that you care about becomes disruptive?

4. **Demonetization:** I mentioned earlier that Moore’s Law is the fifth paradigm in technological evolution (Fig. 1.5) after the development of the electrotechnical, relay, vacuum tube, and transistor paradigms. It refers to the density of integrated circuits (IC), which has doubled every 18–24 months for more than 50 years now, leading to extraordinary computing power. It can be expected that this paradigm will eventually be replaced by the next one, which could very well be quantum.

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110[https://en.wikiquote.org/wiki/Ken_Olsen](https://en.wikiquote.org/wiki/Ken_Olsen)

111[https://tinyurl.com/ybtk4nxx](https://tinyurl.com/ybtk4nxx)
computing,\(^{112}\) but that is beyond the scope of this book. The result of Moore’s Law, however, has extended beyond an exponential increase in computation power; it has also led to massive cost reductions, or demonetization, as the cost of computer memory imploded and the communication bandwidth exploded. Once a device or application has been developed, the cost of replicating it is essentially zero. One current example of demonetization and dematerialization (see below) that I can relate to on a personal–professional level is data centers, which are springing up around the world as a result of digitization. According to the 2019 report by the Global Alliance for Buildings and Construction, IEA, and UNEP, the buildings and construction sector together account for “almost 40% of [global] energy- and process-related emissions” making “climate action in buildings and construction [as] among the most cost-effective” measures we could take.\(^ {113}\) However, the report continues, “the sector is not on track with the level of climate action necessary. On the contrary, final energy demand in buildings in 2018 rose 1% from 2017, and 7% from 2010.” Now ask yourself: What trends will demonetize the products and services in which you have invested and/or built a business around? How might you or your work change when a certain product or service that you care about becomes *demonetized*?

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**Investment Example: Ultra Energy Efficient Data Centers**

As our contribution toward reducing CO₂ emissions and to avoid building stranded assets for future generations, Tom and I invest in ultra-energy-efficient green data centers that use water-cooling rather than air-cooling technologies and thus can reduce construction costs and operating costs by up to 50%.\(^ {114}\) This way we can begin to decouple the increasing need for IT capacity from resource consumption. The greatest challenge we face when doing this is finding architects and construction companies that can build data centers using digital technologies so we can serve the accelerating demand and scale fast. In other words, we are positively disrupting these industries through the application of software within architecture design, vertical team development, paperless construction sites, and so on.

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5. *Dematerialization*: CDs and CD players replaced analog records and record players. However, with exponential growth in computation power and communication bandwidth, as well as significant reductions in storage costs, CD technology was in turn eventually *dematerialized* and eliminated all together. Today we download music and video files from one device to another in no time and at virtually zero cost (the ethics, copyright, and moral rights implications of this are outside the scope of this book). This is another everyday example of how

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\(^{112}\)https://tinyurl.com/y9q8yg5q

\(^{113}\)Global Alliance for Buildings and Construction, IEA and UNEP (2019, p. 3).

\(^{114}\)https://www.ta.hu-berlin.de/res/co.php?id=14935
exponential technology can turn material things into digital applications. We no longer carry around separate heavy GPS equipment, cameras, or video or audio recorders. These devices were dematerialized within only a few years and became an app on our smartphones at no additional cost to users—and the environmental bonus is that we have fewer pieces of equipment to dispose of when we want to upgrade to newer and better versions. Now ask yourself: How will dematerialization affect your own investments, products, or services? Are there any components that would become obsolete? How can you prepare for that?

6. Democratization: Technology has always had a massive impact on society, but it is only when it leads to democratization, or availability at massive scale, that we see how it can also lead to abundance for all. The Internet and mobile communication are prime examples of this. Once products and services are digitalized, they are globally available and thus become ubiquitous. For example, in 2016, 4.8 billion people—two-thirds of the world’s population—had access to mobile communication. This has had a remarkable transformative impact on all our lives. We have transformed how we work and do business with each other, how we connect, and how we entertain or educate ourselves. We raise and educate our children in a different way than we were raised and educated, and we connect with each other differently. Moreover, how we invest our talents, time, money, and resources is changing in significant ways too. Humans are explorers, and we now have the opportunity to become a multiplanetary species, as Elon Musk and other space investors such as Richard Branson, Peter Diamandis, and Jeff Bezos are trying to demonstrate. Now ask yourself: How might your product or service become easily available globally without barriers? What benefits and challenges could arise with the democratization of your products?

Now that we have a deeper understanding of the hidden determinants of technological acceleration, the 6Ds, let us take a closer look at how their manifestation increases that acceleration even more, especially as we embark on the Fourth Industrial Revolution. We will also take a closer look at various applications of exponentially growing technologies, from healthcare to entertainment, to better understand why these sectors are so attractive to investors and entrepreneurs. Moreover, we will look at what we can do to leverage these technologies to address the grand global challenges (GGCs).

115 https://www.ft.com/content/fcb1f970-031c-11e9-9d01-cd4d49afbe3
1.4 Disruptive Technologies and the Grand Global Challenges

The First Industrial Revolution was initiated in the eighteenth century through the invention of the water wheel and the steam engine, which enabled human civilization to move from being an agrarian and rural society to being a largely industrialized and urban society. The Second Industrial Revolution occurred between 1870 and 1914 through electrification, telephony, the phonograph, and light bulbs. It enabled the mass production of consumer goods and the invention of the internal combustion engine and marked the beginning of the massive growth society. The Third Industrial Revolution, also called the Digital Revolution, dates from the second half of the twentieth century, a time that saw wide-scale use of computers—including PCs—by the average person in their own home, general access to the Internet, and the overall development of information and communication technology (ICT). In The Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World, published in 2013, Jeremy Rifkin argues that technological advances have the potential to help us make our society a sustainable one through the large-scale development and deployment of renewable energy, the Internet of Things (IoT), and autonomous transportation. In his view, a circular economy, logistics, communication, and information management are key factors that can take us closer to such deep transformations. Rifkin was basically setting the scene for the Fourth Industrial Revolution, which builds on its predecessor and relies on the exponential development of technology that has, in turn, led to the development of a number of new fields, including AI, robotics, nanotechnology, biotechnology, quantum computing, 3D printing, and autonomous vehicles.

No matter what we do personally or professionally, we are all investors. We cannot not invest. Whether we have disposable income and decide to make a living out of investing per se, or we simply drive a car, or go shopping for food, clothing, or furniture, we are investors. As a species, we invest our time and money, one way or another, and thus influence the economy, politics, the environment, and the state of our planet. Investing is a very personal endeavor. Those of us who are professional investors and company builders are first and foremost human beings with their own preferences, knowledge, and expertise. This is why most investors focus their investment activities on what is immediately important and interesting and brings reward, joy, and fulfillment to them. As you read through this chapter, you will see that it is absolutely possible and realistic to leverage the incontrovertible power of capital to balance your goals as an investor with the goal of addressing the grand global challenges (GGCs).

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116 Schwab (2016).
1.4.1 Human Health and Longevity

What if we could eradicate diseases like Parkinson’s, Alzheimer’s, or ALS (amyotrophic lateral sclerosis, also known as Lou Gehrig’s disease), the progressive neurodegenerative illness that gradually paralyzed eminent physicist Stephen Hawking over the decades? What if we could eradicate the flu and deadly viruses such as HIV or eliminate pain for good? Would we do it? And if we did, who would decide who gets access to treatment? Governments, regulators, scientists, doctors, corporate leaders, individuals, parents? What if only the rich could afford it?

My beloved mother passed away after a decade of suffering from Parkinson’s disease. My father died of bladder cancer, my mother-in-law died of pancreatic cancer, and my father-in-law died of prostate cancer. This is why Tom and I are both deeply interested in alleviating suffering and have a history of investing in medical advances and healthcare in general. We view this as our humble contribution to the integral impact.

We already have ante-natal screening techniques such as amniocentesis that can detect genetic abnormalities in a fetus, and in jurisdictions where women have the right to choose, a fetus with genetic abnormalities may be aborted. Who decides what behavior is ethical and what is unethical? And what of gene editing? There is a growing fear among many people about the implications of gene editing not just for ourselves but also for future generations.

In the context of cancer, for example, the prospect of using gene editing to cure it would most likely be perceived as a positive use of the science, but what if people wanted to have their genes edited to look better or be better at sports? What about bio-engineering an unborn child to have blue eyes, blond hair, or athletic prowess? Should bio-engineering be globally outlawed? What if a country did not comply? Doping is already a serious problem in sport. What would global acceptance of gene editing mean for the Olympic Games? Or the Tour de France? Would all sports competitions become meaningless? What if some people could afford to bio-engineer their bodies to double their life expectancy while others could not afford to eat? The emerging field of digital and synthetic biology raises monumental issues, but it could also solve monumental problems while forcing humanity to come up with better global governance.117

The DNA of living organisms changes on an ongoing basis. It always has. Humans have been genetically modifying organisms for the past 10,000 years by, for example, crossing and selectively breeding new crops and new varieties of dogs and/or other domesticated animals; and viruses and bacteria have been performing

117https://tinyurl.com/y36zkoku
this kind of “gene swapping” for millennia. But researchers have only been able to sequence the human genome and develop the tools to help them change genomes relatively inexpensively in order to achieve specific, desired outcomes since research from the Human Genome Project, launched in 1990 and completed in 2003, became available. DNA editing and gene therapies have changed and will continue to change, life as we know it forever. According to experts, of 50,000 currently known genetic diseases that affect humans, simply swapping one base pair of genes for another in the genetic code has the ability to heal such 32,000 of them. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), for example, may allow us to beat diseases such as cancer and tumors, sickle cell anemia, and cystic fibrosis, to name only a few. By inserting designed molecules into cells, CRISPR changes the existing DNA sequence in that cell precisely, permanently, and relatively inexpensively. This gene-editing technology makes it possible to take a gene inside a virus and use that virus as a vehicle to inject the gene into target cells. It is groundbreaking, it is occurring now, and it has become extremely important in addressing pandemics such as COVID-19. We can use CRISPR-edited genes offer the prospect of allowing us to:

- Develop proper tests for viruses such as COVID-19, as soon as their viral sequence has been identified.
- Genetically alter species of mosquitoes in order to stop the spread of malaria, which is responsible for over 400,000 deaths each year.
- Genetically engineer animals such as horses to have higher muscle mass or cure muscular dystrophy in dogs.
- Enable same-sex healthy female mice to give birth to mice that are then able to have babies on their own.
- Begin to end addiction.

If we can heal muscular dystrophy in dogs, imagine what possibilities lie ahead for humans. We have already seen the use of CRISPR-edited genes in China to enable the birth of baby girls Lulu and Nana, who underwent gene editing while they were single-cell embryos to protect them from HIV. Another gene therapy has

118 Robinson and Dunning Hotopp (1 October 2016).
119 https://www.genome.gov/human-genome-project
120 https://www.sciencedaily.com/releases/2017/10/171025140532.htm
121 https://www.cell.com/nucleus-CRISPR
122 https://tinyurl.com/rhfqvuc viewed 3 April 2020.
123 Poinar et al. (2019).
124 Rooney et al. (2018).
125 Regalado (24 August 2018).
126 Li et al. (2019), https://tinyurl.com/yccetkg3
127 Li et al. (2019), https://tinyurl.com/yccetkg3
128 Cyranoski and Ledford (26 November 2018) and YouTube video https://tinyurl.com/qrkpf2b
been shown capable of altering and/or correcting vision in patients with a rare genetic cause of blindness called choroideremia.\(^{129}\)

These developments have unarguably offered hope to many of us, but they have also created major ethical and moral dilemmas, and 18 leading researchers, including some of the original developers of CRISPR/Cas9, recently called for a moratorium on editing human genes that can be passed on to the next generation.\(^{130}\)

As investors, we can use our capital to get directly involved in, influence, invest in, and potentially accelerate the development of such treatments and cures. The air travel analogy of securing your own oxygen mask in an emergency before helping others is sliding into cliché (not to mention bordering on ironic in the context of grand global challenges), but we cannot effectively address problems such as climate change if we are too unhealthy to function well. In other words, step one should be to address our own health problems, and we can do that through emerging technologies. For example, companies such as Human Longevity, BenevolentAI, Futura Genetics, and Stealth BioTherapeutics, to name only four,\(^{131}\) can help identify, and are increasingly able to address, individual genetic predispositions by leveraging advances in cell-therapy diagnostics, AI for medicine, genomic analysis, or mitochondrial dysfunction, and other health-related areas. Another area that Tom and I and other investors are watching closely is the field of stem cell research. Potential applications of human stem cells are to (a) help the 1.2 million people who await yearly an organ transplant by growing transplantable autologous human organs within the embryos of other mammals as an alternative to xenotransplantation (transplanting animal organs into humans)\(^ {132}\) and (b) naturally regenerate human joints, thus omitting the need to transplant artificial ones.\(^ {133}\) From an exponential investor’s perspective, the fascinating thing is that future solutions in healthcare are likely to come from US tech giants such as Apple, Amazon, Google, and IBM, as well as Asian tech companies such as Alibaba, Samsung, and Tencent. Apple CEO Tim Cook corroborated this when he said that “Apple’s greatest contribution to mankind” will be the empowerment of “the individual to manage their health.”\(^ {134}\)

And let us not forget bacteria. Bacteria have evolved over millennia to be able to react to chemicals in the environment, and that characteristic is being exploited now for the greater good. FREDsense,\(^ {135}\) for example, is a Canadian company that embeds small DNA circuits in bacteria to program them to monitor water quality, produce clean water, and treat wastewater. The signals produced by the bacteria are quantitative and highly accurate and can be picked up in real time by FRED (Field

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129Xue et al. (2018).
130Lander et al. (2019).
131https://www.humanlongevity.com/; https://benevolent.ai/; https://www.futuragenetics.com/en/; https://www.stealthbt.com/
132Yamaguchi et al. (9 February 2017).
133Oberbauer et al. (2015).
134https://mashable.com/article/tim-cook-apple-health/?europe=true#2_RYZocC7kqU
135https://www.fredsense.com/
Ready Electrochemical Detector), which will know instantaneously if a water supply is contaminated. FRED could be used to monitor all sorts of water supplies, including those in the mining, pharmaceutical, or sewage treatment industry. And because it is cost-effective, it could be used to transform water quality globally.

Bacteria can be bio-engineered for a number of other uses as well. Cambrian Innovations,\(^{136}\) for example, a company that was recognized in 2019 by the World Economic Forum as the circular economy tech disruptor, is using electrically functional microbes to produce electricity, heat, and clean water from sewage. And a team of researchers from the United Kingdom and Finland made headlines in the science world when they modified \textit{E. coli} bacteria to produce engine-ready propane, thus rendering fracking obsolete.\(^{137}\)

Moving up the evolution tree from single-cell bacteria, companies such as Modern Meadow\(^{138}\) are experimenting with higher life-forms by altering DNA and injecting it into living cells to grow collagen, an animal protein. That collagen is then used to bio-fabricate leather. It leaves a smaller planetary footprint than raising animals to do so. Several companies are also making progress in the production of meat protein without exploiting animals.\(^{139}\) The photograph below, which I took at the BIOTOPIA Eat Festival\(^ {140}\) in Munich, Germany, shows a mock-up of protein bars made of dehydrated cultured meat that are grown in a laboratory (Fig. 1.7).

\(^{136}\)https://cambrianinnovation.com/

\(^{137}\)https://labiotech.eu/industrial/imperial-turku-escherichia-coli-propane-biofuels/

\(^{138}\)http://www.modernmeadow.com/

\(^{139}\)https://www.scientificamerican.com/article/lab-grown-meat/

\(^{140}\)https://www.biotopia.net/en/ and https://www.biotopia.net/de/events/biotopifestival
Memphis Meats\textsuperscript{141} is a start-up that is producing meat from meat cells instead of animals. It cooks and tastes like regular meat and produces significantly smaller amounts of greenhouse gas emissions than traditional meat production—and there is no slaughter involved.

Organovo, which in 2009 became the first company to receive an NIH grant to create bio-printed blood vessels,\textsuperscript{142} has reproduced human tissue through bio-printing. 3D tissues can be used to study diseases and develop new drugs. Eventually, this bio-printing process could lead to printing tissues and organs for human transplant—a prospect that may sound far-fetched but was demonstrated on April 15, 2019, by Israeli scientists who successfully 3D-printed the first heart using a patient’s own cells.\textsuperscript{143}

These developments are all extremely promising and exciting. We are already using our smartphones, computers, and the Internet to extend our memories, knowledge, and communication skills; and we are fast approaching the point where we take for granted the practice of replacing various body parts with nonbiological materials such as titanium. This all suggests that we are moving from our biological-only evolution toward a hybrid construct that combines both biological and nonbiological elements, such as those that exist today, and will eventually include nanobots—also called nano-robots—that will enter our bodies at nanoscale. We would appear to be on the cusp of the next paradigm shift in human life, moving from biohumanism to neurohumanism to posthumanism.\textsuperscript{144}

**Four Bridges for the Future of Healthcare**

In *Fantastic Voyage: Live Long Enough to Live Forever*, Ray Kurzweil and Terry Grossman\textsuperscript{145} envision three bridges that could lead to radical life extension in humans between now and 2045:

- **Bridge One (now)** consists of today’s antiaging therapies and health advice found in mainstream culture and literature; for example, articles about healthy eating habits, the benefits of regular exercise, meditation, supplements, and the pursuit of a meaningful life.\textsuperscript{146} (In their 2009 sequel to *Fantastic Voyage*, *Transcendence: Nine Steps to Living Well Forever*, they provide a detailed guide to Bridge One.\textsuperscript{147}) The intention of Bridge One is to help slow the aging process until Bridge Two becomes available.

- **Bridge Two (envisioned for 2025–2030)** will draw on advances made during the biotechnology revolution and use antiaging knowledge harvested from decoding the biology of the human genetic and protein codes. Its goal is “understanding and

\textsuperscript{141}https://www.memphismeats.com/
\textsuperscript{142}https://organovo.com/
\textsuperscript{143}https://www.engadget.com/2019/04/15/tel-aviv-university-3d-printed-heart/
\textsuperscript{144}See https://transcend.me/pages/three-bridges-to-immortality
\textsuperscript{145}Kurzweil and Grossman (2004).
\textsuperscript{146}Kurzweil and Grossman (2004).
\textsuperscript{147}Kurzweil and Grossman (2009).
reprogramming the outdated software of life.”  

This could occur, for example, through genetically re-engineering DNA damage, by growing new organs, or by mending a heart after a heart attack.

- Bridge Three (2045–The Singularity) consists of the nanotechnology revolution and AI, which Durairaj et al. expect to help rebuild our bodies at the molecular level through the use of medical nano-robots. Nano-robots—also known as nanoids, nanites, or nanomites—are rather hypothetical devices that can range in size between 0.1 and 10 micrometers and are made up of nanoscale or molecular components. They are intended to perform microsurgery, nano dentistry, diagnosis and testing, gene therapy, and cancer detection and treatment, and thus heal disease.

Kurzweil and Grossman concluded that these three bridges might eventually lead to a tipping point in human existence, which Aubrey de Grey called the “longevity escape velocity”—the point when we should be able to stop and eventually reverse the aging process. In 2018, Kurzweil stated that humanity could possibly reach the “longevity escape velocity” around 2030. That would then induce Bridge Four, which would consist of the human ability to back ourselves up just as computers, smartphones, and other devices currently do. In other words, we could, in theory, encode our knowledge, skills, and personality in the form of data that could be uploaded and backed up in the cloud. In his view, “part of our thinking will be non-biological . . . [which] will be able to grow exponentially so it will ultimately predominate . . . That part will ultimately be so smart that it will be able to back up our biological part as well.”

### 1.4.2 In Service of Our Planet’s Health

Living in a solar-powered age is no longer a dream, because technology—note, not governments—is coming online to address the health of our planet. In 2018, reports showed that the United Kingdom was leading the way in solar power with a record weekly production of 533 gigawatt hours (GWh) of solar power displacing natural

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148 See Kurzweil quote from video at minute 17:30. Viewed 5 August 2018 at [https://tinyurl.com/ued3sfm](https://tinyurl.com/ued3sfm)
149 Perera et al. (2016).
150 [https://www.livescience.com/59675-body-parts-grown-in-lab.html](https://www.livescience.com/59675-body-parts-grown-in-lab.html)
151 [http://news.mit.edu/2015/laurie-boyer-mending-broken-heart-0803](http://news.mit.edu/2015/laurie-boyer-mending-broken-heart-0803)
152 Durairaj et al. (2012).
153 Cavalcanti et al. (2008).
154 Kurzweil and Grossman (2009, pp. 403–406).
155 De Grey and Rae (2007).
156 [https://www.youtube.com/watch?v=_ryxuehnp8k&feature=youtu.be](https://www.youtube.com/watch?v=_ryxuehnp8k&feature=youtu.be)
157 [https://www.youtube.com/watch?v=_ryxuehnp8k&feature=youtu.be](https://www.youtube.com/watch?v=_ryxuehnp8k&feature=youtu.be)
gas as the number one energy source between June 21 and 28, 2018. Germany also achieved a new record that year, with a monthly production of 6.17 terawatt hours (TWh), and Denmark had a record 361 h of sun in May, leading to a 33% increase in solar electricity production.\footnote{http://www.solarpowereurope.org/looking-back-on-a-record-breaking-solar-summer/} While governments of developed nations with strong economies appear to be slow to change—for example, Germany’s government decided to phase out coal only by 2038,\footnote{Commission on Growth, Structural Change and Employment-Final Report. Viewed 6 July 2019 at https://tinyurl.com/y49xcs8s} and the United States’ current government denies the very possibility of human-caused climate change—developing countries are actively moving toward the normalization of sustainable energy sources nationwide. Egypt, for example, is currently building the Benban Solar Park that will be the world’s fourth-largest solar power plant and will produce approximately 3.8 TWh per annum.\footnote{https://en.wikipedia.org/wiki/Benban_Solar_Park} The island nation of Palau, like the Maldives, Indonesia, and many other island nations, is under threat from rising sea levels due to climate change. Palau’s government has therefore pledged to move away from deriving 90% of the country’s current energy from diesel to using 100% renewable energy by the end of this decade. This transition will come at no cost to the government, as it has decided to use technology such as predictive analysis and AI to build not only a digital market place for solar panel manufacturers but also massive storage capacity to initiate the first and fastest shift to 100% renewable energy use.\footnote{https://www.fastcompany.com/90203041/this-island-nation-is-making-the-fastest-ever-shift-to-renewables} And things are happening in the private sector too. In an effort to capture a larger portion of the sun’s electromagnetic spectrum and to yield a 90% more efficient solar cell than traditional modules, NovaSolix, which focuses on renewable solar energy, announced in November 2018 its intention to use carbon nanotubes—which will cost 10% of the price of traditional solar modules—for its technology. The company plans to deliver electricity for 0.3 cents/kilowatt hour (kWh), making it cheaper to build new wind and solar power plants than to run existing, and subsidized, coal and gas plants: the “unsubsidized cost to build new utility wind and solar facilities is equal to, and often less than running already-built fossil facilities.”\footnote{https://pv-magazine-usa.com/2018/11/23/all-i-want-for-christmas-is-a-90-efficient-solar-panel/} This is extremely significant, because now the market, not slow regulators, will dictate reasonable behavior in terms of addressing climate change. Technology is also critical for the unmanned aerial vehicles (UAVs), solar cars, and other electric vehicles that aim to replace current fossil fuel-based transportation and help soothe some of our planet’s pain. For example, Gen4solar, the world-record holder for single-junction solar cell efficiency, has improved the weight-to-power ratio of its solar cell by 160%.\footnote{https://tinyurl.com/uo5q2cr} The intention is to accelerate the adoption of autonomous electric vehicles that can recharge while in use, to extend their...
endurance, and to keep the impact on aerodynamics and design to a minimum. Solar energy must be stored somewhere, of course, and technology is also helping improve storage capacity.

Energy and storage are crucial for digitalizing sustainable mobility. The solutions currently available can only benefit from further development, and this in turn will require the development of new materials. BP and Daimler have both invested in Storedot, which develops modern materials through a combination of nanotechnology and new organic compounds. Storedot has developed technologies for optimized, fast-charging batteries for mobile devices and lithium-ion batteries that can be charged in 5 minutes and have a 500-kilometer range, and WiTricity, a Massachusetts-based company, is working on a cordless technology that should deliver power to car batteries in a wireless manner using magnetic resonance. WiTricity’s technology has the potential to make charging car batteries simpler than filling up your car at the pump in the traditional (that is to say, current) way.

The price of lithium-ion batteries has dropped by an average of 20% per annum since 2010, further contributing to the accessibility factor. Battery technologies are a good example of the challenges we face in balancing the requirements of the SDGs and respecting planetary boundaries. There is significant room for improvement with respect to their environmental and social friendliness, but they are a move in the right direction and, with the proper mindset, we have the potential to overcome their current drawbacks. The important part is the storage aspect. The Tesla Gigafactory 1 is delivering an annualized run rate of approximately 20 GWh, which makes it the highest-volume battery plant in the world. It “produces more batteries in terms of kWh than all other carmakers combined.” Tesla is planning to build an additional 10 Gigafactories worldwide after its Buffalo, NY, and Shanghai, China, plants have been completed in order to accelerate the adoption of renewable power technology and help us break free of the current fossil-fueled economy that is so damaging to the planet.

These technologies are already marking the beginning of the end for coal, gas, and diesel, and they are contributing significantly to the implementation of the Paris Agreement, because while solar energy may not be subsidized, it makes more economic sense to use it rather than energy produced through subsidized coal power plants. According to research by Carbon Tracker, 42% of coal plants are running at a loss today. This is predicted to increase to 96% by 2030, making coal-produced energy financially not viable. In the words of Peter Diamandis, “we no

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164 https://www.store-dot.com/
165 http://witricity.com/
166 https://tinyurl.com/ybvoq6tg
167 Korthauer (2018).
168 Tesla SEC filing. Viewed 12 March 2019 at http://ir.tesla.com/node/18941/html
169 https://en.wikipedia.org/wiki/Gigafactory_1
170 See 42% of Global Coal Power Plants Run at a Loss, Finds World-first Study (30 November 2018). Viewed 3 April 2020 at https://tinyurl.com/vwzf47j
longer kill whales to light our night and we will stop ravaging mountain sides as well.”171

1.4.3 Food and Water

A January 2019 EAT-Lancet Commission report titled Food in the Anthropocene: The EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems declared 2019 the year of nutrition and confirmed that food production is the largest source of environmental degradation.172 With the world’s population expected to reach 10 billion by 2050,173 an overhaul of current food production systems is key to the successful implementation of the Paris Agreement and Agenda 2030. Whether we act as individuals or corporate entities, we can all help to make food production sustainable by:

- **Eliminating fossil fuels use**, thus turning land use into a net carbon sink
- **Stopping net expansion of cropland** by optimizing current land use for food production
- **Significantly reducing water use**
- **Improving fertilizer technologies**
- **Changing our eating habits**
- **Reducing food waste**

What is the state of the art in terms of technology-driven, sustainable food production and water supplies, and how do we repair a damaged environment? In the immediate term, vertical agriculture could hold the key to sustainable food production in urban areas. A large percentage of the growing population will live in megacities, and urban farming offers a way to provide them with fresh food sourced locally, making it both cheaper and environmentally more responsible thanks to the reduced need for transportation to market. AeroFarms, for example, is a mission-driven, certified B (benefit) corporation that uses a patented aeroponic technology to grow plants that need less than 95% of the water generally needed in a conventional outdoor farm, no sunlight, and no soil or pesticides.174 It operates all-year-round inside a former steel mill and paintball arena in Newark, New Jersey, and annually yields approximately 39 times more food per square meter than a traditional farm—and with minimal environmental impact. (“A benefit corporation is a new legal tool that creates a solid foundation for long term mission alignment and value creation. It protects mission through capital raises and leadership changes, creates

171 From the Abundance 360 conference 2019 introduction https://tinyurl.com/y2trxgxf
172 Willett (19 January 2019). See https://tinyurl.com/sublsse and https://tinyurl.com/t3huy2c
173 Roser and Ortiz-Ospina (2017a/2013).
174 https://aerofarms.com/
more flexibility when evaluating potential sale and liquidity options, and prepares businesses to lead a mission-driven life.”\(^{175}\)

Iron Ox, a fully automated farm, is dedicated to addressing multiple grand global challenges, including climate change, by eliminating food waste and providing food security for our ever-growing population through sustainable and scalable food production. It operates inside a former commercial warehouse in San Carlos, Silicon Valley, and uses robots to grow green leafy foods. Its “hydroponic growing system uses 90% less water over traditional farming while growing 30 times the amount of crops” on the same amount of cultivated land.\(^{176}\)

A particularly notable development in this arena occurred on November 1, 2018, when Spread Co., the world’s largest automated vertical farm organization, started shipping leafy lettuce from its Techno Farm Keihanna in Kyoto, Japan.\(^{177}\) The Kyoto farm is the world’s largest in a series of robotic vegetable farms with a production capacity of approximately 30,000 heads of lettuce per day. It is slated to expand to more than 100 locations through a franchise model. Spread Co. uses specialized LED lights designed for vertical farming as well as IoT/AI technologies and self-contained robots. The company has been able to reduce its energy use by 30% and water use by 98% through recycling and does not use any pesticides. The indoor hydroponic lettuce are planted on shelves that are stacked vertically (as the farm category name suggests). This approach allows island nations like Japan to become more self-sufficient in their food production while significantly reducing their land use.

All these technologies offer hope for the future of sustainable agriculture, but it will take time for them to be scaled globally. And of course, while more automated farms could help address climate change, they could also lead to job losses for workers whose livelihoods are currently dependent on agriculture. The future of work is one of the most complex topics that must be addressed within the context of the exponential technology evolution and that I discuss throughout this book. Retraining programs and a universal basic income, also known as guaranteed minimum income, and other initiatives could help address equity imbalances.

**Water**

Technologists are also working on solutions to meet the increasing need for potable water on our climate change-stricken planet. In October 2018, the Water Abundance XPRIZE awarded its grand prize of US$1.5 million to the Skysource/Skywater Alliance for accomplishing a true moonshot (see the moonshot section in Chap. 3) by developing in a 2-year competition a technology to “harvest water out of thin air” using energy-efficient technologies.\(^{178}\) The high-volume water generator can be used anywhere, including disaster areas, and can extract a minimum of 2000 liters

\(^{175}\)https://benefitcorp.net/what-is-a-benefit-corporation

\(^{176}\)http://ironox.com/

\(^{177}\)http://spread.co.jp/en/

\(^{178}\)http://www.skysource.org/
of potable water per day out of the atmosphere by using 100% renewable energy for less than US$0.02 per liter. Another XPRIZE was awarded to 10 finalists in the global US$20 million NRG Cosia Carbon Prize\textsuperscript{179} for developing technologies within the CarbonCure global impact effort to profitably sequester and transform CO\textsubscript{2} emissions from a gas or coal plant into useful products whose value exceeded the cost of extracting the CO\textsubscript{2}. These products could be, for example, nanoparticles that enhance green concrete, plastics, or batteries.

**Lab-Grown Meats and Plant-Based Burgers**

Personally, I have kept meat out of my diet for four decades now. However, on August 14, 2018, I could not resist trying my first meat analogue hamburger, when Jamis McNiven, the owner of the legendary Buck’s of Woodside Restaurant in California convinced Tom and me to try his Impossible Burger, a plant-based protein burger. As a non-meat eater, I was not really in a position to judge its quality, but Tom, a confirmed carnivore, loved it—and we were both thrilled to read in the Buck’s menu: “The future is here” from the perspective of addressing world hunger.

Biotechnology can be used to produce environmentally friendly lab-grown meats through in vitro cultivation of animal cells, a process that uses the extraction and proliferation of animal stem cells to create another product (it is uncannily similar to beer brewing). Livestock in the meat industry are estimated to devour 30% of the world’s grain, account for 25% of land use, and are chief contributors to CO\textsubscript{2} emissions. This is why Just Inc., a Silicon Valley-based start-up that made its name by making vegan eggs from mung beans, later partnered with Japanese company Toriyama to produce Wagyu beef from cell lines. However, just like one of its main competitors, Aleph Farms in Israel, Just Inc. expects it will be a couple of years before it can deliver the first cell-based steak.\textsuperscript{180}

Although companies producing lab-grown meat have attracted significant private investments, some scientists criticize the fact that the acquired knowledge is often protected as trade secrets, and furthermore, progress has not been fast enough to date to make artificial meat widely available to address hunger and poverty.\textsuperscript{181} A new grant of US$3 million, made available in February 2019 by the Good Food Institute,\textsuperscript{182} a think tank in Washington, DC, could help change that, but the grant money is rather a drop in the ocean compared with the tens of millions of dollars invested in Memphis Meats alone over the last 2 years by Bill Gates and Richard Branson. The Good Food Institute grant money will be split between six lab-grown meat and eight plant-based protein projects that hope to shorten the time from lab to market. These synthetic meats could ultimately provide a viable solution to global hunger by using less energy, less land, and less water. However, there is still uncertainty around greenhouse gas emission levels. The extant research suggests clean meat could lead

\textsuperscript{179}https://carbon.xprize.org/prizes/carbon/teams
\textsuperscript{180}https://en.wikipedia.org/wiki/Aleph_Farms
\textsuperscript{181}https://tinyurl.com/y3el5vhm
\textsuperscript{182}https://www.gfi.org/gfi-research-grant-winners-2019
to reduced global warming in the short term because its production does not generate the potent methane that cows do, but the large-scale production process of synthetic meat does result in CO$_2$ emissions, which in the long term—1000 years or more—could become significant.\textsuperscript{183}

**Addressing the Plastics Problem**

There is optimism in some quarters that we may eventually be able to address the plastic soup in our oceans.\textsuperscript{184} In a classic example of why we should never underestimate the power of one, in 2013, 16-year-old Boyan Slat studied the problem of plastic in the ocean for a school science project. Two years later, he founded The Ocean Cleanup to address the problem.\textsuperscript{185} Today, The Ocean Cleanup is close to rolling out an autonomous, solar energy–powered and scalable system to allow us to clean up ocean plastic before it breaks down into microplastics. Despite continued technological setbacks, the company is aiming for a plastic-free ocean by 2050. In a similar vein, scientists at the US National Renewable Energy Laboratory (NREL) recently encountered a transmuted enzyme that eats plastic,\textsuperscript{186} although more research is required to make it deployable at large scale. Hope comes also from the traditional chemical industry, which finally seems to be realizing that recycling plastics could become an important profit source as the “global plastics-waste volumes [c]ould grow from 260 million tons per year in 2016 to 460 million tons per year by 2030.”\textsuperscript{187} Furthermore, as Arnout de Pee et al. noted in a 2018 article for McKinsey & Company, major players in the chemical industry have begun to recognize that “ammonia, cement, ethylene, and steel companies can reduce their carbon-dioxide (CO$_2$) emissions to almost zero with energy-efficiency improvements, the electric production of heat, the use of hydrogen and biomass as feedstock or fuel, and carbon capture.”\textsuperscript{188} De Pee et al. noted in the same article that half of global CO$_2$ emissions result from the manufacturing of ammonia, cement, ethylene, and steel and that the “decarbonization of these sectors will cost [investors, regulators, and businesses] between $11 trillion and $21 trillion through 2050.” In a 2018 report for McKinsey & Company, the same authors observed that “industrial companies can reduce CO$_2$ emissions in various ways, with the optimum local mix depending on the availability of biomass, carbon-storage capacity and low-cost zero-carbon electricity and hydrogen, as well as projected changes in production capacity.”\textsuperscript{189}

All the developments discussed above offer tremendous hope because they confirm that humanity has the ability to address major issues such as decarbonization

\textsuperscript{183}Lynch and Pierrehumbert (2019).
\textsuperscript{184}Moore and Phillips (2012).
\textsuperscript{185}https://www.theoceancleanup.com/
\textsuperscript{186}Austin et al. (2018).
\textsuperscript{187}Hundertmark et al. (2018).
\textsuperscript{188}De Pee et al. (June 2018, p. 7).
\textsuperscript{189}De Pee et al. (June 2018, p. 7).
of industry, solving the plastic soup problem, and carbon sequestration—we just need to adjust our mindset and focus on solving them.

### 1.4.4 On Mobility and Transportation

According to a 2019 Morgan Stanley report, internal combustion engines (ICE)) are expected to be outnumbered by battery-powered electric vehicles (BEVs) before 2050, as the number of electric vehicles is growing exponentially worldwide and is expected to reach 1 billion by 2050, or as much as 90% of all vehicle sales. This development, if it can occur sustainably within the limits of the planetary boundaries, will most likely be fueled less by traditional car manufacturers such as General Motors, Daimler, Porsche, or VW, which currently manufacture expensive BEVs and autonomous vehicles (AVs), and more by arrivistes such as Great Wall Motors, a Chinese company that is, at time of writing, selling an electric car with a 350-kilometer battery range for only US$8680. Morgan Stanley expects that four out of five cars sold worldwide in 2050 will be BEVs. This shift will disrupt not only the traditional auto manufacturers, but also the automotive supply chain, components suppliers, semiconductor manufacturers, chemical producers, and other players in auto-related capital goods.

Like BEVs, AVs could become an essential factor in decreasing pollution worldwide. Tom and I believe that the transition toward using both BEVs and AVs will occur much faster than is currently estimated by linear-thinking analysts, although the high purchase price, limited range of a single charge, limited access to plug-in stations, and limited battery life might slow their adoption in the early stages. Nevertheless, a self-driving future is most definitely in sight, as numerous companies are already testing self-driving cars in California alone. On January 30, 2019, Argo AI, an AV start-up in which Ford invested US$1 billion in 2017, became the 62nd company to be granted a testing permit for autonomous vehicles by the California Department of Motor Vehicles, following in the footsteps of Bosch, Honda, Tesla, VW, Waymo, and Apple, to name but six. Amazon is said to be testing autonomous trucks by Embark to deliver goods to their customers, and in October 2018, the US National Highway Transportation Safety Administration issued an updated AV policy in anticipation of further developments. Other AV initiatives are being launched in heavily polluted countries like China, which is on track to become the first country to deploy AVs at large scale, despite its need to source some fundamental components such as drivetrains, semiconductor chips, and advanced battery technology. According to a report by Roland Berger, a German consultancy, this is

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190 [https://www.morganstanley.com/ideas/electric-car-supply-chain](https://www.morganstanley.com/ideas/electric-car-supply-chain)

191 [https://electrek.co/2018/12/27/great-wall-motor-ora-rl-all-electric-urban-car](https://electrek.co/2018/12/27/great-wall-motor-ora-rl-all-electric-urban-car)

192 [https://tinyurl.com/y29gcdw](https://tinyurl.com/y29gcdw)

193 See [https://www.nhtsa.gov/vehicle-manufacturers/automated-driving-systems](https://www.nhtsa.gov/vehicle-manufacturers/automated-driving-systems)
not only due to the techno-utilitarian attitude of the Chinese government, which favors exponential technologies, but also to the openness of Chinese market, which absorbed more than half of the electric vehicles sold worldwide, and a global network of clients who are open to adopting new technologies in the auto sector. Moreover, the Chinese authorities relaxed their regulatory guidelines for AVs, gave permission to non-Chinese manufacturers such as Daimler and BMW to test their AVs in cities like Beijing and Shanghai, doubled the installed base of their battery-charging infrastructure, ended the ban on ownership of electric vehicles made by foreign manufacturers, and introduced limits on registrations for traditional cars (i.e., ICEs).

Eventually, current transportation systems will be expanded by regulators to address the micro-mobility market as well and will include drones and smaller delivery vehicles which, within the context of the current COVID-19, have gained increased attention. With US$5.7 billion in start-up investments since 2015, the micro-mobility market has also been growing two to three times faster than the car-sharing or ride-hailing markets. More than 85% of those investments targeted China, and several micro-mobility start-ups, such as e-scooter manufacturers Bird and Lime, have amassed valuations estimated at more than US$1 billion.

Another relevant development is LiDAR technology. LiDAR is a surveying method that helps determine the 3D representations of a target, as well as the distances and angles between them. It is the central technology used in autonomous vehicles (with the exception of Tesla vehicles, which use only cameras, radar, and ultrasonic sensors) and works by illuminating a target with a pulsed laser light and measuring the reflected pulses with a sensor. It is a prime example of the massive demonetization process of exponential tech at work: The price of one LiDAR device dropped from about US$80,000 in 2007 to a few thousand dollars at the time of writing, and it is likely to drop even further to only a few dollars once it becomes available on a chip.

In June 2017, Tom and I attended the annual gathering of Toniic, one of the largest global private impact investors networks, in Berlin. While there, I had the opportunity to meet, and listen to a report by, fellow exponential investor Jamie Arbib. We were shocked and dumbfounded by the groundbreaking research results published in his paper. Arbib and his co-researcher, Tony Seba, collected research data and fed it into a systems dynamics model that they had developed. In their report, *Rethinking Transportation 2020–2030: The Disruption of Transportation and the Collapse of the Internal-Combustion Vehicle and Oil Industries*, they draw

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194 Berret (1 October 2018).
195 https://tinyurl.com/yxaqwdrd
196 Heineke et al. (January 2019).
197 https://techcrunch.com/2018/12/03/will-uber-gobble-up-lime-or-fly-off-with-bird/
198 https://oceanservice.noaa.gov/facts/lidar.html
199 Lee T. (2018b).
200 Arbib and Seba (2017).
on their results to argue that humanity is currently embarking exponentially rapidly on the most disruptive era in the history of transportation. According to the World Health Organization, the number of yearly fatalities due to traffic-related incidents throughout the world is 1.25 million.\textsuperscript{201} Arbib and Seba showed that within 10 years of regulatory approval of AVs, this death toll could be avoided.

The driverless car era has already begun. Waymo, the driverless car subsidiary of Alphabet, had approval to build an AV factory in Michigan by January 2019.\textsuperscript{202} Current expectations are that 95\% of the population in the United States will eventually use, or at the very least have access to, on-demand electric AVs. These AVs will not be owned by individuals, says Arbib, but by savvy business people who will build entire fleets to service the population. In the beginning, existing ride-hailing companies such as Uber, Lyft, and Didi will probably try to grab large portions of the new market and newcomers will require large amounts of capital investments for market entry. Arbib calls this emerging type of business Transportation as a Service (TaaS).

A switch to TaaS could have a tremendous impact on consumer spending, as it would mean that the average American family would no longer need to own their own cars and could, for example, save up to US$5600 per annum in transportation costs, which is the equivalent of receiving a 10\% net salary increase. As soon as AVs are approved, electric AVs are likely to replace human-driven ICEs due to their lower maintenance, energy, and insurance costs, and as demand for oil drops, oil prices are expected to tumble, along with their entire value chains. In addition, utilization rates for AVs are expected to be 10 times higher than for ICEs, with up to 1 million kilometers driven per vehicle lifetime by 2030. The TaaS business model could mean the driving cost per kilometer could be as much as 90\% cheaper compared with the cost of buying a new, traditional car and, in terms of operating costs, could be half the cost of driving a regular ICE.

### The Future Is Closer Than You Might Think

Google’s Waymo launched its driverless ride-share and the world’s first self-driving taxi service in December 2018 in the suburbs of Phoenix, Arizona. In March 2018, it started to offer test rides to regular—that is, not research participants—people.\textsuperscript{203} We may be riding a robot taxi soon, a fact that has become particularly relevant within the context of the COVID-19 pandemic and our need for social distancing.

Working on the assumption that the driverless car phenomenon truly takes off, McKinsey substantiates Arbib’s findings in a recent report\textsuperscript{204} by emphasizing the

\begin{itemize}
  \item \textsuperscript{201}https://www.who.int/gho/road_safety/mortality/traffic_deaths_number/en/
  \item \textsuperscript{202}https://futurism.com/waymo-approval-open-driverless-car-factory-michigan
  \item \textsuperscript{203}https://futurism.com/report-waymo-unveil-first-driverless-rideshare
  \item \textsuperscript{204}Pizzuto L et al. (2019).
\end{itemize}
role China will play within this arena, a role expected to catapult it into a market leadership position that could transform “mobility” (the term McKinsey uses in reference to transportation) in a fundamental way. McKinsey expects a substantial share of the mobility market value to shift within a 9- to 10-year time frame away from car purchasing toward a mobility-as-a-service (MaaS—in essence, another expression for TaaS) business model whereby clients will pay per driven kilometer and not per car ownership. New business models will emerge and be driven, as it were, by software and data through a convergence of various disparate industries including the automotive, transportation, software and hardware, and data services industries. Technology players such as Baidu, Tencent, and Waymo are already building or buying AVs to provide transport/mobility services to clients. Waymo, for example, has already decided to transform a factory in Detroit, Michigan, into an autonomous vehicle manufacturing facility. It will work with traditional car manufacturers to add autonomous hardware to existing designs such as Chrysler Pacifica Hybrid Minivans and Jaguar Pace SUVs. And automaker Byton is vertically integrating its vehicles to create “electric cars that are smart, connected, and autonomous. The car will become a platform—a smart device on wheels.” Carsten Breitfeld, founder of Byton, insists that in order to survive in the transport market of the future, organizations need both a mindset and a culture that are more about “consumer electronics and software and the internet and less about the car industry.” Breitfeld considers China to be the perfect country to determine the future of transport because:

- **It is the world’s largest automotive market**, with more than 30 million cars sold annually.
- **The speed of growth is swift in all areas.**
- **There is plenty of capital available**, and investors are flexible and willing to invest not only in early-stage companies but also in teams and ideas only.
- **There is strong political will** to support future developments in all areas, but especially smart electric transportation.

Byton was able to raise US$240 million for its A-round based only on the company’s design, team, and business plan. Tesla decided to go much further, announcing on April 24, 2019, its intention to roll out its Robo-Taxis plans, which it hopes will address climate change, the future of car ownership, and the future of work, and show how Tesla owners can become ridesharing entrepreneurs and financially independent, making up to US$30,000 per year. In 2020, Tesla plans to have overcome the current massive regulatory hurdles and have 1 million Robo-Taxis on the road in order to disrupt the disruptors—that is, the ride-sharing

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205 [https://tinyurl.com/y4t5otpt](https://tinyurl.com/y4t5otpt)
206 Byton founder Carsten Breitfeld. Viewed 17 March 2019 at [https://tinyurl.com/y2xgb1cj](https://tinyurl.com/y2xgb1cj)
207 Carsten Breitfeld. Viewed 17 March 2019 at [https://tinyurl.com/y2xgb1cj](https://tinyurl.com/y2xgb1cj)
companies Lyft and Uber, whose market capitalizations are US$16 billion and an expected US$90 billion, respectively.208

**Electric Aircraft**

A particularly radical departure from traditional transport systems, and one with growing significance, is the use of electric aircraft systems such as unmanned drones and vertically lifting aerial vehicles. These are revolutionizing the future of transport and mobility, democratizing the sky, and enabling new participants to join in. Drones supported by advanced data analytics become geospatial tools. Equipped with high-resolution cameras and detailed sensors, drones have already become indispensable in e-agriculture and are revolutionizing precision agriculture.209 By embedding new technology into agricultural processes, they can contribute to increased crop yields and optimize crop and land surveillance, which will all combine to provide food security for this century’s predicted world population of 10 billion.210 And because they have freedom of movement in the sky, drones can deliver medicine to hazardous or otherwise inaccessible areas, making life safer for those with dangerous jobs—for example, roofers, toxic chemical workers, electrical power installers, and tree surgeons—and providing a lifeline for people living in remote areas or trapped in disaster areas.

Drones are also disrupting current modes of transport. German company Lilium, for example, created the world’s first electric vertical take-off and landing jet (eVTOL) and is in the process of creating the first electric air taxi, which will radically alter how we travel.211 The air taxi is not a flying car but it could become one. Uber revealed in 2018 its drone-like flying vehicle prototype for an aerial taxi service as part of UberAIR. It also announced plans to test these vehicles in Dallas and Los Angeles by 2020 and hopes to ultimately operate what it calls skyports. The Uber electric flying taxi will be manufactured by Bell Helicopter, is scheduled to be operational by 2023, and will be a combination of a “traditional helicopter, a light aircraft, and a passenger-carrying drone.”212 The requisite air traffic systems will be developed in partnership with NASA. In January 2019, Boeing NeXt completed the first flight of its autonomous passenger air vehicle (PAV), which is 9-meters long, can carry up to 227 kilograms, and has a range of 80 kilometers.213 Also in January 2019, Bell introduced eVTOL, an urban hybrid-electric flying taxi that should be in service in the mid-2020s and will use Uber’s own air traffic system, currently under development.214

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208 https://tinyurl.com/y6nrcbs6
209 Adamchuck (2013).
210 Sylvester (2018).
211 https://lilium.com/
212 https://tinyurl.com/y8edxska
213 https://tinyurl.com/ydbjrc5a
214 https://www.theverge.com/2019/1/7/18168814/bell-air-taxi-nexus-uber-flying-car-hybrid-ces-2019
In a classic display of capitalist anticipation, some developers are already constructing luxury apartment buildings with landing pads on their rooftops. And in capital-abundant cities such as Dubai, police are testing Hoverbikes in an effort to be ready for the introduction of aerial vehicles by 2020.

In a slight twist to the transportation story, when Tesla founder Elon Musk decided to do something about the “soul-destroying” traffic in Los Angeles, he opted to do something that was, compared to his previous ideas such as Tesla and SpaceX, “boring.” He announced that he wanted to build an underground transport system whereby people and cars would be taken off regular roads and shuttled around at high speed on electric drivetrains. Thus the Boring Company was born, and in December 2018, the first test tunnel was unveiled in Hawthorne, California. Musk hopes to be able to construct his tunnels at an all-inclusive, final price of US$10 million per mile—which sounds like a lot if you do not know that the current price per mile for a regular highway system is US$200 million–US$500 million.

Managing the Change

Despite their advantages and their ability to address societal challenges worldwide by transforming business models, governments and regulators are still struggling to find a balance between encouraging innovation and attracting further investments and developing policies on data ownership, infrastructure growth, community safety, security, privacy, and airspace management, all while winning and maintaining public confidence. The environmental impact of TaaS (or MaaS) is expected to be dramatic: current estimates are that it will cut air pollution and greenhouse gas emissions by up to 90% and energy demand by 80%. As solar and wind technology are also expected to disrupt the current electricity infrastructure at the same time, we may even have a carbon-free road transportation infrastructure by 2030. Furthermore, James Arbib and Tony Seba predict that the geopolitical significance of oil will vastly weaken, potentially leading to the destabilization of OPEC countries unless they diversify and/or accelerate their move toward the solar age. Conversely, lithium-based geopolitics will develop, as lithium, nickel, cobalt, and cadmium are (at least currently, but who knows what discoveries lie ahead) needed to manufacture batteries. However, the dependency upon these materials is neither comparable to nor as critical as our dependency on oil, because they are needed to build the batteries for the vehicles, are recyclable, and still have 80% capacity when they are taken for recycling. Compare this with the characteristics of fossil fuels.

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215 https://therealdeal.com/miami/2018/12/08/luxury-condo-developers-in-miami-add-landing-pads-for-flying-cars/
216 https://gulfnews.com/uae/crime/video-cops-on-flying-bikes-to-patrol-dubai-by-2020-1.60260681
217 https://www.youtube.com/watch?v=6t8BiLK0mbE
218 Arbib and Seba (2017).
The social and economic impact of TaaS is likely to be very significant. On the one hand, the time gained from being driven rather than driving could lead to a GDP increase of an additional US$1 trillion by 2030 in the United States alone; on the other hand, it will reduce the number of jobs in all disrupted areas. Arbib and Seba are quite clear about the fact that in the United States, there will be job losses of up to 3% of the workforce through the introduction and normalization of AVs, which could amount to a drop in income of US$200 billion. However, some new jobs such as robot repair technicians (see Sect. 1.5, Artificial Intelligence: Revolution, Emergency, Salvation? for more on this) will also be created and mobility will increase, especially in urban areas. According to a UN report, about 23% of the world’s population lived in a city with at least 1 million inhabitants in 2016.219 By 2030 this number is expected to reach 27%, adding to the already dire traffic situation.

Sustainable investors, therefore, have a rather significant market opportunity to make a huge holistic impact. For example, Munich, Germany, a rather conservative city, has already started to implement a smart city initiative together with 11 partners from the business and academic worlds. The project district is called Neuaubing-Westkreuz/Freiham, and its 30,000 residents’ quality of life should be improved in a sustainable manner once the project has been finalized. By applying exponential tech and intelligent use of data, the project intends to reduce fossil fuel consumption and CO₂ emissions by more than 20%, while energy efficiency and the use of renewable energy are both expected to increase by more than 20%. The goal is to create a completely CO₂-neutral city by 2050. In order to achieve all that, the city plans to invest around 20 million Euro in the 350-hectare wide district, with 6.85 million Euro of that coming from the EU.220

1.4.5 Convergence of the Internet of Things

The Internet is already connecting billions of us on and off the planet every day, and 5 billion more people are expected to come online over the next decade. The benefits of being connected are accompanied by a whole host of privacy and security issues, because every single device that comes online is vulnerable to being hacked, an issue that I will touch on briefly at the end of this chapter. Within 5 years there will be potentially 20–30 billion new devices connected with one another. This translates as two to three connected devices for every human on Earth, whether those devices are in our homes, cars, businesses, pets, even our own bodies.

The Connected World

Exponentially growing technology plays a key role in the transition from an analog world to a digitalized one, with the ultimate goal being a planetary nervous system in

219 https://tinyurl.com/zz3t9y9
220 https://www.smarter-together.eu/cities/munich-/
which every single person and thing can be connected. In 2017, the Internet access rate worldwide was estimated at 48%, with 81% access in developed countries and 41.3% in emerging markets.\footnote{https://www.statista.com/statistics/209096/share-of-internet-users-in-the-total-world-population-since-2006/} By 2020, Internet use is predicted to reach 5 billion users worldwide,\footnote{https://www.futuretimeline.net/21stcentury/2020.htm#internet-2020} and the 5G network with 10 Gbps will be key to that. The 5G network is the manifestation of exponential growth in telecommunication: from 3G (384 kbps in 2001) to 4G (100 Mbps) to 5G networks, whose first licenses are being sold as of writing. With 5G, it will be possible to download a 1.5 Gb movie in 0.2 seconds. Google’s sister company Loon, a network of tens of thousands of giant balloons floating 20,000 kilometers above us, will provide balloon-powered Internet to many inaccessible parts of the world; by 2018 it had already partnered with Telkom Kenya to bring connectivity rural Kenya.\footnote{https://www.bbc.com/news/technology-44886803} However, it is imperative to ensure that Internet connectivity, in general, is not monopolized by only a few providers. As exponential investors, we can get involved to make sure this technology is also affordable and opens up access to education, business opportunities, and thus abundance for the people at the bottom of the pyramid.

But the progress of exponential tech does not stop at a few balloons in our atmosphere. The race for satellite supremacy has just begun. OneWeb and Airbus, for example, teamed up to launch a 900-satellite constellation to provide affordable, high-speed Internet network coverage across the world. The first satellites, each of which weighs 150 kilograms, were launched at the end of February 2019,\footnote{https://tinyurl.com/y7gqd35r} and the plan is to produce three satellites per day until all 900 are up and running. Shanghai-based LinkSure Network is planning to challenge Google and SpaceX through its free global WiFi service. It plans to be using 272 satellites by 2026, beginning with 10 satellites in 2020.\footnote{https://tinyurl.com/yd4nkq8q} But all of these plans and developments pale in comparison when we look at SpaceX Services. On February 1, 2019, the company requested permission from the Federal Communication Commission to launch 1 million Earth stations in addition to the 11,943 low-Earth Starlink orbit satellite constellation they had previously deployed.\footnote{https://tinyurl.com/yydk29qq}

Of course, we cannot talk about an interconnected world without talking about the astounding growth of the mobile phone industry. For 2020, it is estimated there will be 6.95 billion connected people, with more than 50% of them being smartphone users; for 2022, global mobile phone penetration is forecast to be 7.26 billion people.\footnote{https://www.statista.com/statistics/218984/number-of-global-mobile-users-since-2010/} As mobile phone owners, we have also intentionally or unintentionally decided to adopt our first wearable. Our phones have numerous...
sensors that provide economic, social, health, and cultural benefits. They also remove our anonymity. (More on that later.)

But it is not only phones that connect us. Cars too are getting smarter and more connected. The digitalization process started in the late 1960s, at the onset of the oil crisis, when car manufacturers began building in electronic processors to help increase fuel efficiency. Since then, the number of built-in sensors per car has grown to an average of 60—used for ABS, cruise control, airbags, parking assist, etc.—and is expected to hit more than 200 in the foreseeable future. This will translate into 22 billion car sensors being used in the automobile industry by 2020.228 A side effect of this will be the increasing interconnectedness between vehicles. Tesla, for example, likely has the most sophisticated technology needed to control and self-drive a car. Its autopilot system is self-learning and, since all Tesla cars are interconnected, the entire Tesla self-driving fleet becomes one exponentially learning self-driving system. Consequently, if one car learns something new, all Tesla cars will learn it and integrate it into their own systems within seconds. As more of us begin to rely on fleets of self-driving and self-learning cars, we may never want to own a car again.

Beyond smartphones and cars, more and more objects in our lives will become more intelligent and self-learning. Even the clothes we wear are changing. Google’s Jacquard project229 integrates interactive fabrics using conductive yarn to let you answer your phone with a tap on your sleeve. We are moving into a world where your sweater has a touch screen, your shirts monitor your health, and your jacket can access your electronic wallet. We will be able to access our world in whole new ways through flexible microchips and skin patches that can be attached to our skin to monitor our heart, brain, and muscle activity. They will measure our blood pressure and eye pressure and help us sleep better. And what if you could monitor your sun exposure through a skin patch that communicates with your smartphone app? In February 2019, L’Oréal made this possible. Representing the convergence of cutting-edge consumer electronics and the skincare industry,230 their app is an AI-powered skin diagnostic service based on scientific research into skin aging. Even more exciting, researchers at Ohio State University Wexner Medical Center developed a computer chip that was then planted in the brain of a man who had been paralyzed in an accident. The chip essentially simulated a neurological bypass and the man regained functional control of his hand.231

On a lighter note, not having to use your car key is already a reality in many traditional cars, but not having to use your home keys ever again or going to a gym where each training device has information on your fitness progress—just like your doctor does—is closer than many of us realize. Microchips and objects are turning

228 http://www.automotivesensors2017.com/
229 https://atap.google.com/jacquard/
230 https://tinyurl.com/yyh5gxdt
231 https://www.sciencedaily.com/releases/2016/04/160413140118.htm
into everyday enabled sources of data, not only through the Internet of Things but the convergence thereof.

**Wearables and Precision Medicine**

Sensors will be instrumental in opening up access to better healthcare data, leapfrogging developments in improved precision medicine, supporting clinical trials, and enabling access to better health through innovation and significant price reductions. They will be the vector for input from wearables such as an Apple watch, Oura ring,232 or implanted chip, all of which monitor their wearers’ vital signs, thus helping empower wearers to take responsibility for their health and wellbeing. Some wearables’ sensors can detect falls and issue a call for help, and others can detect atrial fibrillation (thus helping reduce the risk of strokes and heart failure). An ECG feature on wearables not only monitors the wearer’s heart rate but also sends the data directly to their physician; other features measure body temperature, provide GPS information or WiFi functionality, work as pedometers or altimeters, or provide optical heartrate information; and smart bands233 such as the biosensor developed by the University of Texas at Dallas, use sweat to measure blood sugar, stress,234 and even blood alcohol content levels, performing better in this last task than a traditional Breathalyzer.235 The Tufts University School of Engineering developed a tooth-mounted sensor that monitors in real time what is happening in and around our bodies and provides invaluable healthcare information, including data on glucose, salt, and alcohol intake, via WiFi.236 An additional breakthrough in wearable sensor technology for medical diagnostics was the development of a portable ultrasound sensor that can be powered by a smartphone, developed by engineers at the University of British Columbia, BC, Canada. It is the size of a standard Band-Aid, could reduce the cost of an ultrasound scanner to about US$100, and could mean the difference between life and death in disaster and remote areas.237

**Brain–Computer Interfaces**

If you could connect your thoughts, moods, and brain functions to a computer, would you want to do that? If yes, what benefits would you like to experience? What downsides could you imagine for this kind of technology?

I have practiced meditation since 1980, and I am curious about any technology, technique, or teaching that could enhance my meditation experience. Therefore, a couple of years ago, I purchased Muse,238 a headband designed to leverage electroencephalography (EEG) to detect electrical activity in a meditator’s brain to enhance the meditative experience and facilitate and expedite the transition into an altered

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232 https://ouraring.com/
233 https://tinyurl.com/y6p9md33
234 https://tinyurl.com/y4ep2mfv
235 https://en.wikipedia.org/wiki/Breathalyzer
236 Gerardo et al. (2018).
237 https://tinyurl.com/y4tec3or
238 https://tinyurl.com/y2uyj3py
state. I liked Muse, and I certainly experienced altered states of consciousness when using it while meditating. However, I also have four decades of meditation training, which may have influenced my experience. Suffice to say, I was initially pleased with my purchase. But shortly after I bought it, I discovered that my brainwaves, my experiences, were being shared with Muse, the company, without my consent. This was—not acceptable to me. They were using my data, my brainwaves, without my approval. I felt my privacy had been deeply invaded, and I was not offered the choice to opt out. Technology is advancing increasingly rapidly, and we must keep up the pace to protect our data and have a say in who has access to it. Should we decide to give businesses access to it, I believe we should also benefit from it, financially or otherwise.

We can also harness the benefits of technology through swallowables. Some of these, such as gastroenterological biosensors, can fulfill important healing and diagnostic functions. Gastroenterological biosensors are devices that travel through the body collecting data and detecting warning signs of pathogens or illness such as internal bleeding or cancer. And new brain–machine interfaces allow brain signals to control devices outside the body such as bionic arms.

Such devices, whether they are wearables, swallowables, or anything else, can serve important functions and shift the boundaries between humans and technology. Of course, we already have both brain–computer interfaces and implantable technologies, even though we may not think of them in this way. The brain–computer interface I now have is my hands. With them I use my computer, iPhone, or iPad—but I am very much looking forward to welcoming better interfaces that support my brain function and help me thrive as I grow older. I have three dental implants and am very grateful for them. Have they changed how I feel about what it means to be human? No, I do not define myself through my physical body or my mind. Therefore, I am very much looking forward to enhancing the foundation of the temple of my soul as long as it occurs within a democratic context that recognizes my personal boundaries.

We are on the cusp of significant breakthroughs that could offer a better approach to screening, diagnostics, and treatment to improve outcomes and significantly lower healthcare costs. By leveraging our capital, exponential investors can play a major role in guiding all stakeholders—including those from academia, government, and business—toward a collaboration that would enable the whole of society to benefit from these rapid advances in technology and medicine.

Robotics
When we think of robots, many of us will think immediately of the friendly R2D2, of the Star Wars movies, or with a life-threatening, humanoid robot called Terminator. But in the real world, household robots like the Roomba vacuum cleaner, which I love, have entered our daily lives and are hard to think away. Some people even

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239 https://tinyurl.com/yyfhvj5p
240 https://openbionics.com/hero-arm/
predict a future when we will prefer a robot over a human because of the superior quality of work delivered by a robot. Today’s robots, which are still automatons (repeating pre-programmed tasks) rather than autonomous (making independent decisions based on shifting circumstances), are taking on a variety of activities with various degrees of complexity and jobs that converge at the intersection between computing, sensors, AI, material science, augmented reality, and 3D printing. For many years we gave robots the dirty, dull, and uninteresting jobs like cleaning our floors, mowing our lawns, or stacking boxes in a warehouse. As robots became more “intelligent” through machine learning, smaller, faster, and more adaptive to new and unstructured conditions, we began to give them more dangerous tasks to perform, such as cleaning up in disaster areas like Chernobyl or disposing of bombs and mines in war zones. Following the Fukushima Daiichi nuclear disaster in March 2011, DARPA, the US Defense Advanced Research Projects Agency, initiated a robotics challenge to develop machines that can respond to various challenges, including driving a car, removing debris, or opening a door. One of the teams that rose to the challenge was Boston Dynamics, a very successful MIT spin-off now owned by the Japanese conglomerate SoftBank Group. Boston Dynamics developed Atlas, a bipedal, high-mobility humanoid robot that can walk on two legs in outdoor terrain, leaving the arms free for other tasks, and perform an entire parcours without errors. Atlas was a product of improved computational power, advances in robotics technology, improved sensors, improved and more adaptable materials, and exponentially smaller, faster, and generally better technology than was available to earlier robots. All of those advances, paired with rapid prototyping methods and 3D printing, enabled increased innovation and much better results.

Of course, technology keeps evolving. RHex, for example, designed by the University of Pennsylvania Kod*Lab, can access difficult terrain and so support research in challenging environments such as desert areas. It has six springing legs and can flip, jump, and pull itself up. The modular snake robot, designed by Carnegie Mellon University Robotics Institute, is a legless robot that moves like a snake, can squeeze into tight spaces and can clump by mimicking the movements of animals. Harvard University’s Octobot was inspired by an octopus. The first entirely soft, 3D-printed robot with no electronics or skeleton, it has increased flexibility to wrap itself around objects. The open-source movement in robotics is in full swing and is now supported also by Amazon’s AWS Robomaker and Google’s Cloud Robotics Platform. The latter recently announced its cloud robot services to promote the sharing of ideas and enhance the development of the Robot Operating System (ROS), which simplifies the programming of robots.

241 https://www.darpa.mil/program/darpa-robotics-challenge
242 https://www.bostondynamics.com/atlas
243 https://kodlab.seas.upenn.edu/
244 https://www.ri.cmu.edu/
245 https://www.seas.harvard.edu/news/2016/08/first-autonomous-entirely-soft-robot
246 http://www.ros.org/
Within the working environment, robots are exceptional at performing repetitive tasks, can work around the clock without a break, and do not need unions to protect their interests. (Again, the detailed ethical aspects of those points are outside the scope of this book.) Since 2014, 505 factories across Dongguan, in China’s Guangdong province, have invested heavily in robot technology.\(^{247}\) As a result, in May 2016, FoxCon, an Apple and Samsung supplier, replaced 60,000 factory workers with robots.\(^{248}\) These robots are performing noncomplex tasks. As they become more cost-efficient and more effective than humans over time, they will displace even more humans. Artificial Intelligence, Automation, and the Economy, a report prepared for and delivered to the Obama administration in December 2016, predicted that 6–9% of jobs globally will be automated and 47% of jobs in the United States are at risk of becoming obsolete due to automation within the next 20 years.\(^{249}\)

Using robots rather than humans does not always pose a threat to jobs and/or the workforce, though. In societies like Japan, where the mortality rate is higher than the fertility rate, there is a great need for people in the workforce, and robots are therefore playing an increasingly significant role. The Japanese retailer Uniqlo, for example, replaced 90% of its warehouse staff with robots, thus increasing the potential pool of workers for other sectors.\(^{250}\) Although the Chinese do not (yet!) have that problem, the state-owned, Beijing-based First Bank opened in May 2018 its first, entirely human-free, robot-operated office in Shanghai.\(^{251}\) And can you imagine coming home from work to a perfectly home-cooked meal? Imagine no more, because Japanese technology is about to make it a reality. Miso Robotics, for example, has created Flippy, a robot that helps commercial cooks make food at an affordable price.\(^{252}\) The Alibaba Group owns automated grocery stores, such as Hema, as well as restaurants such as the Freshippo Robot restaurant chains where robots, supported by a few humans, prepare and serve your food, and clean up after you once you have eaten.\(^{253}\) Other companies, such as Alibaba’s direct competitor JD.com, have launched similar initiatives.

 Needless to say, for an exponential investor, robotics—and all other exponential technologies, for that matter—is also closely connected to addressing the future of life, a term I prefer over the more commonly heard “future of work” This is already influencing who we are as human beings and how we want to live (see the section on Artificial Intelligence).

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247 https://tinyurl.com/y86gro75  
248 https://www.bbc.com/news/technology-36376966  
249 https://tinyurl.com/hwvoxrk  
250 https://www.dailydot.com/debug/uniqlo-replaced-tokyo-warehouse-staff-robots/  
251 https://www.youtube.com/watch?v=cMQyZAYp228  
252 https://misorobotics.com/  
253 https://www.youtube.com/watch?v=FFCPKmLAZb4
3D Printing
In 2008, while still living in Silicon Valley, I went to my dentist because of a painful molar. My dentist had just purchased a new device and wanted me to be the first patient to receive the gift of a 3D carved molar. I accepted without hesitation, and 12 years later the crown is still working. Dentists in general, but especially those in Silicon Valley, have been early adopters of 3D imaging and 3D printing; since the late 2000s, sales of in-office 3D printers in the dentistry industry have skyrocketed, and they are expected to reach US$3.7 billion by 2021.254 The adoption of this technology means that dental implants, crowns, dentures, and night guards can be made not only more cheaply but also more accurately by being customized through 3D scanning and high-quality printing materials.

The aerospace industry was another early adopter of the 3D-printing technology, using it for prototyping simple 3D-printed plastic models of parts. Authentise, an additive manufacturing automation company, has already 3D-printed and delivered not only various metal parts for the Airbus A350, but also footwear for Adidas, Nike, and New Balance, and taillights for Bugatti Chiron.255 Now, that is versatility in action.

Now that many of the 3D-printing technology patents are expiring and the cost of printers has dropped significantly, we are set to experience an entire revolution in 3D printing that will create a whole new world in digital manufacturing and the supply chain industry. To be cost-effective, traditional manufacturing counts on the fact that products must be manufactured on a large scale in big factories. Disruption is in plain sight, though. From houses to airplane engines, portable 3D-printer technology enables the creation of objects in a precise and efficient manner—and virtually without waste. The 3D printers are better, smarter, faster, and more efficient at producing high-quality objects than traditional methods. The range of materials used for 3D printing now is vast, running the gamut from various plastics to thermoplastics, from waxes and rubbers to metals and ceramics, and from chocolates to sugars. This opens up the possibility of printing food, complex integrated circuits, or a simple door handle.256 Lowe Innovation Labs, for example, is helping clients create a digital file for the on-demand 3D printing of virtually anything in and at their home.257

Even though this technology is still evolving, it is already possible to make a social impact with it: a 60-square-meter house can be 3D-printed in less than 24 h for under US$4000.258 The house contains a living room, a small office space, one bedroom, one bathroom, and all the necessary plumbing, windows, doors, and electrical systems. Hadrian-X, the brick-laying robot from Fastbricks Robotics, for example, can “print” a house with three bedrooms and two bathrooms within

254 https://www.smartechanalysis.com/reports/3d-printing-dentistry-2016/
255 https://authentise.com/news
256 https://tinyurl.com/y4wlcap9
257 http://www.lowesinnovationlabs.com/bespoke-designs
258 https://www.youtube.com/watch?v=wCzS2FZoB-I&t=4s
The environmental upsides require further research, but the reduced energy demands and reduced pollution due to less transportation needs are rather obvious benefits.

The humanitarian benefits will be hugely significant. Digital manufacturing enables immediate delivery virtually anywhere, and 3D-printed humanitarian aid—from disposable medical solutions to housing, shelter, and sanitation equipment—is already being provided in disaster areas by companies such as Field Ready. An additional benefit is that they bring local manufacturing to disaster zones, bypassing huge supply chains to offer new solutions that are better, faster, and cheaper from concept to the final products needed on the ground, and so they are essentially extending the reach of the aid they offer.

In this new digital manufacturing world, inventory will be less necessary, which is likely to result in the virtual elimination of shipping, and perhaps even of the factory itself, thus significantly reducing CO₂ emissions. Instead of shipping raw materials and finished products around the world, we will send digital designs that our clients can 3D print themselves. We are entering a world where products will be designed and only the design will be marketed. From auto parts to fast fashion, 3D printing on demand has the potential to reduce waste, produce a smaller carbon footprint, eliminate sweatshops, and offer fair treatment and quality pay for quality work. Furthermore, digital manufacturing addresses not only the freedom of design but also the redesign of the entire business model whereby the design itself is sold or licensed and not the entire production and supply chain. This is a good example of the democratization of a traditional industry such as manufacturing in the same way that YouTube democratized video. Anyone with talent, some equipment, and Internet access will be able to create, share, and sell designs easily. However, as manufacturers will eventually simply send digital designs to any user, they will also need to address and prevent piracy. This means finding ways to protect intellectual property rights and introducing patent protection and cybersecurity laws that can be enforced globally and consistently. As 3D printing occurs in real time, designers may find themselves responsible for monitoring the process to ensure that the expected standards are fulfilled and that the design does not get copied and/or stolen.

Even as I have been writing this book, 3D-printing technology has been evolving. In a January 2019 article in *Science*, Brett Kelly et al. described a new 3D-printing technology, which they nicknamed the “replicator,” that can create an object using multiple images of the object to be printed rather than adding layer on layer. The system works like a reverse computer tomography scan. And there is another bonus: “Our technique generates almost no material waste and the uncured material is

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259 https://www.fbr.com.au/view/hadrian-x
260 https://www.fieldready.org/
261 https://www.stratasys.com/resources/search/white-papers/design-for-ddm
262 Kelly et al. (2019, January).
100% reusable,’ said Hossein Heidari, a graduate student in Taylor’s lab at UC Berkeley and co-first author of the work.”

From Augmented Reality to Virtual Reality

I rarely forget a face, but I have always had a hard time remembering names. This is why I was thrilled when, in 2014, Google announced Google Glass, its, ultimately unsuccessful, attempt to augment our experience of the regular world by providing additional, digital information to overlay the real world by using smart glasses. Google Glass tried to help people like me, for example, remember names and faces by delivering information and pictures from its camera via an eyeball-level LED. It is a prime example of augmented reality (AR), which has been around for quite some time now. AR becomes our new reality the moment we enhance any sensory experience with computer-generated sounds or visuals via a headset, phone, computer, or other devices. It permits us to interact with our world in entirely new ways. For example, Magic Leap is creating a new world in which these realities seamlessly blend together to enable extraordinary new experiences (when I first read about it, it reminded me of the movie Minoriti Report). Magic Leap’s intention is to create virtual images that are indistinguishable from the real world and place them there for us to use, integrate, and enjoy.

In the healthcare context, both virtual reality (VR) and AR are bringing relief to people with PTSD by helping them recreate and relive traumatic experiences in a safe environment in an attempt to reduce their trauma, and doctors are finding both AR and VR useful for practicing surgery. (AR differs from VR in that it consists of digital images being added to or superimposed on your real-world surroundings. (At its most basic this would be using something like a Snapchat lens.) With VR, you are cut off from the real world. It is a little like being transported directly into the game world, for example.)

The possibilities are virtually endless. Imagine test driving a car in VR, or using VR to experience the beauty of this planet without trampling over the Great Barrier Reef or contributing to the chaos and clutter on Everest. Imagine learning to become more empathic with people and other cultures by using VR to “walk in somebody else’s shoes.” Imagine journalists, for example, going into war zones without risking their lives, or low-income students being able to travel the world.

We still do not know how these technologies will affect us, of course. Standard market projections focus on how AR will become smaller and faster, but past technology disruptions show that this view could be too narrow and overlooks the impact of converging technologies—for example, in the way mobile technology has converged with the Internet. AR, and to some extent VR, is on a collision course with other emerging exponential technologies—for example, the Internet of Things (IoT), 3D printing, and machine learning, to name only a few.

263https://www.sciencedaily.com/releases/2019/01/190131143330.htm
264See, for example, https://hbr.org/2018/03/how-augmented-reality-will-make-surgery-safer
Blockchain: Truth Defender or Environmental Disaster?

Blockchain is a mathematical, decentralized, public, virtual structure (a chain of blocks), based on distributed ledger technology (DLT), that was built to create a shared and cryptographically secured database of digital transactions.\(^\text{265}\) It is a collective, perpetual, append-only (unchangeable and only extendable entries) general ledger with virtually “unbreakable” (using current computing technology) database entries. Could it be both a workable replacement for our current, outdated financial systems and an answer to the grand global challenges?

The first blockchain application was Bitcoin, a cryptocurrency mined in 2009 by a programmer who called himself Satoshi Nakamoto and whose true identity remains unknown. Apart from having developed the technology, Nakamoto’s principle achievement consists in convincing the participating agents, who do not necessarily trust each other, to agree that a distributed, “unbreakable,” and shared accounting ledger gives a truthful reflection of all transactions and thus can be trusted. That agreement eliminates the need for a centrally regulated authority (for example, a bank in the case of cryptocurrency) to provide oversight. This is extremely significant because it shakes the foundations of our current financial and economic systems.

Trust is a treasured human value. It is fundamental to feeling safe and secure and has always been key to the healthy functioning of any society. It is, therefore, also a guarantor for the peaceful and secure exchange of valuable goods. However, securing trust has been challenging since the beginning of human civilization. This is one of the reasons why writing, mathematics, and ledgers were invented: they document the ownership of property as well as the exchange thereof. For example, Christine Proust, a researcher of economic archives who has documented old Babylonian mathematical tablets, has demonstrated that metrology and value notation was already being taught in Mesopotamia by the end of the third millennium BC.\(^\text{266}\) Such ledgers (often double entry) were originally made of bone, stone, and later paper and served to document value transactions including money, which was invented to simplify the exchange of goods.

In more recent history, governments tried to secure trust through centralized and regulated banks as well as armies of accountants and auditors, all of which contribute significantly to the various dimensions of the cost of trust. The financial crisis of 2007/08 showed us in no uncertain terms that when things go wrong, the cost of trust may be higher than we could have imagined. That crisis nearly destroyed the global economic system, with US$25 trillion being obliterated from the value of the stock markets by October 2008.\(^\text{267}\) It also revealed how easy it was for major financial organizations to ignore and bypass governmental regulations.\(^\text{268}\) What started as a liquidity crunch evolved into:

\(^{265}\) Orcutt (2018, p. 18).

\(^{266}\) Proust (2009).

\(^{267}\) Naudé (January 2009).

\(^{268}\) Casey and Vigna (2018, pp. 10–16).
• A disruption of capital flows
• A flood of currency crises
• The total breakdown of some of the largest financial institutions in the world, including Lehman Brothers, which in 2007 had reported record revenues and profits, all of which were endorsed by Ernst & Young, the company’s auditor
• The bailout of “too big to fail” governmental institutions such as Fannie Mae and Freddie Mac
• Severe downturns in global stock markets
• The failure of major businesses and the weakening of economic activity, which led to the 2008–2012 global recession, including the European sovereign-debt crisis

As we know now, Lehman Brothers was not the only institution to inflate its balance sheets. From Barclays to Washington Mutual Bank to Deutsche Bank, major banks were fined hundreds of billions of dollars for being dishonest. This crisis demonstrated the true cost of trust. No wonder many people were demanding and actively looking for better options. Nakamoto eventually came up with one that avoided human participation and relied instead on mathematics and impenetrable cryptography. Blockchain became the technology and Bitcoin, the resulting cryptocurrency. Beyond tracking monetary transactions that represented until recently more than 90% of all transactions, blockchain can be an immensely disruptive force for various industries, permitting secure record-keeping and peer-to-peer transactions, reducing the risk of corruption, minimizing transaction friction, and allowing for a secure exchange of patented products. It could disrupt the financial system and eventually render centralized authorities and systems, such as banks or other intermediaries, obsolete. Therefore, it is not surprising that these previously unchallenged major players are getting nervous. Their main point of criticism is the use of blockchain for money laundering and other illegal, thus not transparent, transactions that cannot be supervised in order to avoid fraud.

There is another side to the blockchain, one that is rarely considered but is important from the perspective of an integral investor. Michael Casey and Paul Vigna note that there are also social implications of using blockchain for the 2 billion people on the planet who are considered too poor to be trusted with a bank account. Lack of trust prevents them from having a bank account and thus from participating in and benefitting from the global economy. They are therefore essentially locked into poverty. Blockchain allows this group of people to override those restrictions. It enables participants to wire money anonymously and perform secure transactions without involving intermediaries, such as a notary, clerks, or lawyers whose costs (cost of trust) are not insignificant. Some blockchain start-ups, including

269 Krugman (2009) & (2012); Stiglitz (2010).
270 Allen (2013).
271 https://tinyurl.com/yd8lxzdik
272 Casey and Vigna (2018, pp. 10–16).
the Finnish fintech MONI, provide refugees with access to funds through DLT-secured transactions. MONI has been working with the Finnish Immigration Services since 2015 to give qualified refugees a prepaid credit card, secured by a digital ID number stored on a blockchain, that gives the cardholder access to government benefits.\textsuperscript{273}

Another important social application of blockchain could be the control and administration of legal identities, especially for the 1.1 billion people in the world who, according to the World Bank, are “invisible” because they cannot prove their identity and lack any official recognition (ID) of their existence.\textsuperscript{274} As a consequence, they struggle to access social services. Given that these services include access to vaccinations, the implications are dire not only for the 33% of this group who are children under 5 years old but also for their wider communities. ID2020 is a private-public partnership digital identity alliance that aims to use DLT technology to change this.\textsuperscript{275}

In addition to highlighting the need for trust, the cost of trust, and the dependence on intermediaries, Casey and Vigna, point to tech giants like Amazon, Google, and Facebook, which have built right under our noses new centralized monopolies using “the most important currency in the world: our digital data.”\textsuperscript{276} By controlling our digital data, they are now able to control us. This is why, Casey and Vigna say, it is in our collective interest to “overturn this entrenched, centralized system” by securing our data using blockchain. Increased awareness of this application of blockchain may explain, at least in part, what Casey and Vigna describe as the “gold-rush-like scene in the crypto-token market, with its soaring yet volatile prices.”\textsuperscript{277}

A further benefit of blockchain technology could be the transference of physical possessions into cyberspace, the ability to possess a digital asset. Because copying digital products such as software, music, or e-books is easy, licensing regulations and safeguards have not proven effective. Blockchain and bitcoin make the ownership of a digital asset through a unique verification code possible. Because nobody can “alter the ledger and double-spend,” or duplicate, a bitcoin, it can be conceived of as a unique “thing” or asset.\textsuperscript{278} Therefore, a new economy could be created around these digitized assets that would be managed by blockchain-encrypted software. Regular money is independent of its usage. Through the application of blockchain technology, it can become programmable. According to Casey and Vigna, this could translate as follows:

\begin{itemize}
  \item[273] https://moni.com/
  \item[274] https://tinyurl.com/yxnxtfhh
  \item[275] https://id2020.org/
  \item[276] Casey and Vigna (2018, p. 14).
  \item[277] Ibid.
  \item[278] Ibid.
\end{itemize}
The contract representing the transfer of ownership of goods between the participants becomes “smart,” not only automated in the context of banks and money owners.

The contract-executing computers are monitored by a decentralized and distributed network of blockchains.

All participants in the “smart contract” ensure a fair transaction.

There is no need for a third party/intermediaries.

Open relationships at global scale are possible.

Communities can begin to self-govern because programmable money (tokens) and smart contracts provide a secure and trustworthy foundation.

It also means that, in theory, decentralized economies could become possible through this kind of “token” economy, although there are several downsides that would need to be addressed (see below).

In his forthcoming white paper *The Role of a Parallel Digital Blockchain Associated Currency to Finance Our Sustainable Development Goals (UN SDG)* Stefan Brunnhuber presents a 30-step guideline for major stakeholders on how blockchain (DLT) technology could be used to implement the 17 UN SDGs globally. Brunnhuber estimates the implementation cost at around US$5 trillion annually over the next 20 years and deems traditional financing models unfit to provide the necessary funding. He, therefore, suggests a parallel, blockchain-secured, electronic currency that could provide the necessary means, finances, and actions to make it happen while benefitting from the distributed ledger technology and its “traceability, trust, and transparency, lower transaction costs, reduce additional energy consumption, and enable business automation, cross-organizational harmonization, authorization, accountability and authentication.”279 Such a program could take advantage of the built-in social contract of DLT and help reduce corruption while increasing the efficiency of each transaction and the overall decentralized economy built with and through it. The devil is in the detail, of course. If such ideas could be implemented, they could both revolutionize and disturb the global economy as well as our current financial systems.

Meanwhile, regulators all over the world are regarding the cryptobubble and cryptocurrencies, such as “permissionless” blockchains Bitcoin or Ethereum, that have been issued through Initial Coin Offerings280 (an ICO is the rough equivalent of an Initial Public Offering (IPO) in the regular investment world) as relatively easy ways to avoid security laws and as new, speculative money-making schemes. The author of the bestselling book *The Wisdom of Crowds*, James Surowiecki, even goes as far as to call Bitcoin “a calamity, not an economy.”281 In an *MIT Technology Review* article from May 2018, Surowiecki emphasizes the important role of governments in regulating our economic and financial systems through the central

279 Brunnhuber (2019, pp. 10–11).
280 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3080098
281 Surowiecki (May/June 2018, p. 28).
banks’ control of various currencies. By being able to issue debt in the local currency, governments can also help manage business cycles, combat unemployment, and address financial crises. Cryptocurrencies would create “a more volatile and harsher economy, in which the government would have limited tools to fight recessions and where financial panics, once started, would be hard to stop.”

Only the future will show what will happen, but by 2018 the Chinese government, for example, had already imposed an official ban on ICOs and cryptocurrency-based crowdfunding and advertising schemes. Twitter, Facebook, and Google did likewise, although the latter rolled them partially back only a few months later. Of course, change is constant. Facebook, for example, announced on June 18, 2019, a white paper in which it revealed details about its own cryptocurrency, Libra, which is expected to become available during the first half of 2020.

People could use their regular money to purchase Libra (so-called stable) coins and spend them either by buying things or transferring them to other people. Libra’s “mission is to enable a simple [digital] global currency and financial infrastructure that empowers billions of people,” especially the unbanked, by removing transaction fees common to regular credit cards and (international) money transfers. Needless to say, Facebook’s declaration shocked the international finance world, particularly the central banks that, due to lack of cryptocurrency regulations, feel their national currency sovereignty is being threatened by Facebook’s growing monopoly. Others regard it not only as a major disruption but also as the potential beginning of an international cryptocurrency race that could weaken and undermine the global economy. Although it has tightened cryptocurrency regulations, China’s central bank has been working on a digital yuan since 2014 and is presumably planning to launch it through several organizations, including Tencent’s WeChat Pay and Alibaba’s Alipay.

Its digital currency may become China’s key vehicle for enhancing its global economic position in the midst of the current trade war with the United States and, who knows, Libra could become a major ally.

But how secure is blockchain really? A closer analysis induces major doubt. For example, a 2016 attack that targeted Ethereum’s blockchain was able to lift 3.6 million Ether, approximately US$80 million worth, from the Decentralized Autonomous Organization (DAO), a blockchain-based investment fund. Luckily, the theft was “undone” through the application of a software update (called a hard fork) which essentially created a different history in the blockchain in which the money was not stolen. A much larger theft, however, took place in January 2018: US$523 million worth of the digital currency NEM disappeared from Coincheck, a Japanese

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282 Surowiecki (May/June 2018, p. 30).
283 https://www.loc.gov/law/help/cryptocurrency/china.php
284 https://support.google.com/adspolicy/answer/2464998
285 https://tinyurl.com/ybt6wfck
286 https://libra.org/en-US/white-paper/
287 https://tinyurl.com/y3sa3mt6
288 https://en.wikipedia.org/wiki/The_DAO_(organization)
The NEMs were stolen by hackers, who may never be identified, and the funds seem gone forever. This demonstrates that what is supposed to make the blockchain secure—namely (a) the cryptographic fingerprint (called hash) that is unique to each block in the chain, (b) the consensus protocol by which all participants/computers in the network (called nodes whose owners are called miners) agree on the common history, and (c) the links between the blockchain that include the previous hashes making it extremely difficult to retroactively change a previous entry—is not secure after all.

Another major downside is the extraordinary amount of computer power (including cooling requirements) and thus the energy required for the mining of new, encrypted blocks that can be added to the blockchain to secure new transactions. Current implementations are extremely energy-hungry and consume vast amounts of electricity, which translates into a significant carbon footprint. In a paper published by the MIT Center for Energy and Environmental Policy Research in November 2018, researchers showed that the energy consumption of Bitcoin per annum was around 48 TWh. They estimated that the annual carbon emissions from Bitcoin production range between 21.5 and 53.6 Mt. CO₂ and therefore called for regulatory intervention. According to journalist Kathryn Miles, “Bitcoin is wrecking the environment” because of the currently used “energy-devouring proof-of-work approach” by blockchains that have been mined thus far mostly in China and Romania where there was little regulation and plenty of energy. A less energy-hungry alternative could become the proof-of-stake system, which requires capital as a guarantee. However, the implementation of such systems has turned out to be rather complex and thus not much better than the inefficient, slow, and hardly scalable proof-of-work approach.

This all may change with the onset of quantum computing as the most evolved computation technology, a paradigm change, that enables the most advanced form of cryptography using quantum theory as suggested by Russian researchers Aleksey Fedorov, Evgeniy Kiktenko, and Alexander Lvovsky. In their article “Quantum Computers Put Blockchain Security at Risk,” Fedorov et al. note that up to 10% of the global GDP will most likely be stored in blockchains by 2025 but encourage all blockchain tech users—for example, the finance, healthcare, and manufacturing sectors, but especially cryptocurrency issuers like Bitcoin—to integrate quantum technology if they want to survive. The authors consider the overall blockchain encrypted market to be worth more than US$150 billion and request increased data security, accountability, and transparency, particularly when the protected information is currency. They think that quantum computers “will be able to break a blockchain’s cryptographic codes,” based on their single line of defense (traditional cryptographic algorithms that issue digital signatures), within the next 10 years,

289 https://tinyurl.com/ya8wzn & https://tinyurl.com/y5sv8smf
290 Stoll et al. (December 2018).
291 Miles (May/June 2018, p. 33).
292 Fedorov et al. (19 November 2018).
rendering them obsolete. At the same time, quantum computers, once available, should be able to provide the solution to this problem by issuing quantum signatures through quantum cryptography using quantum Internet, and so on.293 The conversation around blockchain remains exciting but is less existential than the one about the potential threat already arising out of the artificial intelligence (AI) revolution. MIT physicist Max Tegmark calls that “the most important conversation of our time.” 294

1.5 Artificial Intelligence: Revolution, Emergency, Salvation?

The general enthusiasm about AI that erupted in 1956 was soon followed by the AI winter.295 That winter dawned not only because of lack of funding but also because of insufficient data, networking ability, and computing power to fulfill its promises. At the time, these promises included applications in computer vision, natural language processing, robotics, machine learning (particularly neural networks), and, my personal favorite, expert systems—knowledge-based systems that were trying to replicate human decision-making using object-oriented programming and rule-based inference machines. Today’s resurgence of AI is basically due to the exponential growth in computing power (see Chap. 2) and the massive amounts of data now available, both of which fed the technological development of neural networks and their ability to mimic the qualities of the human brain. The purpose of this chapter, however, is not to add to the myriad books defining and explaining the extremely complex field of AI. My intention is instead to provide investors and company builders with enough knowledge to help them apply AI technologies to address current existential threats, particularly climate change, and, more crucially, understand the pitfalls to which AI development, if left unchecked, could lead. It is my conviction that AI is on its way to becoming a serious exponential threat itself.

AI Changed My Life in 1983

Originally, I wanted to study mathematics, but by the time I was ready to enroll at university, computer science had emerged and with it the opportunity to make math more practical, an idea that appealed to me. I, therefore, enrolled in computer science at the Karlsruhe Institute of Technology (KIT) in 1979. I loved the math classes and electronics classes, but I did not particularly enjoy (continued)

293 https://tinyurl.com/y37e4wzb
294 Tegmark (2017, p. 22).
295 https://en.wikipedia.org/wiki/AI_winter
the programming languages. From Assembly 8080 to Pascal, I found them rather cumbersome appropriations of human thinking, and it was not until I came across the field of artificial intelligence (AI), in particular expert systems, that my interest in AI was ignited. That occurred in 1983, when I attended the International Joint Conference on AI (IJCAI) in Karlsruhe, my university town. That conference set the course of my life, thanks to two significant decisions I made. One was to listen to a presentation by Stanford Professor John McCarthy, who coined the term AI in 1955 with the intention of recreating human intelligence in a computer and invented LISP, a practical mathematical notation, programming language, particularly to support AI programming, in 1958. The second decision was to find out more about Knowledge Engineering Environment (KEE), a programming environment developed using LISP by IntelliCorp, an AI software supplier founded by Stanford Professor Ed Feigenbaum, Dr. Thomas P. Kehler, and others. I was thrilled. Using LISP and KEE, I could write code in a similar way to how I thought as a human being without having to twist my mind around to fit the syntax of traditional programming languages like Pascal, Fortran, or COBOL. Less than a year later, I was an exchange student at Stanford University, where I attended John McCarthy’s AI classes. In 1986, after completing my diploma thesis on Expert Systems for VLSI Design at KIT, I joined IntelliCorp.

1.5.1 AI Is Not a Substitute for Human Stupidity

Climate change and nuclear threat are not the only existential threats we are facing. AI poses a third significant threat, particularly if it evolves to superintelligence, “a challenge for which we are not ready now,” says Oxford philosopher Nick Bostrom. Bostrom echoes the thoughts of many, including Max Tegmark, Edward Snowden, and Yuval Harari, with the latter insisting we should never underestimate “human stupidity.” Almost daily, we are confronted with news, and sometimes warnings, about how various forms of AI algorithms and applications are increasingly taking control of our lives. These warnings have increased since some AI implementations began outperforming human intelligence in domains as

296 http://www-formal.stanford.edu/jmc/reviews/bloomfield/bloomfield.html
297 https://en.wikipedia.org/wiki/Lisp_(programming_language)
298 https://en.wikipedia.org/wiki/IntelliCorp_(software)
299 https://tinyurl.com/y6xlpndc
300 Bostrom (2014, p. 259).
301 Harari (2018, p. 179); Snowden (2019); Tegmark (2017).
302 https://tinyurl.com/yyj5abwn & https://tinyurl.com/y6eo852a
1.5 Artificial Intelligence: Revolution, Emergency, Salvation?

...diverse as poker and chess games to the game of Go.\textsuperscript{303} For example, AlphaGo Zero, an application developed by British company DeepMind, surpassed the capabilities of its previous version AlphaGo, which was the first AI to defeat the human world Go champion. AlphaGo Zero “achieved superhuman performance, winning 100–0 against the previously published, champion-defeating [its predecessor] AlphaGo” by training itself.\textsuperscript{304}

More recently, Google Assistant used Duplex, Google’s current AI voice application, to make a phone call to schedule a haircut appointment in a salon without anyone realizing it was an AI.\textsuperscript{305} Despite this success, Duplex did not pass the Turing test, named after Alan Turing, the British mathematician/computer scientist who decoded Enigma, the famous German encryption machine during World War II. Turing developed the test in 1950 to establish a computer’s ability to display intelligent behavior similar to that of humans so that it could pass as a human.

The potential of AlphaGo Zero, Duplex, and similar AI applications is so significant that AI expert and venture capitalist Kai-Fu Lee puts AI at the center of the political fight for the “new world order.”\textsuperscript{306} In his book AI Superpowers, Lee estimates that by 2023, the AI battle between the United States and China will most likely be won by China, which “seems poised to seize global leadership”\textsuperscript{307} in most of the following four AI waves:

1. Internet AI is ubiquitous in and controls people’s lives through applications such as Netflix, YouTube videos, and platforms such as Amazon, Facebook, Alibaba, Baidu, and Google that already seem to “know” our preferences, interests, and shopping patterns. Those applications use algorithms to learn more about, label, optimize, and manipulate people. The significance of Internet AI applications became obvious when Cambridge Analytica purchased and used Facebook data to understand, target, and manipulate American voters during the 2016 presidential election.\textsuperscript{308} Lee sees China at a 60–40 advantage over the rest of the world for three reasons: (a) its total number of Internet is higher than those of the United States and Europe combined, (b) its frictionless payment ability, and (c) its online-to-offline platforms (that “turn online actions to offline services,”\textsuperscript{309} essentially navigating online users to brick-and-mortar service providers), which breed innovative AI applications.

\textsuperscript{303}Bostrom (2014, pp. 12–13).

\textsuperscript{304}Silver et al. (19 October 2017, p. 354).

\textsuperscript{305}https://tinyurl.com/yasguzo5 & https://tinyurl.com/y2hgdg5w & https://tinyurl.com/yxcfoyh4

\textsuperscript{306}Lee, K.-F. (2018a). Refer to page 136 for a “balance of capabilities between the United States and China across the four waves of AI, currently and estimated for 5 years in the future.” For a more recent comparison by Lee, see his presentation during the a360 (Abundance 360) conference from January 2019. Viewed October 17, 2019 at https://tinyurl.com/yyh9h9a6

\textsuperscript{307}Lee, K.-F. (2018a, p. 139).

\textsuperscript{308}Nadler et al. (2018).

\textsuperscript{309}Lee, K.-F. (2018a, p. 68).
2. **Business AI** is the second wave that uses AI technology to take advantage of and mine massive amounts of well-structured corporate databases and conventional enterprise software (legacy systems). These are available in more traditional companies such as insurance companies, banks, law offices, and hospitals, which have used human experts to categorize, search, and label their data for many decades. AI can now help humans make better sense of data and so make better decisions. For example, businesses can develop complex neural networks using IBM Watson, a deep-learning service that helps data scientists design their own AI-based decision-making systems to provide better correlations between the available data for accounting, inventory, or management purposes. One of the more promising applications of *business AI* seems to lie in the healthcare field, particularly in terms of predictive medicine and diagnosis, but also for knowledge dissemination. For example, Jim Wang, CEO of NovaVision Group, a Chinese healthcare conglomerate, thinks that AI could level the playing field regarding the quality of healthcare provided in rural and urban areas in China. Lee considers that the United States is currently leading (US 90–China 10) in *business AI* simply because of the historical development of legacy systems. He considers that China is likely to take the lead in public services in the future.

3. **Perception AI** is the third wave. It takes advantage of audio, visual, and other sensory intelligence to feed and run AI algorithms. For example, Amazon Echo and Alexa devices are digitizing the audio environment through voice recognition and natural language processing, Alibaba’s City Brain parses information from cameras in order to digitize traffic flows, and Apple’s iPhone X uses computer vision and object recognition to safeguard mobile devices. Lee calls this merging of the online and offline worlds that *perception AI* facilitates OMO (online-merge-offline). This integrated environment driven and controlled by *perception AI* will, according to Lee, make, for example, pay-with-your-face, robot-assisted shopping, and individually tailored education, possible and accessible to users. The convenience of such OMO systems presupposes, of course, the user’s permission not only for face and voice recognition purposes but also for accessing personal banking data and individual preferences and habits. Culturally, there are, however, huge differences at play. Lee asserts that the Chinese are more willing to trade their privacy for convenience than the Americans and Europeans, who are accustomed to and value democracy, privacy, and freedom. Lee gives China a clear advantage over the United States on *perception AI* simply because of its headstart on privacy elimination and the massive amount of data available from the country’s large network of cameras and sensors in public areas. The crucial battle for privacy protection as a basic human right has just begun. (See below for more on this.)

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310 https://tinyurl.com/y3kcjdcm
311 https://tinyurl.com/y7agxhmj
312 https://www.alibabacloud.com/et/city
4. *Autonomous AI* “represents the integration and culmination of the three preceding waves,” states Lee. He believes that “combining these superhuman powers yields machines that don’t just understand the world around them—they shape it.”

The premise for *autonomous AI* is the ability of machines to see, hear, sense, and optimize the massive amounts of data they collect and that will eventually render them autonomous. Lee considers the United States to currently be in the “commanding lead (90–10),” but “in 5 years’ time [he gives] the United States and China even odds of leading the world in self-driving cars, with China having the edge in hardware-intensive applications such as autonomous drones.”

(In earlier chapters we talked about the ongoing emergence of self-driving cars, autonomous robots, and autonomous drone technology. Once these are legally accepted they will all be examples of autonomous AI. For now, they are classified as automated, not autonomous: autonomous AI is allowed to make decisions and improvise as conditions change.)

Only the future will tell who leads the world in AI technologies. What we know for now is that China has understood the importance of AI development for its future position in the world and has “spurred myriad policies and billions of dollars of investment in research and development from ministries, provincial governments and private companies.” China is leading the world in solutions for natural language processing, computer vision, and robotics, and the average citations for AI papers authored by Chinese researchers are above the world average, albeit still lower than those of their US counterparts, who currently represent the largest AI talent pool. Before going deeper into the changes, challenges, and impact AI developments could have for societies and cultures around the world, let us get a better understanding of the current state of AI technology.

### 1.5.2 Demystifying AI

Two major technological advances in the mid-2000s brought an end to the AI winter: (1) the exponential growth in computing technology discussed earlier (Fig. 1.5) and (2) the increasing availability of data.

Both were crucial for the progress of neural networks with machine learning and deep learning (Fig. 1.8).

The learning technology embedded in neural networks was originally brought to the wider public in 1986 when researchers David Rumelhart, Geoffrey Hinton, and Ronald Williams published a paper describing “a new learning procedure, backpropagation, for networks of neuron-like units... [that] repeatedly adjusts the

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313 Lee, K.-F. (2018a, p. 128).
314 Lee, K.-F. (2018a, p. 136).
315 O’Meara (21 August 2019).
weights of the connections in the network” and helps train the neural network more efficiently. However, the deep learning revolution was unleashed on the world through a paper by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton titled *ImageNet Classification with Deep Convolutional Neural Networks*. The paper won the ImageNet competition and revolutionized computer vision in 2012. Figure 1.8 shows the correlation between AI (also dubbed GOFAI for Good Old-Fashioned AI), machine learning, and deep learning.

Machine learning is a subset of AI, the algorithmic process through which AI creates nonbiological intelligence by analyzing and learning from large amounts of data in order to develop and adapt its own algorithms without external instructions.

Deep learning, on the other hand, tries to imitate the deep neural networks of the human brain. It gets increasingly better at recognizing and emulating humans’ decision-making patterns and enables computers to understand ever-higher concepts from low-level data. For example, in order to win the game of Go, players have to use their own intuition to make their moves. Trying all possible solutions, even through the use of a computer, would be virtually impossible because the number of potential combinations is larger than the number of atoms in the universe. Thus, AlphaGo, an application developed British company DeepMind, now owned by Google, is a deep learning AI that somehow developed its own

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316 Rumelhart et al. (9 October 1986).
317 Krizhevsky et al. (3 December 2012).
318 https://en.wikipedia.org/wiki/ImageNet#ImageNet_Challenge
319 Tegmark (2017, pp. 86–89).
intuition and beat Lee Sedol, the world’s Go champion in March 2016. This is a
development that many AI experts said would not happen for at least another decade,
although in 2015 Volodymyr Mnih et al. had published a paper titled *Human-Level
Control through Deep-Reinforcement Learning*[^20] in which they revealed how they
applied behaviorist psychology techniques with positive reinforcement to classic
machine learning. The reinforcement process allows AIs to become increasingly
better at making predictions and to eventually make decisions without human
intervention. For example, AlphaGo Zero surpassed the capabilities of its previous
version, AlphaGo, achieved superhuman performance levels, and won 100–0
against AlphaGo by training *itself* and therefore “no longer [being] constrained by
the limits of human knowledge,” said DeepMind co-founder Demis Hassabis[^21].

Based on sophisticated algorithms called (artificial) neural networks, deep learning is
behind the radical technology advances we can find today in, for example, MRIs,
satellite photography, facial recognition, language understanding, and simultaneous
translation, to name only a few. Thanks to deep learning, self-driving cars could
become safer, more reliable, and eventually better drivers than some humans (see the
section on the Evolution of Mobility and Transportation).

### Defining Intuition

The Cambridge dictionary defines intuition as “(knowledge from) an ability to
understand or know something immediately based on your feelings rather than
facts: Often there’s no clear evidence one way or the other and you just have to
base your judgment on intuition” ([retrieved October 21, 2019, from https://
dictionary.cambridge.org/dictionary/english/intuition](https://dictionary.cambridge.org/dictionary/english/intuition)). I personally consider
most definitions of intuition restrictive because they tend to reduce humans
to either cognitive and/or emotional beings. I, therefore, subscribe to a multi-
perspectival, more integral view, and mode of knowing described in more
detail through Ken Wilber’s Integral Theory[^22] (see Chap. 2).

An additional example of an application of AI that benefits humanity is the
integration of collective intelligence and AI technology within the area of faulty
protein folding as it occurs in illnesses such as Parkinson’s and Alzheimer’s
disease[^23]. Proteins are key building blocks of biology, and their shapes, which define
their function, depend on the sequence of their amino acids. Under normal circum-
stances, proteins take the most energy-efficient shape, but sometimes they can
become tangled and fold in an unhealthy way, leading to disease. Some scientists
have been using custom computer programs on supercomputers to try to understand
and predict how a protein unfolds, although success has been limited to date.

[^20]: Mnih et al. (26 February 2015).
[^21]: [https://tinyurl.com/y39f8hyg](https://tinyurl.com/y39f8hyg)
[^22]: Wilber (2000).
[^23]: Agbas (30 August 2018).
However, there have been some successes from possibly unlikely quarters. FoldIt is a crowdsourced protein folding prediction computer game conceived by computer science professor David Salesin and biochemistry professor David Baker, both of the University of Washington, and developed by a team under Zoran Popovic, an associate professor of computer graphics, also at the University of Washington. The combination of computing power and gamers’ intuition turned out to be a very powerful one. In 2011, it proved key to a victory in the fight against HIV/AIDS. But these advances did not stop at supercomputing or crowdsourcing. In December 2018, Google’s DeepMind introduced the world to AlphaFold, a deep learning application based on neural networks for predicting protein folding to accelerate drug research. AlphaFold is, however, only the beginning of AI’s ability to make a real impact in the realm of disease treatment and medical breakthroughs. These distinctions lead us to another way of classifying AI, namely:

**Narrow AI** (also known as ANI: Artificial Narrow Intelligence), called “‘weak AI’—the variety devoted to providing aids to human thought” by Nils Nilsson, is the kind of AI available today and includes the examples mentioned thus (e.g., facial recognition, natural language processing, machine translation, data-driven decision-making, and self-driving vehicles). **Narrow AI** is not even close to matching human intelligence. It lacks consciousness, self-awareness, and emotions, but it is able to learn and to enhance itself (e.g., DeepMind AlphaGo and DeepMind AlphaGo Zero).

**General AI** (also known as AGI: Artificial General Intelligence), or what Nilsson calls “‘strong AI’—[as] the variety that attempts to mechanize human intelligence” whereby intelligence is defined by Max Tegmark as “maximally broad” (as opposed to narrow AI) and has the “ability to achieve complex goals.” AGI is anticipated to perform high-level reasoning, solve complex problems, learn, plan, think in an abstract manner, strategize, innovate, create, and make judgments based on uncertainty. According to Hans Moravec, however, “it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.” This observation is called Moravec’s paradox. It is expected that human-level AGI should be able to accomplish any goal at least as well as a human so that it can pass the Turing test and become a universal Turing machine. However, in order to

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324 https://fold.it/portal/info/about
325 https://www.scientificamerican.com/article/foldit-gamers-solve-riddle/
326 https://deepmind.com/blog/alphafold/
327 Nilsson (2009, p. 319).
328 Nilsson (2009, p. 319).
329 Tegmark (2017, p. 50).
330 Moravec (1992/1988, p. 15).
331 https://en.wikipedia.org/wiki/Moravec%27s_paradox#CITEREFMoravec1988
achieve that, AGI should experience consciousness, empathy, and sentience; the ability to perceive, feel, and subjectively experience something. Tegmark believes that “there’s a non-negligible possibility that AGI progress will proceed to human levels and beyond,”\textsuperscript{332} which could lead to an intelligence explosion, the \textit{singularity}, with the creation of superintelligence and beyond.

\textit{Super AI}, also known as \textit{ASI (Artificial Super Intelligence)}, is defined as an AI that uses AGI to become superintelligent. Oxford philosopher Nick Bostrom defines superintelligence as an intellect that outperforms “the best current human minds across many very general cognitive domains.”\textsuperscript{333} He posits that ASI could emerge within 30 years of AGI, which, according to various sources, could occur by 2075 with a probability of 90\%\textsuperscript{334}.

How far we really are from achieving AGI or superintelligence is subject to much speculation and discussion.\textsuperscript{335} However, we cannot afford not to be part of further developments in this field, because they can turn into an existential risk for humanity if left unchecked. According to Bostrom, “superintelligence is a challenge for which we are not ready” and “some little idiot is bound to press the ignite button just to see what happens.”\textsuperscript{336} Needless to say, we must do whatever is required to prevent that from happening, and in the next section, we will take a closer look at the potential and challenges of AI, particularly from the perspective of investing and company building.

1.5.3 \textbf{Why AI Must Be Regulated}

Elon Musk is a well-known critic of unsafe and unethical AI. He argues that, if we do not pay attention, the percentage of nonhuman intelligence (i.e., AI) on our planet will continue to grow until it supersedes human intelligence, with potentially dire consequences.\textsuperscript{337} Echoing the words of the late Stephen Hawking, Musk warned about the dangers of AI in saying, “We need to be super careful with AI. Potentially more dangerous than nukes”\textsuperscript{338} while expressing his frustration about his futile efforts to get governments to regulate it.\textsuperscript{339} During a panel with Alibaba’s founder Jack Ma at the 2019 World Artificial Intelligence Conference, Musk stated, “Most people underestimate the capability of AI” and “the biggest mistake AI researchers

\begin{itemize}
\item \textsuperscript{332}Tegmark (2017, p. 133).
\item \textsuperscript{333}Bostrom (2014, p. 52).
\item \textsuperscript{334}Bostrom (2014, pp. 18–21).
\item \textsuperscript{335}Bostrom (2014); Kurzweil (1999) & (2001); Tegmark (2017).
\item \textsuperscript{336}Bostrom (2014, p. 259).
\item \textsuperscript{337}https://tinyurl.com/y6nzdoyx
\item \textsuperscript{338}https://tinyurl.com/y2x4ba7j
\item \textsuperscript{339}https://www.youtube.com/watch?v=5taE_br3Vr8
\end{itemize}
are making is to assume that they are intelligent.” In his view, the difference between AI and humans in the future will be like the difference between current humans and chimpanzees. Counteracting Musk’s assessment, Ma argues that “only college people are scared of AI, street-smart people [like him] are not,” because once people begin to understand themselves better, they can improve the world. Musk jokingly called Ma’s statement “famous last words” and argued for the importance of fighting for the preservation of human consciousness. Musk added, “If you can’t beat them, join them” which is one of the reasons he invested in Neuralink, a company that creates brain–machine interfaces aiming to enhance the bandwidth and other capabilities of the human brain. This is obviously an emotive topic. In order to understand what “join[ing] them” means, we must understand what is at stake, what we are trying to preserve, what we are fighting for, what consciousness is, and what human intelligence is. More importantly, we must understand what AI is, the dangers associated with its development (starting with AGI and ASI), and what the rest of us, particularly investors and company builders, can individually do to “secure the future of consciousness such that the light of consciousness is not extinguished” without going to Mars.

As in so many other areas, Musk has shown us the way. In January 2015, he donated US$10 million to the Future of Life Institute, an organization founded by Max Tegmark, Jaan Tallinn, Anthony Aguire, et al., to keep “AI beneficial for humanity,” jumpstart AI safety research, and make sure AI is regulated before it spirals out of control. After agreeing that superintelligence presents a clear and present danger to humanity, in January 2015 the “world’s top artificial intelligence developers sign[ed an] open letter calling for AI-safety research,” which on January 6, 2017, led to the development and adoption of the 23 Asilomar AI Principles. These principles acknowledge the benefits of AI without being blinded by them. I have also signed them, and I encourage everyone to do the same and to adhere to them. They are clustered under the headings of research issues, ethics and values, and longer-term issues.

Several other initiatives have since been launched. For example:

- OpenAI, a nonprofit organization in San Francisco (https://openai.com)
- The Machine Intelligence Research Institute (MIRI) in Berkeley, California (https://intelligence.org)
- The Leverhulme Center for the Future of Intelligence in Cambridge, UK (www.lcfi.ac.uk)
- The K&L Gates Endowment for Ethics and Computational Technologies at Carnegie Mellon University in Pittsburgh, Pennsylvania (https://www.cmu.edu/ethics-ai/)

340 https://www.youtube.com/watch?v=f3lUEnMaiAU
341 https://www.youtube.com/watch?v=f3lUEnMaiAU
342 https://tinyurl.com/y8xvpr6s
343 https://tinyurl.com/y42nlfrp & https://futureoflife.org/ai-principles/
• The Future of Humanity Institute in Oxford, UK (https://www.fhi.ox.ac.uk).
• The Center for the Study of Existential Risk in Cambridge, UK (https://www.cser.ac.uk)
• The industry partnership for beneficial AI between Amazon, DeepMind, Facebook, Google, IBM and Microsoft (https://www.partnershiponai.org)

But what exactly are the traps and dangers of AI?

1.5.4 Intelligence and Consciousness

Earlier I discussed the stages of evolution and referred to Tegmark’s definition of life as “a process that can retain its complexity and replicate”344 while evolving from:

• A simple biological stage, Life 1.0, to
• A cultural stage, Life 2.0, to
• A technological stage, Life 3.0, where it can design both its software and hardware and can take control over its own future.

Life 3.0 is what AGI could achieve in the twenty-first century. However, there are some dissenters from this opinion. First, there are the “techno sceptics” who believe that AGI will not occur for several hundreds of years. Then there are the “digital utopians,” including Google’s co-founder Larry Page, one of “the most influential exponent(s)” of a digital life as the next step in cosmic evolution. According to Tegmark, Page is convinced that the outcome of Life 3.0 would most certainly be good. Page insists we should let go of “AI paranoia,” as it could delay the further evolution of digital life, thus causing “a military takeover of AI.”345 Tegmark has become a proponent of the third alternative, the “beneficial-AI movement.” This possibility could eventually also enable Life 3.0 in this century, but its “good” outcome must be enforced through hard work and global cooperation—and as we have seen, he is not alone in this opinion.

Addressing these significant topics will take time and require a major collective effort at national and international levels. From an investor’s perspective, we can only aim at gaining a clearer idea about the various issues at hand so we can take informed decisions on how to contribute to the future of life in a way that benefits us all in an integrally sustainable fashion. So, let us continue to understand the terms artificial intelligence, intelligence, and consciousness before moving on to highlighting the potential dangers of an unchecked AGI.

In Life 3.0, Tegmark defines AI as “non-biological intelligence,” intelligence as the “ability to accomplish complex goals,” and AGI as the “ability to accomplish any

344Tegmark (2017, p. 48).
345Tegmark (2017, p. 32).
cognitive task at least as well as humans.” He also acknowledges that “there is no undisputed definition of consciousness” and uses the “broad and non-anthropocentric definition consciousness = subjective experience” without going too deep into philosophical discussions surrounding the “hard problem” of consciousness that debates whether or not matter has consciousness. In simple terms, humans are using their natural intelligence, including their various levels of consciousness/awareness, to build AI machines that should eventually be able to complete any job as well as their human builders. The thorniest conversation would arise if AIs eventually became conscious, had feelings, and subsequently were entitled to rights. We must look at the ethical considerations of this potential eventuality before it is too late, but because we are at the very beginning of this change, we do not recognize and are therefore ignoring the double exponential growth of the technology evolution. Not only are we prey to Moravec’s paradox, but, as Elon Musk noted, we have not yet developed the required sense of urgency to protect ourselves. Moreover, if we are to build artificially intelligent systems, we must understand intelligence first, and to date, we have only a partial understanding of it.

One concept that I deem extremely important within the context of AI, but which is rarely discussed, is that of human mindset evolution. During the course of our lives, we can grow and develop our mindsets, our human software as Tegmark calls it, and have the opportunity to acquire wisdom and virtues and grow to later stages of consciousness evolution (see Chap. 2 for more on this). If left unchecked, this growth could actually lead to AI programmers building their own biases into the AI applications they develop, which in turn would lead to unethical and unsafe AIs. For example, shortly after Google launched with great fanfare their AI-driven machine learning software Google Photos, it emerged that it was identifying Black people as “gorillas.” While this was later acknowledged to be a major mistake, it is symptomatic of the very real risks of programmers building their own biases into AIs—for example, biased views on gender or racial bias in healthcare algorithms. (Remember GIGO: garbage in, garbage out? Personal bias, especially bias that programmers are blissfully oblivious to, creates a similar type of challenge.)

While such biases are likely to be more or less accidental, due to the programmers’ lack of awareness, some AI algorithms have been deliberately and specifically designed to keep users glued to certain platforms such as Facebook, Amazon, or YouTube in order to increase revenues. In a 2019 article for the MIT Technology Review, Karen Hao writes about how Google is enhancing its YouTube machine learning algorithms. A tiny increase of 0.24% in user engagement can translate into

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346Tegmark (2017, p. 39).
347Tegmark (2017, p. 315).
348https://www.bbc.com/news/technology-33347866
349https://tinyurl.com/y6aqj56d and https://tinyurl.com/yyjtgc62
350https://tinyurl.com/y2ez4c2y
millions of dollars in additional revenue for the company.\footnote{351} A more sinister example of this occurred on February 17, 2019, when a YouTuber exposed a so-called wormhole that facilitates the exploitation and monetization of child pornography.\footnote{352}

### 1.5.5 Data Hunger, Privacy Violation, and Ethical Implications

AI algorithms are data-hungry because without data they cannot function. Their main purpose is to collect massive amounts of data to improve themselves, which in turn translates into higher revenues for their operators. Before Google went global and made billions of dollars selling our information, for example, nobody thought much about its vehicle driving through our streets and taking pictures of our houses, cars, gardens, and yards. Before it became known that Facebook, to give another example, illegally sold millions of personal data sets to the UK-based Cambridge Analytica, thus enabling Russian hackers to target and significantly influence American voters during the 2016 election, few people either took AI algorithms seriously or considered them dangerous.\footnote{353} In fact, few people think twice about the fact that Facebook, Amazon, Alibaba, or Google, etc., are using their clients’ private information to make millions of dollars by selling that information without the owners’ explicit permission. At the time of writing, no one has yet asked for a share of the revenue derived from their data, although it would seem only fair to do so.

When I ask people about their opinions about privacy, most say they have nothing to hide. But “saying that you don’t care about privacy because you have nothing to hide is no different from saying that you don’t care about freedom of speech because you have nothing to say,” states whistleblower Edward Snowden in his 2019 book \textit{Permanent Record}.\footnote{354} In other words, if we care about preserving our democracies along with \textit{all} our precious human rights—equality, freedom, and liberty—we must think again, and more deeply. Why? Because our freedom is priceless, and it is certainly not up for grabs. “Just because this or that freedom might not have meaning to you today doesn’t mean that it doesn’t or won’t have meaning tomorrow, to you, or to your neighbor.”\footnote{355} I grew up in Romania under Ceausescu’s dictatorship fully aware that “walls have ears.” I remember vividly how my parents and I always lowered our voices when we talked about something vital, such as our plans to emigrate to West Germany in 1973. In fact, we continued to lower our voices for many years after we relocated to Germany. Today, I am being reminded of the lack

\footnote{351}\url{https://tinyurl.com/y2tooww6}
\footnote{352}\url{https://tinyurl.com/y5bdh946}
\footnote{353}\url{https://tinyurl.com/y9rorxln}
\footnote{354}Snowden (2019, p. 208).
\footnote{355}Snowden (2019, p. 209).
of freedom I experienced during my childhood and I am worried. I am worried because we all carry potential surveillance devices with us. We keep them in our homes, trusting that they serve us rather than spy on us. But we must not be naïve. To keep our democratic freedoms, we, as investors and company builders, must act decisively before it is too late. Existing AIs have already begun penetrating our world, presenting us with distinctive and significant ethical questions, and we currently lack precise and stable answers for them. This became more obvious to me during my participation in the Augmented Intelligence Summit, held and organized by the Future of Life Institute in March 2019.\textsuperscript{356} We discussed various topics related to beneficial AI, including the future of healthcare, work, criminal justice, and ethics. The conversations were informed by an excellent paper titled “AI Policy: A Primer and Roadmap” by law professor Ryan Calo, who does not think that AI presents an existential threat to humanity in the foreseeable future.\textsuperscript{357} He insists, however, that the conversation around AI ethics needs not only simple ethical standards but also policy and binding rules to enforce it. In his view, these policies should address the following questions:

- \textit{Justice and equality} through “the capacity of algorithms or trained systems to reflect human values such as fairness, accountability, and transparency (‘FAT’),”\textsuperscript{358} which would include bias and material decisions with respect to financial, health, and liberty outcomes.
- \textit{Use of force} as a special case of AI-enabled decision-making (that bears the responsibility for the choices made by machines) and consensus about meaningful human control, especially with respect to decisions to go to war.
- \textit{Safety, certification, and cybersecurity}, especially with respect to autonomous systems, such as in cars, robots, but also in airplanes (e.g., the 2019 Boeing 737 Max scandal).\textsuperscript{359}
- \textit{Privacy and power}, as discussed above within the context of data hunger and its ownership, as consumer privacy has become increasingly under siege with citizens having little or no ability to avoid various forms of surveillance.
- \textit{Various cross-cutting questions} that would make sure that, because of its complex and novel nature, the topic of safe and beneficial AI is addressed as a whole and not in bits and pieces. In general, law and technology are seen as too slow to react to one another. That could backfire in this case, given the exponentially growing nature of AI technology and the lack of expertise at the policy level, to name a few issues.
- \textit{Taxation and displacement of labor}, which is concerned with the prospect of AIs displacing jobs currently performed by humans (e.g., through autonomous

\textsuperscript{356}https://futureoflife.org/augmented-intelligence-summit-2019-2/
\textsuperscript{357}https://lawreview.law.ucdavis.edu/issues/51/2/Symposium/51-2_Calo.pdf
\textsuperscript{358}Calo (2017, p. 9).
\textsuperscript{359}https://www.theguardian.com/business/2019/oct/23/boeing-profits-737-max-mcas-scandal
vehicles), providing universal basic income by imposing taxes on AIs (i.e., robots), or taxing innovation and progress.

AIs cannot advance without automatically learning from an ever-increasing amount of data. However, the most important issue regarding data regulation is not about what to do with data and how to handle it once it has been collected. We must focus instead on the *prevention of data collection* in the first place. Data should not be collected without the explicit consent of data owners—in other words, us. (A further distinction must be made with respect to the legality or illegality aspect of data collection, discussed below.)

At the EU level, there are several activities taking place around General Data Protection Regulations (GDPR), a legislation that passed in April 2016 and was enforced in May 2018. The GDPR aims at protecting the data privacy of each EU citizen, including those in the European Economic Area, by giving individuals control over their own data, forcing data collectors to disclose their data collection practice, and limiting the data retention time. (When you are asked to give your consent to a website regarding its cookie practice, know that this is the result of this or similar laws.) In June 2019, the European Commission published a detailed OECD report, *Artificial Intelligence in Society*, that looks at and assesses policy and governance interventions on how the acceleration of AI development is affecting global economies and societies. The report honors the importance of AI applications in myriad areas including mobility, healthcare, criminal justice, marketing, security, and safety. Under the guidance of a high-level, multistakeholder group of experts, the OECD also developed the first international AI standards, including its own AI Principles, agreed on by multiple governments. Furthermore, on April 8, 2019, the European Commission published its “Ethics Guidelines for Trustworthy AI.” According to these guidelines, trustworthy AI must be:

- “Lawful” in accordance with existing laws and regulations
- “Ethical” with respect to ethical principles and regulations
- “Robust” with respect to both technology and the social environment

It must also obey human agency and oversight, privacy and data governance, transparency, diversity and fairness, accountability and responsibility, and human and environmental wellbeing standards, and be technically robust and safe. Does this all mean that the NSA, Facebook, Amazon, YouTube, and Google have stopped illegally collecting data from Europeans? Well, no. It means that we, the people, have begun to fight back, watch what is going on, and act. This is an important first step in the age of exponentially growing technologies (where we are subject to

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360 https://tinyurl.com/y2wpcvc3
361 https://ec.europa.eu/jrc/communities/sites/jrecties/files/eedfee77-en.pdf
362 https://tinyurl.com/y6e9okmz and https://tinyurl.com/y5b44wef
various types of hacking from AI to biotech, a separate topic that is beyond the scope of this book.\textsuperscript{363}

We must also be aware of the \textit{legality issue}. Why? Because legality does not always equate to democratic law. Since Snowden’s whistleblowing in 2013, we have learned that numerous governmental organizations are collaborating with major telecommunications and technology companies to access our data, invade our privacy, and exercise power and control over us under the pretext of national security.\textsuperscript{364} According to information made available to the German newspaper \textit{Süddeutsche Zeitung}, major politicians such as German Chancellor Angela Merkel, ex-Italian Prime Minister Sergio Berlusconi, and former UN General Secretary Ban Ki-Moon are subject to surveillance and privacy invasion. All three have had confidential phone conversations intercepted.\textsuperscript{365} Snowden has also alerted us something even more disturbing: hacking our privacy—even hacking the American constitution—is sometimes perfectly \textit{legal}.\textsuperscript{366} We should, therefore, be deeply concerned about how some governments are changing the law to fit their need for surveillance under the pretext of terrorism investigation without a court order. For example, the US PRISM program “enabled the NSA to routinely collect data from Microsoft, Yahoo!, Google, Facebook, Paltalk, YouTube, Skype, AOL, and Apple, including email, photos, video and audio chats . . . transforming the companies into witting coconspirators.”\textsuperscript{367}

Stuart Russell, UC Berkeley professor and author of \textit{Human Compliance: Artificial Intelligence and the Problem of Control}, and one of the speakers at the 2019 Augmented Intelligence Summit, confirms what Bostrom, Musk, Harari, and Tegmark have been saying all along: “We must plan for the possibility that machines will far exceed the human capacity for decision making in the real world” by creating and gaining access to a superintelligence, which could be the biggest but also “the last event in human history”\textsuperscript{368} (by which he implies that humans may not have a future thereafter). I am mindfully optimistic that we will succeed because there are many ways to avoid disaster. Like Isaak Asimov, who devised the three laws of robotics,\textsuperscript{369} Russell specifies three principles for “provably beneficial” machines/AI that could help humanity steer toward the future we want\textsuperscript{370}:

- The only objective of machines is “to maximize the realization of human preferences.”
- The “machine is initially uncertain about what those preferences are.”

\begin{flushleft}
\textsuperscript{363}Harari (2017).
\textsuperscript{364}https://en.wikipedia.org/wiki/Edward_Snowden
\textsuperscript{365}https://tinyurl.com/yyxf4vjf
\textsuperscript{366}Snowden (2019, p. 223).
\textsuperscript{367}Snowden (2019, pp. 223–224).
\textsuperscript{368}Russell (2019, p. xi).
\textsuperscript{369}Chase (2015, p. 164).
\textsuperscript{370}Russell (2019, p.173).
\end{flushleft}
The “ultimate source of information about human preferences is human behavior,” whereby preferences are individually defined, are all-encompassing, and address everything humans might ever care about.

### Asimov’s Three Laws of Robotics

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Like Russell, world-renowned Stanford teacher and Baidu chief scientist Andrew Ng thinks AI will transform every possible industry “just as electricity transformed almost everything 100 years ago” and that we must assess the vital role of AI in our everyday life, address our security needs, take advantage of untapped data sources to inform our AI algorithms, and find out how we can disrupt ourselves before it disrupts us.

As a trained AI and computer scientist, I have learned to live with the idea that this extraordinary technology can be used to do both good and bad. This is why I have chosen to stay alert, become deeply involved with it, and be right there at the forefront of the development, ready to act for the greater good using my investing and company-building skills. While I want to feel protected by my own country and its government, especially in a global world that is not always ruled by democracy, I also want to have sovereignty over my own data. Therefore, I do not agree with either governments or companies legally or illegally invading our privacy and collecting our data to exercise power or control. Moreover, I do not think it is right for companies to collect our data to enhance their AI algorithms without our consent. This is as much a governance and policy issue as it is an issue of values, ethics, and morals that should be sourced at the highest possible levels of consciousness (world-centric or Kosmos-centric). Rather than worry about being subjugated by out-of-control AIs, I would rather leverage the benefits of exponentially growing technologies to solve the current climate and myriad other crises plaguing us globally and locally. On a round planet, there is no choosing upsides.

Moving forward, the vital question should no longer be whether “AI is more dangerous than nukes,” because we can establish with certitude that AIs can become more dangerous. The potential danger becomes perfectly obvious once we begin to understand what is truly possible. Thus, the question is not about whether an autonomous car is more dangerous than a horse carriage or a metal knife more dangerous than fire. No, we must go well beyond these superficial conversations,

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371 https://www.gsb.stanford.edu/insights/andrew-ng-why-ai-new-electricity
because technology development is part of our human journey through time and space. We must not only make sure we keep AIs under control but also go much deeper to truly understand the bigger picture. We must begin to understand ourselves, our place in the universe, and within the bigger picture of evolution—but not only evolution, also its underlying feature, namely exponential growth. No matter how educated we are, our minds cannot truly comprehend, let alone address, exponential growth, because we are linear thinkers by nature. Yet in the light of AI progress, we can, and must, make this quantum leap in evolution and take control.

We must grow and reach higher levels of consciousness so we can imbue our AIs with wisdom and a mindset that rests in the later stages of consciousness (see Chap. 2). If we do not, we risk being eliminated by the very AIs we are developing.

According to Kurzweil’s Law of Accelerating Returns, the speed, cost-effectiveness, and power of the evolutionary process increase exponentially over time. That could eventually render traditional humans obsolete. In Chap. 2, I discuss Ken Wilber’s Integral Theory and how evolution applies positive feedback. This process results in exponential growth over time so that the rate of exponential growth itself grows exponentially, which is even more difficult for humans to understand. Technological evolution has evolved to support our biological evolution. The next paradigm shift is already occurring from biological thinking to a hybrid construct that combines both biological and nonbiological thinking such as smartphones, computers, nanobots, and so on, moving from biohumanism to neurohumanism to posthumanism.

I am cautiously optimistic that we can create a truly inspiring future if we win the race between the growing power of AI and other technologies and the wisdom with which we manage them. To win this race, we must adopt a different strategy than our old one, which allowed us to learn from our mistakes as we explored the creation and use of fire, combustion engines, even atomic power. Within the context of AGI, synthetic biology, or an AGI-driven nuclear arms race, we must get it right from the start by making it safe, because these technologies could obliterate us. We must take control of what future AIs are allowed to do. Because there are different levels of consciousness, we must ensure that wise democracies from world-centric levels of consciousness drive our decision-making. We must ensure that a Gandhi-type, not a Hitler-type, informs our decisions (see Chap. 2). Only if we understand and honor the existence of different stages of consciousness evolution will we be in a position to create beneficial AIs. Will these AIs be driven by an egocentric or ethnocentric mindset that would create separation and nationalistic tendencies, or will we make sure that our AIs are implementing a world-centric or even Kosmos-centric level of consciousness for us all? The decision is ours to make. We will see in Chap. 2 and Chap. 3 how a more holistic approach to investing has a role to play in such decision-making.

\[372\] Kurzweil (2005).
1.6 Summary of Chapter 1

Thus far, we have looked at some of the most important contexts in which humanity operates these days and which are relevant from the perspective of an investor who wants to have a positive impact in the disruption era. We live in exciting, and fast-changing, times. The remarkable advancements in technology and the capital flowing into its ongoing development could give techno-enthusiasts like me a reason to believe that progress will continue at the current, exponential pace, largely uninhibited by the current climate emergency, the vulnerability created by our current outdated financial systems, or as yet unknown other challenges, and that technology—including AIs—will eventually solve our current issues before it is too late to reverse the damage our species has inflicted on ourselves and our planet. For many, it appears to be a zero-sum game whereby we put all our eggs into the technological basket. The “race of our lives” would then be defined by free-market mechanisms that eventually bring us to a safe place where we all win within a business as usual scenario and hope reigns supreme. Hope is, however, a good student but a very bad master. What could be a better master? Von Weizsäcker and Wijkman in Come On!, Pope Francis in his encyclical Laudato Si,’ and Steven Pinker in Enlightenment Now, have all called for a new Enlightenment. But why do we need a new Enlightenment? What is wrong with the old one? Von Weizsäcker and Wijkman agree that in order to be able to address the global challenges, a new Enlightenment must:

- **Be world-centric** rather than Eurocentric
- **Go well beyond individual freedoms** and the separation of state and Church
- **Address the current philosophical crises** mainly caused by the current destructive practices of modern capitalism

Enlightenment 2.0, say von Weizsäcker and Wijkman, ought to be wisdom-driven, a balance between nature and humanity, short- and long-term goals, acceleration, and steadiness, and the private and public realms. It should also encourage achievement and reward justice and equity. But there is also a new dimension that we must realize, namely what Maja Göpel calls The Great Mindshift. In order to implement such a new global, wisdom-driven model for thriving on our blue planet, however, we must dig deeper and look well beyond the external manifestations of applying a technological, regulatory, scientific, social, or environmental lens. We must take a closer look at the source of wisdom and virtue. We must look within at the hidden determinants of such exterior transformation—our interiors both individual and collective. This is what we will do next.

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373 Pope Francis (2015).
374 Pinker (2018).
375 Von Weizsäcker and Wijkman (2018).
376 Göpel (2016).
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