Ten Lessons for a Post-Pandemic World

FAREED ZAKARIA

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INTRODUCTION

The Bat Effect

THE *NEW YORK TIMES* called it "the spiky blob seen around the world." In late January, Alissa Eckert and her colleague Dan Higgins at the Centers for Disease Control and Prevention were tasked with creating an illustration of the novel coronavirus. What was needed was "something to grab the public's attention," Eckert later explained to the *Times*. What they produced was an image of a silvery globe with bright crimson spikes. It was evocative and disturbing, and it was soon everywhere, appearing in newspapers, magazines, and on television news. If right now you are imagining what a coronavirus looks like, then chances are you are thinking of the Eckert-Higgins rendering or a derivation of it. In the slightly macabre world of professional medical artists, the picture is known as a "beauty shot," an up-close depiction of a single viral particle, making it look menacing but also massive. In fact, the novel coronavirus is about 1/10,000th the size of the period that ends this sentence.

We are often advised to think big. But maybe we need to start thinking small. We're good at imagining the big, traditional dangers we face, however unlikely they have become, such as military attacks and invasions, and planning large-scale symmetrical responses to them. Governments spend trillions of dollars to build vast militaries, track the movement of armies across the planet, and practice war games against potential foes. The United States alone devotes almost three-quarters of a trillion dollars to its defense budget every year. And yet, we were unprepared to defend against a tiny microbe. It may well turn out that this viral speck will cause the greatest economic, political, and social damage to humankind since World War II.

This is a book not about the pandemic, but rather about the world that is coming into being as a result of the pandemic and—more importantly—our responses to it. Any large shock can have diverse effects, depending on the state of

the world at the time and on how human beings react—with fear or denial or adaptation. In the case of the novel coronavirus, the impact is being shaped by the reality that the world is deeply interconnected, that most countries were unprepared for the pandemic, and that in its wake, many of them—including the world's richest nations—shut down their societies and economies in a manner unprecedented in human history.

This book is about a "post-pandemic world" not because the coronavirus is behind us, but because we have crossed a crucial threshold. Almost everyone alive had been spared from experiencing a plague, so far. But now we know what a pandemic looks like. We have seen the challenges and costs of responding to it. The Covid-19 pandemic could persist, but even if it is eradicated, new outbreaks of other diseases are almost certain to occur in the future. With this knowledge and experience, we now live in a new era: post-pandemic.

What exactly are the consequences of this pandemic? Some have suggested that it will prove to be the hinge event of modern history, a moment that forever alters its course. Others believe that after a vaccine, we will quickly return to business as usual. Still others argue that the pandemic will not reshape history so much as accelerate it. This last scenario seems the most likely outcome. Lenin is supposed to have once said, "There are decades when nothing happens, and then there are weeks when decades happen." The post-pandemic world is going to be, in many aspects, a sped-up version of the world we knew. But when you put life on fast-forward, events no longer proceed naturally, and the consequences can be disruptive, even deadly. In the 1930s, many developing countries were modernizing at a steady pace, moving people from agriculture to industry. The Soviet Union decided to brutally accelerate that process. This decision, the collectivization of agriculture, led to famine, the "liquidation" of millions of farmers, a hardening of dictatorship, and the deformation of Soviet society. A world on steroids can suffer unpredictable side effects.

Post-pandemic life will be different for countries, companies, and especially individuals. Even if economics and politics return to normal, human beings will not. They will have been through an unusual, difficult trial and have a sense of newfound, hard-won opportunity. Having survived the Spanish flu, a character in William Maxwell's 1937 novel, *They Came Like Swallows*, feels a sense of "wonder clinging to him (for it had been a revelation: neither he nor anyone else had known that his life was going to be like this)." As the worst passes, we emerge into the "dead cold light of tomorrow," as the writer Katherine Anne Porter put it in her 1939 semi-autobiographical novella, *Pale Horse, Pale Rider*, about surviving the same pandemic. Her last line: "Now there would be time for everything."

PLAGUES HAVE CONSEQUENCES

We should have seen it coming. The coronavirus may be novel but plagues are not. Western literature begins with one. In the opening verses of Homer's *Iliad*, the Greek armies are being ravaged by pestilence. It turns out to be divine punishment directed at their leader, the vain, avaricious, and quarrelsome King Agamemnon. The first serious history written in the West hinges on a plague. Thucydides' *History of the Peloponnesian War* chronicles the long conflict between the two superpowers of the age, Athens and Sparta. Toward the beginning of the war, Thucydides writes, a terrible plague swept through Athens, killing vast numbers of able-bodied citizens and, most significant, the city-state's peerless leader, Pericles. The two sides had very different political systems: Athens was democratic, Sparta a more rigidly run warrior society. Sparta eventually prevailed, and it's not a stretch to say that, had there been no plague, Athens might have won, and the course of Western history would have been different—with a vibrant democracy becoming a successful role model rather than a flame that burned brightly, but then flickered out. Plagues have consequences.

The most consequential by far was the bubonic plague, which began in Central Asia in the 1330s and spread to Europe in the following decade. One medieval chronicler accused the Mongols of introducing the disease to the continent by launching plague-ridden corpses into a Genoese fortress by catapult—an early bioweapon. More likely, the plague spread through global commerce, borne by the caravans and ships that plied goods from the Orient to major ports like Messina in Sicily and Marseilles in France. Also called the Black Death, it was carried by fleas on the backs of rats and attacked the lymphatic system of its victims, causing suffering and death on a scale that has never been seen since. Up to half of Europe's population was wiped out. The disease, like many, was never fully eradicated. The World Health Organization still reports a few hundred cases of bubonic plague every year, luckily now treatable with antibiotics.

The bubonic plague had seismic effects. Scholars believe that with so many dead, the economics of the time was turned on its head. Walter Scheidel explains that labor became scarce and land abundant, so wages rose and rents fell. Workers won more bargaining power and nobles lost out. Serfdom withered away in much of Western Europe. Of course, the impact varied from country to country based on each one's economic and political structures. Inequality actually rose in some places that took repressive measures. For example, noble landlords in Eastern Europe used the misery and chaos to tighten their hold and impose serfdom for the first time. Beyond these material effects, the plague prompted an intellectual revolution. Many fourteenth-century Europeans asked why God would allow this hell on earth and questioned entrenched hierarchies—which had the ultimate effect of helping Europe break out of its medieval malaise and setting in motion the Renaissance, Reformation, and Enlightenment. From death and horror came

science, modernity, and growth. With Covid-19, thankfully, we do not face the same mass mortality. But might our era's pandemic provoke a similar spirit of societal introspection, an equivalent shock to our complacency?

The historian William McNeill, who wrote the seminal survey *Plagues and Peoples*, was drawn to epidemiology because he was trying to explain a puzzle: Why were small numbers of European soldiers able to quickly conquer and convert millions of people in Latin America? The Spanish explorer Hernán Cortés, for example, started off with 600 men facing an Aztec Empire of millions. The answer, McNeill found, involved plagues. The Spanish brought with them not only advanced weaponry but also diseases like smallpox, to which they had built up immunity but the natives had not. Estimates of the death toll of the ensuing outbreaks are staggering, ranging from 30% of the population at first to 60% to 90% over the course of the sixteenth century—all told, tens of millions of people. McNeill imagines "the psychological implications of a disease that killed only Indians and left Spaniards unharmed." One conclusion the natives drew, he speculates, was that the foreigners worshipped powerful gods. That might help explain why so many of them submitted to Spanish control and converted to Christianity.

The pandemic still lodged in our memory is the Spanish flu, which hit the world in the midst of World War I and killed some 50 million people, more than twice the number that died in the fighting. (It was called the Spanish flu not because it began in Spain, but because that country, being a noncombatant in the war, did not censor news. The outbreak of the disease was thus reported extensively out of Spain, which led people to assume it originated there.) Science has progressed enormously since the early twentieth century. Back then, no one had ever seen a virus, much less knew how to treat this new infection: electron microscopes had not been invented, nor had antiviral drugs. Still, the three most important guidelines from health authorities at the time—social distancing, masks, and handwashing—remain three of the four most important mechanisms used today to slow the spread of coronavirus, until the development of a vaccine. The fourth, regular testing, is the one modern addition.

In more recent decades, outbreaks of SARS, MERS, avian flu, swine flu, and Ebola spread quickly and widely, leading many experts to warn that we were likely to face a truly global epidemic soon. The public took note, too. In 1994, Richard Preston's best-selling book, *The Hot Zone*, detailed the origins of the Ebola virus. The 2011 film *Contagion*, inspired by the SARS epidemic of 2002–3 and the swine flu pandemic of 2009, imagined a virus that claimed 26 million lives around the world. In 2015, Bill Gates gave a TED Talk warning that "if anything kills over 10 million people in the next few decades, it's most likely to be a highly infectious virus." In 2017, he sounded the alarm louder, predicting in a speech at the Munich Security

Conference that there was a reasonable chance that such a pandemic would erupt in the next ten to fifteen years.

By then, it did not take much foresight to imagine a pandemic and to argue for investing more time, resources, and energy toward stopping it. In June 2017, when President Donald Trump proposed budget cuts in the key agencies that dealt with public health and diseases, I devoted a segment of my CNN show to the topic, saying:

> One of the biggest threats facing the United States isn't big at all. Actually, it's tiny, microscopic, thousands of times smaller than the head of a pin. Deadly pathogens, either man-made or natural, could trigger a global health crisis, and the United States is wholly unprepared to deal with it. . . . One only needs to look back 100 years to 1918, when the Spanish flu pandemic killed an estimated 50 million people around the globe. In many ways, we're even more vulnerable today. Densely packed cities, wars, natural disasters, and international air travel mean a deadly virus propagated in a small village in Africa can be transmitted almost anywhere in the world, including the United States, within 24 hours. . . . Biosecurity and global pandemics cut across all national boundaries. Pathogens, viruses, and diseases are equal-opportunity killers. When the crisis comes, we will wish we had more funding and more global cooperation. But then, it will be too late.

It was too late. We had ample warning to gird ourselves for Covid-19. But beyond the specific dangers of a pandemic, we should have recognized the general possibility of a shock to our system.

After the Cold War, the world settled into a new international system marked by three forces, one geopolitical, one economic, and one technological—American power, free markets, and the Information Revolution. All seemed to work together to create a more open and prosperous world. But it was still a world full of crises—some of which would careen out of control. The Balkan wars, the Asian financial collapse, the 9/11 attacks, the global financial crisis, and now Covid-19. While they are all different, they have something crucial in common. They are all *asymmetric* shocks—things that start out small but end up sending seismic waves around the world. This is particularly true of the three that will be judged as the most enduring—9/11, the crash of 2008, and the coronavirus.

The 9/11 attacks shook the globe, focusing attention on a particular backlash to this new world, which many in the West had previously ignored. The attacks brought to center stage the furies of radical Islam, the tensions in the Middle East, and the West's complicated relationship with both. They then provoked a ferocious response from the United States. The country scaled up a vast domestic security apparatus—but also launched wars in Afghanistan and Iraq and targeted operations elsewhere, spending, by one estimate, $5.4 trillion on the "War on

Terror." That campaign led to bloodshed, revolution, repression, and refugees, with millions of casualties and fallout that persists to this day.

The second shock was entirely different, a financial crash of a kind familiar in history. Good times led to rising asset prices, which led to speculation, then to bubbles, and finally, inevitably, to collapse. Although the crisis began in the United States, it spread quickly across the planet, plunging the world into the worst economic downturn since the Great Depression. The economy recovered slowly but markets boomed, heightening the divide between capital and labor. When it came to politics, the crisis had complex and corrosive effects. Even though the roots of the crash lay in the excesses of the private sector, in many countries, people did not move to the left economically; they moved to the right culturally. Economic anxiety bred cultural anxiety, hostility to immigration, and a nostalgic desire to return to a familiar past. Right-wing populism gained strength across the West.

The third shock is the one we are living through. It may be the biggest of them all, and it is certainly the most global. What began as a health-care problem in China soon became a global pandemic. But that was only the start. The medical crisis prompted a simultaneous lockdown of all business across the globe, resulting in a Great Paralysis, the cessation of economics itself. By some measures, the economic damage from this pandemic already rivals that of the Great Depression. The political consequences will play out over the coming years in different ways in different countries. The social and psychological consequences—fear, isolation, purposelessness—might endure even longer. Covid-19 is having deep and lasting effects on each of us, repercussions we cannot yet fully grasp.

And yet each of these three massive, global crises turned on something small, seemingly trivial. Think about the 9/11 attacks, launched by nineteen young men, armed with the simplest and crudest of weapons, small knives, not so different from those used in the Bronze Age 4,000 years ago. But those nineteen men set in motion a wave of warfare, intelligence operations, revolts, and repression around the world. Or consider the origins of the global financial crisis—one obscure financial product, the "credit default swap," a kind of insurance policy mostly on mortgages, was bundled and re-bundled, sliced and diced, sold and resold, until it became a $45 trillion market, three times larger than the US economy, and three-quarters the size of the entire global economy. And when that market crashed, it took the world economy with it and, in due course, triggered a wave of populism. Without credit default swaps, there might never have been a President Donald Trump.

And in the case of this pandemic, we now all recognize how a tiny viral particle, circulating in a bat in China's Hubei Province, has brought the world to its knees—a real-life example of the butterfly effect, whereby the flapping of a

butterfly's wing might influence weather patterns on the other side of the world. Small changes can have big consequences. In power grids or computer networks, if one tiny element breaks and then shifts its load to another, which then breaks, it can produce a chain reaction that grows ever larger, like a ripple that becomes a roaring wave. It is termed a "cascading failure." A single software glitch or broken transformer can shut down an entire system. Something similar happens in biology. A minor infection in the blood can lead to a tiny clot that, through a chain reaction, can cause a massive stroke—a process called an ischemic cascade.

In earlier ages, epidemics were considered something outside of human agency or responsibility. The word *influenza*, for example, traces back to an Italian folk attribution of colds and fevers to the influence of the stars. In time, however, perceptions changed, and humans focused more on the features of the problem that were readily apparent, an important step toward then seeing what could be done about the problem. The French started calling influenza *grippe*, from the word for "seizure," likely referring to the tightness felt in the throat and chest. Ever since 1990, sudden, massive seizures have gripped the world—about one every ten years—with cascading effects. We will have more. They don't happen by conscious design, but neither are they entirely accidental. They seem to be an inherent element of the international system we have built. We need to understand that system—in other words, understand the world in which we live—in order to see the emerging post-pandemic world.

LESSON ONE

Buckle Up

THE COVID-19 PANDEMIC is *new*, upturning many of our daily patterns and presumptions. But it has also revealed aspects of the world that are very old. This emergency has highlighted one of the oldest truths about international life—that ultimately, countries are on their own. When the pandemic struck, nations that had long cooperated—in Europe, for example—shut their borders and focused on their own survival. That would not surprise scholars of international relations, who have noted that the most important difference between domestic and international politics is that in the latter, there is no supreme authority, no world government, no Leviathan that maintains order. That basic condition has led many thinkers to conjure up an international realm of perpetual competition and conflict. Thomas Hobbes described countries as always "in the state and posture of Gladiators; having their weapons pointing, and their eyes fixed on one another." In fact, history is filled with periods of war *and* peace. Over the last century, countries have spent more time at peace than at war. Trade, travel, and investment across borders have soared. Nations have created mechanisms and institutions to cooperate and solve common problems. But in the end, in extremis, they walk alone.

Covid-19 hit a world that gained its essential structure in the years after the Cold War. With great-power rivalry subsiding and global trade booming, nations got linked by the strong bonds of interdependence. But economic integration also created countercurrents, as countries jockeyed for advantage and new economic competitors rose to become geopolitical challengers. In these same years, the Information Revolution ensured that everything—goods, services, culture, and ideas—moved around at warp speed. As did disease. All these tangible and intangible flows still course through every country on the planet, yet no one nation can shape them on its own. Everyone is connected, but no one is in control.

In other words, the world we live in is open, fast—and thus, almost by definition, *unstable.*

It would be hard to bring stability to anything so dynamic and open. It turns out that in any system, of these three characteristics—open, fast, stable—you can have only two. An open and fast system, like the world we live in, will be inherently unstable. A fast and stable one will tend to be closed, like China. If the system is open and stable, it will likely be sluggish rather than dynamic. Think of the nineteenth-century Austro-Hungarian and Ottoman empires: vast, open, diverse—and decaying. This "trilemma" is an adaptation of an idea of Jared Cohen's, the technologist, who observed that computer networks must choose two of three qualities: openness, speed, and security. Economists have their own version of this idea, the "policy trilemma," which posits that countries can have two of the following three: free-flowing capital, independent central banks, and a fixed exchange rate. They're a bit wonkish, but all these trilemmas get at a simple notion—if everything is open and fast-moving, the system can spin dangerously out of control.

Consider our highly dynamic form of global capitalism, which can result in supercharged growth but also financial crashes and economic tailspins. From the mid-1930s to the early 1980s, when financial markets were more regulated, serious financial panics were few and far between. In recent decades, however, as governments deregulated finance, we have witnessed one crash after another: the Latin American debt crisis, the savings and loan collapse, the Mexican "Tequila" crisis, the Asian meltdown, the Russian default, the implosion of Long-Term Capital Management, the bursting of the tech bubble, and the global financial crisis. More open, more dynamic, more unstable.

We have created a world that is always in overdrive. Human development in every sense has dramatically accelerated over the last two centuries, and that pace has quickened further in the last few decades. People are living longer, producing and consuming more, inhabiting larger spaces, consuming more energy, and generating more waste and greenhouse gas emissions. Just one example: a 2019 UN report, written by 145 experts drawn from fifty countries, concluded that "nature is declining globally at rates unprecedented in human history." It noted that 75% of all land has been "severely altered" by human actions, as has 66% of the world's ocean area. Ecosystems are collapsing, and biodiversity is disappearing. As many as 1 million plant and animal species (of 8 million total) are threatened with extinction, some within a few decades. All these strains and imbalances produce dangers—some that can be foreseen, and others that cannot.

ACTION AND REACTION

To understand this model of relentless action and reaction, think about the three

great crises of the twenty-first century—9/11, the financial crash, and Covid-19—one political, one economic, and one natural. In the first, 9/11, we saw that the supposedly unstoppable march of capitalism, democracy, and American hegemony had produced an angry, violent reaction in parts of the Muslim world. The West and its values were sweeping the planet, but it turned out that not everyone was happy about this. The backlash was that of a disgruntled minority—after all, terrorism is the weapon of the weak—but still it took the world by surprise.

The 2008 crash was the outgrowth of an economy in which finance had run wild, so much so that financial engineering was routinely more profitable than actual engineering. Wall Street invented more and more esoteric products, derivatives piled on derivatives, encouraging people to take more and more risks for smaller rewards. Add to this the relentless focus on home ownership, which led the government and private firms to lure more and more people to buy bigger houses and take on more debt. Ultimately, the system grew so complex that it took only a small shift in housing prices to unravel altogether. The crisis was the economic equivalent of a cascading failure.

The pandemic, for its part, can be thought of as nature's revenge. The way we live now is practically an invitation for animal viruses to infect humans. The Centers for Disease Control and Prevention estimates that three-quarters of new human diseases originate in animals. That was the case for AIDS, Ebola, SARS, MERS, bird flu, swine flu, and, most likely, the novel coronavirus. Why do diseases seem to be jumping from animals to humans at a faster pace in recent decades? Because in many parts of the world, people are living closer to wild animals. Developing countries are modernizing so quickly that they effectively inhabit several different centuries at the same time. In Wuhan and other such cities, China has built an advanced, technologically sophisticated economy—but in the shadows of the skyscrapers are wildlife markets full of exotic animals, a perfect cauldron for animal-to-human viral transfer. And the people who live in these places are more mobile than ever before, quickly spreading information, goods, services—and disease.

Our destruction of natural habitats may also be to blame. Some scientists believe that as humans extend civilization into nature—building roads, clearing land, constructing factories, excavating mines—we are increasing the odds that animals will pass diseases to us. Covid-19 appears to have originated in bats, which are hosts to many other viruses, including rabies and Ebola. Why bats? They have highly developed immune systems and defense mechanisms, such as a feverishly high body temperature when flying, which select for stronger viruses. Bats can endure viruses that might quickly debilitate other animals, giving the viruses greater opportunity to spread.* Bats also gather in large numbers in close proximity to one another, creating perfect breeding grounds for viral

transmission. Just outside San Antonio, Texas, you can find the Bracken Cave Preserve, home to the world's largest colony of bats. Between March and October, over 15 million Mexican free-tailed bats congregate there and roam the skies at night, producing sights and sounds so dramatic that they are called a "batnado."

Bats used to live farther from humans. But as we encroached on their habitats, their diseases increasingly became our diseases. In Malaysia, rainforests have been cut down for decades in order to produce palm oil and lumber. Over time, this deforestation pushed fruit bats closer and closer to places where they could sustain themselves. Many clustered around pig farms, feeding off the mango and other fruit trees that grew there. And so in 1998, a virus called Nipah, hosted in bats, appears to have infected pigs which then infected farmworkers. Something similar was probably at work with the novel coronavirus, which likely found an intermediate host—perhaps the pangolin, whose scales are used in traditional Chinese medicine—before infecting humans. "We are doing things every day that make pandemics more likely," said Peter Daszak, an eminent disease ecologist. "We need to understand, this is not just nature. It is what we are doing to nature."

As economic development moves faster and reaches more people, we are taking ever-greater risks, often without even realizing it. Think about meat consumption. As people get richer, they tend to eat more meat. When this happens globally, the effect is staggering: some 80 billion animals are slaughtered for meat *every year* around the world. (And that doesn't even count fish.) But supplying this enormous demand comes at great cost to the environment and our health. Animal products provide only 18% of calories worldwide, yet take up 80% of the earth's farmland. Meanwhile, meat is now produced as if in a nineteenth-century factory, with vast numbers of animals packed together in gruesome conditions. Most livestock—an estimated 99% in America, 74% around the world—comes from factory farms. (Organically farmed, grass-fed meat is a luxury product.) These massive operations serve as petri dishes for powerful viruses. "Selection for specific genes in farmed animals (for desirable traits like large chicken breasts) has made these animals almost genetically identical," *Vox*'s Sigal Samuel explains. "That means that a virus can easily spread from animal to animal without encountering any genetic variants that might stop it in its tracks. As it rips through a flock or herd, the virus can grow even more virulent." The lack of genetic diversity removes the "immunological firebreaks." Samuel quotes the biologist Rob Wallace: "Factory farms are the best way to select for the most dangerous pathogens possible."

The 2009 H1N1 swine flu outbreak seems to have arisen in North American pig farms, while many avian flus have been traced to poultry-producing factory farms in East Asia. Factory farms are also ground zero for new, antibiotic-resistant bacteria, as animals are bombarded with antibiotics that kill most bacteria but

leave those that survive highly potent. Johns Hopkins professor Robert Lawrence calls antibiotic-resistant bacteria "the biggest human health risk of factory farms." Some 2.8 million Americans fall ill from antibiotic-resistant bacteria annually, according to the CDC, and 35,000 of them die a result. That's one person every fifteen minutes. Globally, the death toll is 700,000 a year. And yet, meat consumption keeps rising every year.

TEMPTING FATE

It's strange that in America we have not learned the lesson that hasty, unplanned development can provoke a backlash. After all, the country has experienced several, most notably the 1930s Dust Bowl, the greatest ecological disaster in North American history. The event is seared in the American imagination, depicted in novels and captured in movies. The bitter tale of desperate Dust Bowl migrants inspired John Steinbeck's *Grapes of Wrath*—describing the plight of people who could be called America's first climate refugees. And it is a story of human action causing a natural reaction.

The Great Plains are the semiarid places east of the Rocky Mountains and west of the Mississippi River. The wind blows fast over these lands, sometimes scarily so. Over centuries, probably millennia, nature's solution was to grow grass that held the loose topsoil in place. But by the late nineteenth century, as the pioneers headed west, lured by promises of fertile farmland, they tilled the prairies, turning the grassy plains into wheat fields. The farmers felled trees that served as windbreaks, and turned the soil over and over, until there was no grass and the topsoil had been reduced to a thin, loose layer just covering the hard land beneath.

Then came bad weather. Starting in 1930, the region was hit by four waves of drought. With the drought came winds—ferocious gales that blew off the entire layer of topsoil with a force that few humans had seen before and kicked up dust storms that blackened the sky. By 1934, the topsoil covering 100 million acres of land had blown away. The heat intensified the suffering—1934 was the United States' hottest year on record until 1998. Thousands died and millions fled. The farmers left behind were plunged into a decade of poverty.

We are tempting fate similarly every day. Climate change is a vast topic that deserves its own books and warnings. But suffice it to say that we are now watching its effects on almost every part of the natural environment. It is bringing a tropical climate to more of the world, thus creating more hospitable conditions for disease. It is also turning more land into desert—twenty-three hectares every minute, by the UN's estimate. In 2010, Luc Gnacadja, who headed the organization's effort to combat desertification, called it "the greatest environmental challenge of our time," warning, "The top 20 centimeters of soil is

all that stands between us and extinction." Thirty-eight percent of the earth's surface is at risk of desertification, and some of it is caused less by global climate change than by something more easily preventable: the over-extraction of water from the ground. One of the world's most crucial water sources is the Ogallala Aquifer, which sprawls through the semiarid lands of South Dakota, Nebraska, Kansas, Oklahoma, and Texas and supplies about a third of the groundwater used to irrigate American farms. This seemingly bottomless well is in fact being emptied by agribusiness so fast that it is on track to shrivel by 70% in less than fifty years. If the aquifer ran dry, it would take 6,000 years for rainfall to refill it.

You may say that this is not new. Human beings have been altering natural processes ever since they learned how to make fire. The changes picked up speed with the invention of the wheel, the plow, and most dramatically, the steam engine. But they intensified, particularly in the twentieth century and in the last few decades. The number of people on the planet has risen fivefold since 1900, while the average lifespan has doubled. The increase in lifespan goes "beyond the scope of what had ever been shaped by natural selection," explained Joshua Lederberg, the biologist who won the Nobel Prize at age thirty-three for his work on bacterial genetics. In a brilliant, haunting speech in 1989 at a virology conference in Washington, DC, Lederberg argued that we have changed our biological trajectory so much that "contemporary man is a man-made species."

Lederberg called human beings' continued economic and scientific advancement "the greatest threat to every other plant and animal species, as we crowd them out in our own quest for *Lebensraum*." "A few vermin aside," he added, "*Homo sapiens* has undisputed dominion." But he pointed out that we do have one real competitor—the virus—and in the end, it could win. "Many people find it difficult to accommodate to the reality that Nature is far from benign; at least it has no special sentiment for the welfare of the human versus other species." Lederberg reminded the audience of the fate that befell rabbits in Australia in the 1950s, when the myxoma virus was unleashed upon them as a population-control measure. Eventually, rabbits achieved herd immunity, but only after the virus had killed over 99% of those infected in the first outbreaks. He concluded his speech with a grim image: "I would . . . question whether human society could survive left on the beach with only a few percent of survivors. Could they function at any level of culture higher than that of the rabbits? And if reduced to that, would we compete very well with kangaroos?"

If you aren't already worried enough, remember that we have considered the dangers only of natural reactions to human activity, from pandemics to global warming. But could humans use disease as a weapon? There are a few examples in history. The scholar Toby Ord has pointed out in his book *The Precipice* that, as far back as 1320 BC, sheep infected with the bacterial disease tularemia were driven

from one kingdom to the next in Asia Minor. In modern times, the Soviet Union had a sophisticated bioweapons program, employing 9,000 scientists at its peak, to weaponize everything from smallpox to anthrax. Advances in biology and technology mean that today, it would take only a few trained scientists and a small investment to produce deadly pathogens.

I have always considered bioterror to be the most important under-discussed danger facing us. Since 9/11, the United States has focused much of its energy on stopping the spread of nuclear weapons. It went to war in Iraq chiefly to stop that country's supposed nuclear program, and it has threatened war with Iran and North Korea on the same grounds. Nuclear nonproliferation remains at the top of the US agenda; a vast body of arms-control treaties regulate these weapons internationally. But nuclear weapons are hard to build and relatively easy to detect. Bioweapons are far more practical to develop; they can be made cheaply and secretly in small laboratories on shoestring budgets. Their impact is almost unthinkably large: the death toll from manufactured pathogens could easily reach into the millions, even higher. And yet this danger gets little attention. The main international forum for preventing it, the Biological Weapons Convention, is an afterthought. As Ord notes, "this global convention to protect humanity has just four employees, and a smaller budget than an average McDonald's."

OUR RESILIENT WORLD

This is a gloomy compendium of threats. And given the unstable nature of our international system, it may seem that our world is terribly fragile. It is not. Another way to read human history is to recognize just how tough we are. We have gone through extraordinary change at breathtaking pace. We have seen ice ages and plagues, world wars and revolutions, and yet we have survived and flourished. In his Nobel acceptance speech, Joshua Lederberg acknowledged that nature usually seeks an equilibrium that favors mutual survival between the virus and the host—after all, if the human dies, so does the parasite. Human beings and our societies are amazingly innovative and resourceful. This planet is awe-inspiringly resilient. But we have to recognize the ever-greater risks we are taking and act to mitigate them. Modern human development has occurred on a scale and at a speed with no precedent. The global system that we are living in is open and dynamic, which means it has few buffers. That produces great benefits but also vulnerabilities. We have to adjust to the reality of ever-increasing instability —now.

We are not doomed. The point of sounding the alarm is to call people to action. The question is, What kind of action? There are those, from the right and left, who want to stop countries from growing economically and shut down our open world. But should we tell the poorest billion in the world that they cannot escape

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