INGENUITY THEORY:
CAN HUMANKIND CREATE A SUSTAINABLE CIVILIZATION?

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I: Introduction

My research is inspired by several key questions: Are we creating a world that's too complex to manage? Do the "experts" really know what's going on? Are we really as smart as we think we are? And, most importantly, Can we solve the problems of the future?

Sometimes it seems like the world is going haywire. Sometimes it seems like humankind is confronting one crisis after another, in ever-quicker succession.

War in the Persian Gulf. The lightning spread of severe acute respiratory syndrome. Deadly heat waves in Europe and India. Electrical failures that plunge millions of people into darkness. Day after day of horrendous terrorist attacks and retaliations in the Middle East. Millions of people dying of AIDS in Africa.

Is there something new here? Has the world changed in some profound respects and become more dangerous and unhinged? Or should we simply come to expect events like these on a busy planet packed with six billion people?

Every generation feels it lives on the cusp of chaos. People always feel that change is too rapid and that the world is becoming too complex and unpredictable, but in the end they often manage well. Indeed, despite a widespread perception of constant crisis, the past decades have brought astonishing material and social progress to much of humanity. Why shouldn't coming decades be similar?

Many people have great faith in the capacity of humankind to use its ingenuity to solve its most pressing problems—and that faith is completely understandable. On balance, even compared to the situation a generation ago, things are going very well today. Human beings have longer and healthier lives. A larger proportion of the human population lives in democracies than ever before. Market-based economic policies are now accepted far and wide. The specter of nuclear cataclysm has largely vanished. In many ways, this is the best of times.

And there's no reason, these optimists go on, why things shouldn't continue to get better. Optimists on the right of the political spectrum say that global capitalism will further raise humanity's general prosperity and start narrowing the gulf between the richest and poorest societies. Optimists on the left believe that the communication revolution will stimulate a fluorescence of global civil society and create networks of activism that promote human rights and help protect the environment. Optimists of all political stripes claim that the widening and deepening of democratic practice around the world will lead to less war, because democracies don't fight each other. And those who put their hopes in technology are confident that new energy technologies, like hydrogen fuel cells, will reduce our dependence on fossil fuels and our output of climate-changing carbon dioxide; while aquaculture and genetically modified crops will help us feed a human population 50 percent larger than today's.

Most of these arguments boil down to a simple and bold assertion: human beings are smart enough—when given the right incentives—to solve any problem they might face.

But are these optimists right? The question really breaks into two parts: first, are the problems we're confronting as individuals, societies, and a species becoming harder? And, second, if so, can we really solve them?

These are the questions I'll consider during this lecture this evening. My answer to the first will be a strong "yes." And my answer to the second will be "too often not."

I'll argue that some of the problems we're creating for ourselves are so complex, opaque, fast-paced, and simultaneous in their occurrence that we can't hope to address them effectively. And the sooner we understand this fact, the sooner we can begin to adjust our behavior in ways that could prevent catastrophe.

II: Ingenuity

Grim assessments of the human prospect have a long history and, sometimes, even a good pedigree.

In 1945, at the end of his extraordinarily life, the novelist H.G. Wells observed that "hard imaginative thinking has not increased so as to keep pace with the expansion and complications of human societies and organizations." This was, he went on, "the darkest shadow upon the hopes of mankind."

Wells put his finger on a crucial and often overlooked point. We are indeed in a race between hard imaginative thinking—or what I call ingenuity—and the ever-expanding complications of our world. And in too many critical places, and on too many critical issues, we're losing that race.

Ingenuity, as I define it, consists of "sets of instructions that tell us how to arrange the constituent parts of our physical and social worlds in ways that help us achieve our goals." Ingenuity is like cooking recipes, and these recipes allow us to manipulate, process, and reconfigure the matter that surrounds us—the materials in the ground, the gases that in the atmosphere, and the organic components of our biosphere—into things that improve our lives.

Take, for example, the laptop computer in front of me. By itself, this device probably has more power than all the computers available to the U.S. Defense Department in the 1960s taken together. Yet it consists of nothing more than reconfigured rock and hydrocarbons. We have extracted materials from the ground and, by following an immensely long and elaborate set of instructions, refined and reconfigured them into this remarkable device here. The same is true for every human-made thing around us, including the lights above our heads, the furniture we're sitting on, and the food on our plates.

The value of this ingenuity perspective is clearest when it's contrasted with the conventional economic view—a view that, in Western societies at least, permeates our understanding of human and social behavior.

The economic paradigm—or worldview—holds that human beings are rational consumers, who engage in consumption, production, investment, and saving. When conventional economists analyze how we produce the things around us, like laptop computers, they usually focus on the inputs of capital and labor, which they identify as "factors of production." Capital consists mainly of the machines used to make things like laptops, while labor is the work applied to running these machines. Sometimes economists acknowledge the importance of resources (which they call "land") and of ideas, but, in general, they give little thought to the independent productive role of ideas.

In contrast, I identify practical ideas as critically important.

Human beings—according to my ingenuity paradigm—are pragmatic problem solvers. What truly distinguishes us from other species is, I believe, our capacity to generate and implement sets of instructions—or ingenuity—to solve our problems. So this perspective highlights our requirement for ingenuity and our ability to supply it. And the key inputs are matter, energy, and ideas.

We can state the relationship among these inputs as follows: human beings use ingenuity to guide the application of energy to arrange the matter around them (including materials and people) in ways that they hope will solve their problems.

Notice, too, that we use sets of instructions not just to tell us how to arrange and configure the natural materials of our world, but also to tell us how to arrange people in our organizations and institutions. So we have to distinguish, at minimum, between two types of ingenuity.

If "technical ingenuity" consists of recipes for making technologies like laptops, cars, and furniture, then "social ingenuity" consists of recipes for setting up court systems, markets, and parliamentary democracies. Although ideas for new technologies tend to attract popular attention, it turns out that social ingenuity is more important. Indeed, social ingenuity is a precursor to technical ingenuity: we don't get the new technologies we want unless our economic institutions—especially our markets—reward innovators for the risks they take; and well-functioning markets take huge amounts of ingenuity to design, set up, and run.

III: Requirement

With all this as background, we can now ask some useful questions. First, is our requirement for ingenuity rising, and if so why? Second, can we supply the ingenuity we need? And third, if we can't, what does this situation mean for our future?

Let's focus for the moment on the first question. I argue that our ingenuity requirement is skyrocketing. But this doesn't mean, by itself, that we're in trouble, because it's possible we can supply all the ingenuity we need. It does mean, though, that if we're going to keep up with—and hope to solve—the problems we face, we will have to work much harder and be much smarter.

Our need for ingenuity is rising largely because of changes in the intrinsic character of the systems we live within and depend upon. Critical technological and social systems—from computer networks to the international financial systems—are rapidly becoming more complex, and they are operating at an ever-faster pace. In some cases, they are also becoming more susceptible to sharply unpredictable or—as specialists call it—"nonlinear" behavior.

The evidence of rising complexity is all around us. Just take a look at some common technologies, like your car engine, your computer, or the thermostat in your house. As inventors, designers, and engineers have tried to boost the performance of each of these technologies, they have added layer after layer of new components and sub-systems—in a process the renowned economist W. Brian Arthur calls "structural deepening."

Car engines have been fitted with pollution-control devices and computer-controlled fuel-injection systems; household computers have sprouted tape back-up systems, video cams, high-performance speakers, and batches of exciting software; and your thermostat now includes a programmable chip that adjusts your house's temperature minute-by-minute, and often room-by-room, throughout the day.

It's true that these advances have often made many of our commonplace technologies easier to use, decreasing our immediate inputs of effort and ingenuity: because our cars have starter engines, we don't have to crank-start them anymore—which is clearly a good thing—and because our computers have graphical interfaces, we don't have to learn the intricacies of DOS. But when our cars, computers, and other devices break down, their background ingenuity requirement is revealed. Years ago, many of us could fix our cars and computers. Now we have to turn to outside specialists; and the specialists themselves often have to turn to further specialists. Clearly, our overall need for ingenuity to invent, deploy, and maintain our technological systems has vastly increased.

What is true of technologies is also true of organizations and institutions. In general our corporations, bureaucracies, governments, and market institutions are becoming more complex—they are adding, in the vernacular, more administrative, legal, and regulative "bells and whistles"—as they try to perform more efficiently and quickly and as they try to do more in a competitive social and economic environment.

But structural deepening is not the only cause of our world's rising complexity. Another is the rising connectivity of the networks in which individual technologies, organizations, and institutions are embedded. Here I contrast a simple network with a more complex one: especially with the arrival of new and better means of communication, the number or density of links among the nodes in these networks has increased dramatically.

Moreover, the rate at which we move material, energy, people, and particularly information across these links has soared, as I illustrate here:

We are probably only in the middle of this sigmoid curve. Yet in the last three decades alone, we have seen perhaps a hundred-million-fold increase in the capacity to move information between our organizations, our corporations, our computers, and ourselves. This greater velocity of transfer means that, in general, the pace of events within our networks has shot up.

Soaring connectivity and pace are most obvious in networks were information transfer is key, like international equity, debt, and currency markets and today's tightly integrated, globe-spanning systems of industrial and agricultural production. These networks rely upon technologies—especially computer systems, the Internet, and the Web—that have made the movement of huge amounts of information essentially frictionless. Yet we also see the effects of increased connectivity and pace in our everyday lives: most of us now feel perpetually drained by obligations and demands that seem to converge from every direction. How often, these days, do we feel that too many people can contact us and that there's simply no time, anymore, to think or reflect?

Another factor boosting our ingenuity requirement is the sometimes-unpredictable behavior of critical networks. As our financial systems, computer networks, and industrial economies have become more complex and operate at higher velocity, they've become more opaque to their operators and managers. These managers are frequently faced with "unknown unknowns"—situations in which they are ignorant of their ignorance, in which they don't even know what questions to ask about why their networks behave the way they do. We feel the same bewilderment every time we look under the hoods of our cars—here, under their bonnets I suppose—to observe the incomprehensible tangle of wires, hoses, belts, and computer components that resides there now.

This is not necessarily bad news, because complex networks can be quite stable and resilient over time, and so need little management. But the popular

assumption that greater network connectivity and complexity leads to greater stability and resilience is wrong. Recent research shows that much depends on the details of how a given network is connected. Some networks, like the international financial system, are so tightly coupled and contain so many self-reinforcing feedback loops, that they are vulnerable to cascading failures—as we saw in the 1997-98 global financial crisis, which spread like wildfire around the planet. Other networks—including the Internet and our electricity grids—depend critically upon a few highly connected non-redundant nodes, and if these nodes fail, then the whole network is vulnerable to sudden failure, as we've seen recently in North America and Italy. In all these situations, managers must remain highly vigilant and must supply a great deal of ingenuity to prevent breakdown.

IV: Globalization

Our need for ingenuity is soaring in our personal lives and in our national societies and networks. It's also soaring in our global affairs. Humankind has become a planetary force. Although we've been crisscrossing the globe for millennia, and although we've been trading raw materials and manufactured goods around the world for many centuries, only in the last fifty years or so have we created densely interlinked economic, social, and technological systems that are truly planetary in scope. And only recently, too, have our environmental impacts become planetary: for the first time in our species' history we're disrupting the deepest processes of Earth's climate and ecology and altering its fundamental flows of energy and vital elements, like carbon, nitrogen, and sulfur.

This is the true character of globalization—a phenomenon that many people talk about but that many also misunderstand. It's not simply a process of rising economic interdependence among countries. That's something that has been underway for hundreds of years. Globalization is really a much broader and, in many ways, more recent phenomenon

—an almost vertical rise in the complexity, pace, connectedness, scope, and often unpredictability of all humankind's activities and impacts. It's as much about the lightening spread of new diseases around the planet, the infestation of the Great Lakes by foreign mollusks, and the arrival of waves of immigrants at Europe's gates as it is about trade negotiations, farm subsidies, and currency convertibility.

Our planetary systems are now enormously complex, full of surprises, and often tightly interlinked in ways we don't remotely understand. This means we often can't predict their behavior. It also means that we manage them badly; too frequently we don't succeed in managing them at all. Even worse, as time passes we seem to be making some of these systems more unstable and dangerous. The international economy flips between order and turbulence, the planet's climate sits on the cusp of radically new behavior, and the world's skewed distribution of wealth and power generates immense potential for mass violence. Whether we're talking about new drug-resistant pathogens, our voracious appetite for hydrocarbon energy, or the emergence of mega-terrorism, the problems we face spill across geographical and intellectual boundaries, their intricacies often exceed our wildest imaginations, and they converge and intertwine in totally unexpected ways.

I want to illustrate these characteristics of globalization by taking you a long way from London—to Antarctica and a research station at Lake Vostok, not far from the South Pole.

From the 1970s into the 1990s, an international team of scientists, originally led by Russians, drilled down into one of the ice sheets that cover much of the southern continent. They extracted a four-kilometer-long cylinder or "core" of ice that represents a record of Antarctic snowfalls going back 420 thousand years.

Over this immense period of time, each new snowfall compressed the previous one beneath it, and the layers upon layers of snow accumulated into the vast ice sheets we find in Antarctica today. Through precise and painstaking analysis of the ancient snowfalls in the ice cores—including the air bubbles trapped in the snow—the scientists determined both the atmosphere's carbon dioxide concentration and its average temperature over Antarctica at the time the snow fell.

What they found shocked them: they had unlocked from the ice evidence that humankind could be throwing the planet's climate completely out of kilter.

During the 420 thousand years, carbon dioxide concentrations and air temperature varied almost in lockstep: as the carbon dioxide concentration rose, the temperature rose; as the carbon dioxide concentration fell, the temperature fell. The scientists knew that this close correlation between carbon dioxide levels and temperatures didn't necessarily mean that changes in carbon dioxide levels caused the changes in temperature. But the ice cores provided impressive—as lawyers would say—prima facie evidence of the link between

carbon dioxide concentrations and temperature.

But what was most shocking was how humankind had already shoved the carbon dioxide concentration far outside the range of fluctuation that had prevailed for hundreds of thousands of years. As we see from the vertical segment on the right of the carbon dioxide line, today this concentration is a third higher than the concentration in preindustrial times. Most experts now believe that in the next one to two centuries we will see at least a doubling, and perhaps a quadrupling, of carbon dioxide concentrations from preindustrial levels.

And this increase is happening in the blink of an eye—relative to the time span of 420 thousand years.

Experts can't say for sure what effect the increase will have on the planet's average temperature. But the Vostok ice cores suggest temperature will rise, and rise fast. Computer models predict that the warming of the next hundred years will probably happen faster than any warming of the last ten thousand. And once we get beyond a doubling of carbon dioxide—something that will probably occur sometime in the last half of this century, certainly within the lifetimes of our grandchildren—scientists' models of the global climate break down. At that point, they don't have a clue what will happen.

One thing, though, is certain: with each incremental ton of carbon we emit from our cars, powerplants, and logging operations, we are producing, inexorably, an atmosphere that is greatly different from the one that influenced human civilizations in the past. In fact, in the next two hundred years, we may produce an atmosphere with carbon dioxide levels that Earth hasn't seen in hundreds of millions of years.

It's not just carbon dioxide, although carbon dioxide emissions and climate change are getting a lot of attention these days. Around the planet, we are moving so much rock and dirt, blocking and diverting so many rivers, converting so many forests to cropland and pastureland, releasing such huge quantities of heavy metals and organic chemicals into air and water, and generating so much energy, methane, and nitrogen compounds that we are perturbing the deepest dynamics of our global environment.

A similar pattern is unfolding in practically every domain of human activity. We seem to be doing more of everything, over larger areas, faster than ever before. It's as if we've got our collective foot slammed down on the world's accelerator pedal. And in the process, we are creating problems for ourselves whose magnitude and complexity are almost beyond comprehension.

V: Supply

In response to an evermore intertwined, unpredictable, and urgent array of technical and social issues, we must make faster and more sophisticated decisions about technologies, policies, and institutional arrangements. In other words, to solve our myriad problems—within our personal lives, within our societies, and at the level of global affairs—we need to deliver ingenuity in greater quantities at greater speed in more places.

This brings us to the second question: can we always supply the ingenuity we need? I contend that a variety of factors restrict our ability to generate and implement ingenuity. I identify four elements to what I call the ingenuity supply chain: brains, science markets, and politics.

We can begin with brains, because the amazing cognitive machine between our ears is the primary engine of our ingenuity supply. It's where our ideas for solving our problems are born. Although I won't address the issue in detail here tonight, there are reasons to believe that the complexity and velocity of today's vital economic, social, technological, and ecological systems now exceed the human brain's raw abilities—abilities that evolved hundreds of thousands of years ago, in Africa, in radically different circumstances from today's.

There are other concerns about the human brain, too. Its capacity for easy adaptation to incremental change—like the slow warming of our climate—keeps us from seeing how we are creating a qualitatively new and possibly dangerous world. Its hard-wired cognitive rules of thumb and shortcuts—essential tools for dealing with large amounts of information—are woefully inappropriate when we're enmeshed in nonlinear, tightly coupled systems in which small things and small events can matter a lot. Its tendency to simplify and dichotomize issues when under stress is unsuited to snarled problems that demand subtlety and nuance of thought. And its relentlessly optimistic temperament—what the anthropologist Lionel Tiger has called our "biology of hope"—shortens our time horizons and instills in us a potentially fatal imprudence.

Science and technology are also critically important to ingenuity supply. Because this is a subject of par-

ticular interest to this audience, I will focus on it for a moment. Although science faces no theoretical limits to its progress, at least in the foreseeable future, practical constraints often slow useful developments.

First, science's rate of advance depends on the characteristics of the natural phenomena it investigates, simply because some phenomena are intrinsically harder to understand than others. So the production of useful new knowledge in these areas can be very slow. A good example is the history of the development of fusion power. This may be the ultimate energy source—the power that drives the sun and the stars—but physicists have had huge difficulty harnessing it on Earth. Fifty years ago, experts widely predicted that fusion energy would be commercially available by the end of the 20th century. Despite enormous investments in research, today that goal is still fifty years away.

Second, the cost of scientific research tends to increase as it delves deeper into nature: it requires more expensive scientific instruments and equipment, and it demands more specialized scientific expertise, because as our knowledge base grows, and given the human brain's inherent cognitive limits, it's harder for one person to master anything more than a narrow subfield.

Third, the institutions that govern and guide science—from its laboratories to its procedures for funding research and for peer review of scientific papers—may not function well and may not give scientists the incentives they need to do good work. In many parts of the world where scientific and medical knowledge is desperately needed, laboratories are inadequately funded, scientists are not properly trained, and journals aren't available. Even in societies with advance scientific institutions, deeply entrenched disciplinary boundaries can hinder the creative cross-disciplinary cooperation needed to deal with the profoundly interdisciplinary challenges facing humankind.

Fourth, society as a whole may not provide a supportive context for science. For instance, in the West we have seen a groundswell of distrust, misunderstanding, and even fear of science. These popular attitudes often distort our research priorities and discourage the best and brightest from becoming scientists.

As a result of these impediments, acting singly or together, there is often a critical time lag between the recognition of a problem and the delivery of enough ingenuity, in the form of useful technologies, to solve that problem. Progress in the social sciences is especially slow, for reasons we don't yet fully understand; but we desperately need better social scientific knowledge to build the sophisticated institutions today's world demands.

Returning to the ingenuity supply chain, just a few words on the remaining two factors: markets and politics. As I've already mentioned, markets help societies generate and deliver ingenuity by giving entrepreneurs incentives to produce and implement knowledge. But these incentives are often skewed or too weak—our energy prices, for instance, don't begin to reflect the potential cost of climate change to future generations—which means we often get the wrong kinds of solution to our problems.

Finally, in all societies a major impediment to ingenuity supply is political opposition by elite groups that would be hurt by change. Surprisingly, new communication technologies have probably made this impediment worse. Although many people believe that these technologies—especially the Internet and the World Wide Web—invigorate democracy and make it easier to find collective solutions to our problems, the story is less clear than it seems. In many cases these technologies—by permitting vested interests to mobilize their political power more effectively—have instead boosted the ability of these groups to block useful reform of markets and political institutions. (A good recent example is the action by farmers and agro-industries—in world trade negotiations—to block the reduction of agricultural subsidies.)

Moreover, new communication technologies have produced a horrendous overload of information in our everyday lives, which shortens attention spans, limits our time to reflect on critical matters of public policy, and makes policy arguments more superficial.

In other ways, too, technological change has shifted power away from governments towards small groups. The spread of plastic explosives and of lighter and more lethal weapons—from assault rifles to rocket-propelled grenade launchers—has dramatically strengthened insurgents, secessionists, and terrorists.

Violent small groups will achieve their ultimate technological leverage when they get hold of weapons of mass destruction. Notice I say when, not if. Within a decade or two, some of these groups will almost certainly have crude biological, chemical, or nuclear weapons. I'm not being a wide-eyed alarmist here—the best people in the business of analyzing this threat believe the risk of nuclear terrorism, especially, is very real. The world now harbors in excess of 1000 tons of uranium 235, much of

it stored in scattered and insecure locations in the former Soviet Union. With sufficient skill it takes only 50 kilograms to make a crude atomic device. If a terrorist can obtain 100 kilograms—less than one hundredth of one percent of the world's total stockpile—little skill is needed: with such a quantity, it's relatively easy to create an explosion in the multi-kiloton range. Cities like this one are very likely targets, and such an attack would level much of London's core.

As it becomes easier for small numbers of people to inflict massive trauma—often in the form of massacres of civilians and terrorist bombings—more societies are likely to become locked in downward spirals of violence that block social and institutional renovation.

VI: Consequences

So an adequate supply of ingenuity at all times and places is not assured. Ingenuity does not always appear in the right amounts when and where we need it. To one degree or another, as H.G. Wells so clearly recognized, we're all locked in a race between a soaring requirement for ingenuity and a sometimes-inadequate supply—a situation that can produce what I have come to call an "ingenuity gap."

So we come to the third question: What does this situation mean for our future?

In general, I argue, when we lag in our ingenuity supply, we see widening gulfs between rich and poor and between powerful and weak societies.

We also see widening gulfs between rich and poor and between powerful and week people and groups within our societies.

As a species, on some matters we're clearly losing the race between ingenuity requirement and supply: for instance, we're not effectively addressing major global challenges like climate change, the collapse of many of the planet's fisheries, the resurgence of infectious disease, persistent global economic instability, or the rise of mega-terrorism. Nevertheless some societies, especially those in the capitalist West, are doing better in the race than others, because they are rapidly raising the rate at which they supply ingenuity. They buy air conditioners if they're affected by heat waves, build new dams if they experience droughts, grow their fish in aquaculture farms, and use subsidies to buffer themselves from the vagaries of the international economy. But those societies that are very poor, especially in regions like Africa, are losing the race decisively: they are not meeting the ingenuity requirements of our increasingly complex and fast-paced world. These differences are further widening the already huge contrasts of wealth and opportunity among human beings.

Even within highly adaptive societies, some people cope far better than others with the demands and rising complexity of their day-to-day lives. The United States, for instance, is probably the most adaptive society in human history, but the gap between its winners and losers is widening, and large numbers of its citizens are falling further and further behind. Median family incomes for 80 percent of the population have barely risen in more than 40 years, while the income of the top 5 percent of families has doubled.

Do these failures to cope—as individuals, as societies, and as a species—really matter? Yes they do. Research shows that social and economic inequality tends to correlate with higher levels of violence. The global distribution of wealth, power, and opportunity is already grotesquely unequal and will become more unequal yet, so we can expect our world to become increasingly violent.

The path we are following, as individual societies and as a species, is unsustainable. Our social, economic, and technological systems are now incomprehensibly and often unmanageably complex, they operate at unprecedented velocities, and they produce sudden, sharp, and often harmful surprises over ever-shorter intervals of time. Our rising consumption of energy and fresh water is unsustainable, and we are putting enormous strain on the planet's natural environment, including its climate system. In coming decades, these deep stresses could converge and combine in ways that cause violent breakdown of states and a collapse of global economic and political institutions.

In conclusion, I'll raise a final question: How should we address these multiple challenges? In this new world, what should we do?

I have many suggestions, too many to outline them all here—perhaps we can discuss some of them during the question period. I have suggestions applicable at each stage of my model of ingenuity requirement and supply—we need to, for instance, boost our support for science; we need to make our markets work better; and we must try to renovate our democratic institutions so that they aren't so easily hijacked by powerful special interests.

But I've come to believe that there's one overriding

imperative: we must reduce the rate at which our requirement for ingenuity is rising. We have to ease up on the global accelerator pedal. Because if we don't slow down and simplify things voluntarily—if we allow the complexity, speed, and unpredictability of the systems we've created to go on increasing, unchecked—these systems will sometimes fail catastrophically. In other words, system failure will eventually slow down and simplify things for us, whether we like it or not.

This imperative means, among other things, that we urgently need to reduce our load on the natural environment by lowering the material throughput of our economies. We should also increase the resilience of our complex systems and networks—from our electrical grids, to our food supply systems, to the international financial system. We need to loosen the coupling among these systems' components, increase their buffering capacity, and increase the redundancy of their most critical components.

But if we're to accomplish these and similar changes, we will have to address and in some cases adjust some of our most basic values—utilitarian, moral, and spiritual values—that underpin our high-consumption lifestyles, our highly unequal economic arrangements, and our hyper-paced and too tightly coupled social, economic, and technological relationships.

People don't like to even think about their values, let alone change them. So confronting and changing our values, I'm convinced, will be our greatest challenge of all.