CHAPTER 20

The Three (Four) Pillars of Sustainable Development or "The Great Race"

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I recall a slapstick film from back in the mid-1960s with the title The Great Race. In it, the quintessential hero (the Great Leslie, dressed in white, of course) is challenged by a despicable and traditionally melodramatic villain known as Professor Fate, who proposes an epic over-ground automobile race from New York to Paris, travelling the long way across Siberia. Despite a massive pie fight, promoted at the time as the biggest one ever, and Fate's many scurrilous attempts to cheat along the way, things work out in the end, although not without extensive damage to the iconic Eiffel Tower!

The title of the movie — as well as some of the movie's intense drama and confusion — came to mind as I was thinking about the subtopic at hand: the three pillars of sustainable societal, ecological and economic development. Let me explain.

We do indeed face a momentous race between two competing, fast-developing and, at times, countervailing tendencies. The first is the acquisition of sophisticated knowledge about the complex and non-linear relationship between humankind and the planet that supports and nurtures all life. The second is the absolutely urgent need for innovative technologies to be deployed to improve human welfare and, at times, to avert catastrophes. It is abundantly clear that we need more "deployable innovation for sustainability" — and need it now.

In many ways, this "great race" informs the work of our university system, because it is "on our watch" that this race needs to be won. If we would have had the sophisticated current-day biophysical and chemical

understanding 100 years ago, then many of the "wicked" problems we now face — e.g. resource scarcity, biodiversity loss, poor air quality, deleterious climate change and its severe weather impacts, fresh water unavailability, food and soil degradation, and conflict avoidance — would, quite possibly, have been long ago resolved. Conversely, if today's deepening knowledge were still 100 years off into the future, then we would, in all likelihood, have no chance of avoiding ecological and societal collapse. Sometimes, it seems to me to be a coincidence of cosmic proportions that the required knowledge is emerging at the very time that humanity needs it. On our watch.

So, what is the role of a large public university system in this, the "great race" of our times? As president of the University of Illinois System, I think about this often. Our system has nearly 86,000 talented students enrolled in three universities across the state of Illinois, more than 750,000 living alumni, and roughly $1 billion per year in externally funded research, with faculty expertise covering most if not all fields of intellectual interest. It also has a formal and deeply felt mission to serve the public good through its original land-grant university in Urbana-Champaign, its large research-intensive public university in Chicago (the third largest city in the United States), and its comprehensive liberal arts university in Springfield, the state capital. Each university has a distinctive character and setting, and a different range of focus. For example, the University of Illinois at Chicago is home to one of the nation's largest medical schools and an expansive, innovative healthcare system focused on population medicine in a world city. The University of Illinois at Urbana-Champaign has a highly ranked engineering school with special renown across the computer and information sciences. And the University of Illinois at Springfield has particular expertise in public policy, criminal justice and Abraham Lincoln studies. Despite these very complementary differences, all three of our universities share in a common mission — to serve the public good.

A university system blessed with our assets must, then, drive the rapid development of new knowledge and technologies that can be deployed to build and sustain human prosperity. We intend to work on this as individual universities and in the collective, but primarily through extensive partnerships — with governmental, non-governmental and private (commercial) enterprises and individuals.

In our published strategic framework that guides our work, adopted in 2016, we use the terminology: "optimizing impact for the public good." When I think about this kind of optimization, I often use the following simple heuristic equation:

$$\boldsymbol{II = (EE \times SS)^{MM}}$$

Here, *I* is "impact", which is the element to be optimized. Impact is dependent on both "excellence", *E*, and "scale", *S*. Without excellence, it is very difficult to innovate rapidly, and without larger scales, the products of the

innovation cannot be deployed as efficiently, either by individuals or through commercialization strategies. This heuristic relationship leads one to a greater appreciation of the impact that a large and excellent public university system, such as ours, can have. In this thinking, 86,000 students carry with them a much larger potential for impact than do a few thousand students, even those from first-rate universities — as long as institutional excellence is not diluted or traded away as size grows. In this equation, the product of excellence and scale is then raised to the power of what I refer to as institutional *Magic* (M). If M is less than unity, the resultant impact is degraded. If M is much greater than unity, then exciting non-linear enhancements to impact happen.

What is the magic? The nominal exponent, M, is essentially here to represent institutional *culture* — all those special things that combine to characterize a vibrant institution. These are elements such as a deep commitment to teaching and learning; visionary and trusted leadership; talent acquisition, recognition and support; collaborative impulses; the ability to build teams and to generate and sustain effective and authentic partnerships; access to major facilities and resources; the ability to navigate and interconnect disciplines; the fulsome embrace of diversity in all forms (approach, background, discipline, etc.); and the willingness to take risks in pushing the envelope of new knowledge. I am sure any reader would be able to develop his or her own list of such attributes. But, with this thinking in mind, those institutions with both scale and excellence that also have a vibrant (i.e. magical) institutional culture can have a tremendous impact on the world.

What, then, is the role of a large, excellent, vibrant university system in building the societal, ecological and economic underpinnings for a sustainable future? I postulate here that such institutions provide the very best opportunities for solutions that can serve society into the future. Going even further, I suggest that these are perhaps the *only* institutions capable of taking on the challenge to win the great race of our times. Even the largest, best-endowed companies can lack the required multi-disciplinary expertise, the central role in developing human capital, and the risk-taking culture. It follows that we, in the leadership of large, public, research-focused university systems, should recognize a special responsibility to act with urgency to solve the grand challenges related to sustainability.

In the next few paragraphs, I provide modest comments on some of the particular approaches that I believe will be essential to success (and add a pillar to the discussion):

EDUCATION

The first imperative (and the fourth pillar!), of course, is the fundamental commitment to lifelong education. It is critically important to have

institutions, particularly at the higher education levels, that nurture students' abilities to think critically, to write sensibly and cogently, to exhibit discernment in recognizing what is true and what is false, and to rely on evidence-based decision-making whenever possible. Modern pedagogical approaches should focus on effective and demonstrable learning, teamwork, skills development and a combination of both analytical and critical thinking. In this regard, the social sciences and the arts and humanities are every bit as vital as the canonical science, technology, engineering and mathematics (STEM) disciplines.

I feel it necessary here to single out the scholarly work and education in the social sciences, arts and humanities. As I wrote recently when initiating a system-wide initiative to celebrate the arts and humanities: "Research and creative breakthroughs in these arenas help us imagine new approaches to today's societal challenges, drawing from deep historical experience, finely honed craft, and expertise in collaboration and improvization. The humanities and the arts also serve diverse publics by nurturing the human spirit, by offering inspirational new experiences, renewed connection to records of the past, and frameworks for living within difference and debate."

Although some economic headwinds have undoubtedly harmed the arts and humanities at many universities due to public misperceptions of lower-paid employment opportunities for graduates, I believe that it is very important for university systems like ours to continue to build and support these fields of scholarship for all the richness and benefits they bring to society, including the kind of lateral thinking and problem-solving needed to win the great race.

A last comment here about the social sciences, arts and humanities. When I was the Assistant Director for the Geosciences at the U.S. National Science Foundation from 2010-14, we toyed with avoiding the word "sustainability" and replacing it with "thrivability". Although a bit of a mouthful, the latter term implies that we seek a healthy and secure future for our children — not just one that sustains an imperfect, and perhaps miserable, status quo. We will absolutely need university-based scholarship in the social sciences, arts and humanities — as well as all the biophysical sciences and engineering — to approach a future where the human condition is celebrated and nurtured and humankind actually does thrive.

SOCIETAL PILLAR

There are many challenges associated with sustainability that lie within the province of research universities. Alan Leshner, the long-term former CEO of the American Association for the Advancement of Science (AAAS),

described what he saw as the major global societal issues facing humanity in a 2011 talk on the challenges of building a global science community. His list included the following: sustainability; renewable energy; information and communication technology; universal access to education; poverty and economic opportunity; technology-based manufacturing and jobs; intellectual property rights; terrorism and security; disasters; vaccines and medical therapies; quality and accessibility of health care.

It is noteworthy that every one of these issues is under intensive study within universities like ours, with faculty experts engaged from within and across many different disciplines who also are connected to external partners inside and outside government. These disciplines include all of the sciences and engineering, but also the social and behavioural sciences where human decision-making under conditions of risk and uncertainty is a new emphasis. Since such decision-making will be at the very core of successfully addressing the societal grand challenges of our times, the contributions of these non-STEM fields (including economics) will be immeasurable.

While it is very difficult to forecast with any kind of precision the transformative breakthroughs in non-STEM areas that can address these grand challenges directly, it is hard to imagine substantial progress in any of these areas without universities playing a catalytic, central role. Dr Leshner's list interestingly includes "intellectual property rights" — and I take this, in part, as a signal of the growing importance of the kind of public-private (university-industry) partnerships discussed below.

ECOLOGICAL PILLAR

The ecological pillar for sustainable development is, I believe, the most important one. After all, nothing else much matters if the natural platforms supporting human existence erode away from us. The current knowledge base of the state, pressure/response, and resultant changes to the ecological system has been developed — and must be extended and maintained — by means of a healthy university research and development base. A quick look at the authorship and citation listings for the influential and authoritative reports of the Intergovernmental Panel for Climate Change (IPCC) will quickly demonstrate the significance of university-based or university-connected researchers in developing the modern scientific understanding of the human/planet relationship.

Earth system models — using supercomputing technology, and involving many scientific experts worldwide — are quickly improving and now include most of the important coupled ocean, atmosphere, soil and land processes that control the climate system at a high level of sophistication. The Community

Earth System Model (CESM) community model, for example, developed by the National Center for Atmospheric Research (NCAR), where I was director for eight years, has shown an exciting level of predictive skill at both the regional level and over many different temporal and spatial domains. Outputs from this sophisticated class of model — and further developments — are critical to improving detailed knowledge and understanding of what lies ahead of us, contingent on the socioeconomic scenario that society will follow. The NCAR-CESM and other similar models are among the most important human artifacts of our time and will need to be nourished through the continued upgrading of computational capabilities and access to "big data" describing the earth system for scientific validation. It is a continuing triumph of modern science that these complex modeling systems and their outputs are generally available to the public for free, and that future developments continue to be carefully validated in an open-source environment.

In addition to the numerical models, large observational systems are coming of age around the world. Oceanic observatories, ecological networks, seismological arrays and atmospheric remote sensing systems from ground and space are all contributing to winning the great race. An analysis of the National Science Foundation budget will quickly demonstrate how important these large-science infrastructural facilities are to the expert scientific community.

But there are also significant political challenges in further developing and refining this knowledge base and turning it into an action agenda. I recall helping draft the first position statement on climate change and greenhouse gases published by the American Geophysical Union (AGU) in 1999. AGU is the largest professional society of geoscientists in the world (I was later to become AGU president for a two-year term). This first statement has been replaced several times by more comprehensive ones, but I vividly recall the splash that was made in 1999 on its release — at a standing-room-only National Press Club event in Washington, D.C. I was one of a handful of scientists defending the new position statement in the context of the very active and highly charged US presidential election process underway in 1999. I felt very inadequately prepared for the political backlash. The reporters were mainly focused on the *triple negative* phrase in the 1999 report: "*AGU believes that the present level of scientific uncertainty does not justify inaction in the mitigation of human-induced climate change and/or adaptation to it*." This formulation frustrated many of the attending journalists who wanted greater clarity in terms of an action agenda. Our cautious but scientifically defensible statement, however, was absolutely appropriate for its time, but I confess to a determination to never again employ a triple negative in such work!

Even by 1999, of course, the jury had largely come in on the scientific case for human-induced climate change and the slow-moving but now accelerating threat it was bringing to society.

Unfortunately, the political response to this situation remains muted and insufficient, even 20 years later. Many members of the general public, particularly in the United States, have become convinced that anthropogenic climate change is not real and, therefore, is not something that requires resources to address. I attribute this, in part, to entrenched commercial interests and their effective communication strategies, but also to the fairly muddled presentation of the "kitchen table" implications of the mainstream scientific consensus by the expert community. Once again, future university research — ranging well into the economics, communications, journalism, and public policy domains — will be needed to clarify societal options using our best and most sophisticated quantitative analyses and predictions of change.

ECONOMIC PILLAR

As in all forms of human activity, economic forces will determine the pace and results of societal change related to the new external pressures. Perhaps the first thing to note here is that there needs to be significantly more effort expended on the full-cost accounting and economic impact of changes and pressures. A discussion of carbon taxation is just the tip of the iceberg of what is needed. We will have to develop new *figures of merit*, beyond the dollar, to make and sustain resource allocation decisions. Human welfare impacts need to be quantified and given much higher weighting in such decisions than is the case at present. Key questions abound. What is the true cost of degraded air quality in the GDP of a country and who bears those costs if the polluted air is travelling from elsewhere? What will climate change-induced reductions in crop productivity do for childhood malnutrition and how much will it cost to remediate those effects? What coastal regions should be armored to combat sea level rise and what happens to the insurance costs in other, lower priority settings? Questions like these can and will be answered rigorously and authoritatively in university settings, but that work must commence and be fully funded and energized.

Secondly, it should be realized that there is simply not currently enough funding from all of the world's national science agencies combined to appropriately support the needed research and innovation for sustainability going into the next decade.

So, we must ask the question, how will all this be funded?

Several years ago, I estimated the international level of governmental (funding agency) support for climate science, including all the remote-sensing satellite assets in space today, to be on the order of magnitude of $10 billion per year. Although this may seem like a large investment, it is dwarfed by the costs incurred annually by extreme events such as droughts, floods

and heat waves that are all increasing in frequency and severity. In my opinion, the desperately needed augmented funding base for the applied research needs in earth system science will have to come, therefore, from the most heavily affected private sector — notably the finance, insurance and reinsurance houses that underwrite the large infrastructural investments around the world and which are very focused on systemic risk mitigation to control their costs. Such sources of support can and should augment the worldwide research and capacity building base for this kind of research by an order of magnitude into the next decade. These new dollars should be spent, in significant part, in the appropriate university communities.

SUMMARY

Universities should reinforce and augment the bio- and geo-physical research efforts, including all fields of engineering and the critical behavioural sciences. Deployable technological advances and commercialization strategies must be generated rapidly in support of tomorrow's decision-makers. A major (order of magnitude at least) increase in funding levels is needed and this will require tapping into the most heavily affected private sectors.

A recommitment to the educational process to develop the human capital needed for "thrivability" is needed. The deleterious changes associated with climate, air quality, fresh water availability, food production and the like will undoubtedly dominate the narrative of the rest of the 21st century and beyond. Our future students will be extremely motivated to contribute to solutions and will want to be fully prepared to address this complex set of interrelated challenges. In this educational transformation, the role of the arts, humanities and social sciences will all need to be fully integrated.

More and more sophisticated earth systems models with regional fidelity will be required to support important and costly decisions on mitigation, tactical withdrawal, and resource allocation. Universities will need to address not just the likelihood of projected changes, but also the more complex questions of societal adjustment, cost and systemic risk mitigation — terms that more fully resonate with the private sector. In this regard, a public-private-governmental triad needs to be established to create the economic circumstances and partnerships that naturally favour more sustainable activity.

Finally, we will have to invent and deploy mechanisms to decarbonize the atmosphere. As I write this, the carbon dioxide level in the atmosphere has breached 415 parts per million (May 2019) — a level that would have seemed to have been very unlikely and extremely problematic 20 years ago. Active strategies to physically remove greenhouse gases from the atmosphere will need to be designed, developed and piloted. Examples in our own university system include the development of "artificial leaf" technology,

designed to remove carbon dioxide from the atmosphere and the testing of large-scale soil additives to enhance weathering processes in agricultural settings. Many other technologies will be needed, involving what is commonly called "geoengineering."

So, the future will be one of extensive public-private-governmental collaboration and partnerships — led and catalysed by universities, with new sources of funding, new and intellectually rich research pathways, and new quality metrics and figures of merit that do not currently exist.

This is what is needed to win the great race.