



OPPORTUNITIES AND LIMITS IN THE CREATION OF USEFUL KNOWLEDGE FOR SUSTAINABLE DEVELOPMENT

Michael M. Crow
President, Arizona State University

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At long last we have come full circle to recognize what our intellectual forebears knew all along, even before the advent of organized science and the modern research university: our collective relationship with the natural environment requires that we think at scale and across time. A thousand years of university evolution and four hundred years of scientific focus on the ever smaller and more fundamental secrets of nature have quite nearly eliminated our ability to think at multiple scales or on multiple dimensions. It has also virtually crippled our ability to engage between and among the subjects necessary to find our way to a sustainable coexistence with the natural environment. During this same timeframe, through a remarkable manipulation of limited knowledge, significant brute force, and an overwhelming amount of hubris, we have shaped a world that in all likelihood cannot sustain our long-term enhancements in wealth generation and, more generally, quality of life for humanity.

Our hubris is driven largely by an over-reliance on what we know versus what we do not know, particularly in the area of sustainability. In addition, our ability to conceptualize key critical questions is limited by our inherent cognitive, social, philosophical, and behavioral constraints. Each of these limits plays a critical role in our apparent inability to organize our learning and discovery enterprises to produce successful sustainable futures. The simultaneous realization of the imperative for sustainability, the design flaws in our knowledge enterprises, and the limitations in our ability to formulate appropriate questions, places us at a critical juncture in our evolutionary history as a species. Will we be able to adapt as a collective culture or will we, as was the case with earlier proto-humans and even some marginal cultures of our present species, be less successful than required for survival on the planet we are about to inherit, a planet with a population of nine to ten billion?

Central to the outcome of these questions is the design of our research universities and the organization of our knowledge enterprises. These institutions have the potential to

transform society but are slow to adapt to the pace of change. Academic culture is hidebound by behavioral norms or astonishing orthodoxy. Universities, because of their ability to create new knowledge across numerous dimensions and their role in establishing the general state of knowledge that serves as the basis for major decisions regarding our scientific and technological understanding of nature, possess a unique responsibility to advance their design in as creative, innovative, and thoughtful a way possible. But if our objective is to advance the linkage of knowledge with action to produce sustainable development as an outcome, it would first be essential to frame our intellectual dilemma. The need to link knowledge with action is self-evident but in order to advance sustainability we must advance our conceptualization of three primary factors.

The centrality of sustainability

The design of a sustainable interface between the natural environment and the built or designed environment is as essential to our collective well-being as any intellectual pursuit of the age. Along with human rights, sustainability is the single most central intellectual question of our age. It is an epochal question that must be addressed by the citizens of a planet with a population that already exceeds six billion and is projected to approach ten billion. It trumps all other issues because unless we achieve sustainability there is not going to be a place for all of us on this planet and our quality of life will become unendurable. Without sustainability we will collectively suffer unimaginably negative outcomes. We are very close to the tipping point and I believe that we have quite a dilemma on our hands. While some of us in the academy have come to recognize what I term the centrality of sustainability, we have yet to conceptualize its implications fully.

We cannot conceptualize the sustainable interface between the built and natural environment to a sufficiently robust degree. While many in the academy are involved in this effort, we have not yet even reached consensus regarding optimal outcomes nor determined whether we could design a sustainable interface at scale. Six to ten billion people make a lot of demands and exert considerable stresses on our environment—overpopulation is associated not only with widespread hunger and poverty but also global climate change, the ozone hole, air and water pollution, environmental disasters, rampant extinction of species, exhaustion of natural resources, and destruction of ecosystems. The impact of the dominant life form on the planet is exacerbated particularly when billions more start consuming at increasingly high levels.

The scientific enterprise that we have been conducting up to this point has in my view generated entirely too many unintended consequences. One need only think of the seventy thousand synthetic chemicals that have been introduced into the environment. The science we have been doing has been driven by an overly simplistic logic that tells us that if we do the science, then good will follow. Nearly every outcome from

Hurricane Katrina in the summer of 2005 had been predicted either by natural scientists or social scientists. Yet we lacked the capacity to translate that knowledge in a manner that was useful either prior to the hurricane or in its aftermath. Our failure to protect against and respond to this relatively mild hurricane should be an embarrassment to the nation. Nor did our knowledge make any difference in the outcome for Hurricane Mitch in Central America in 1998. In both cases everything that happened was predicted but had no bearing on the outcome. These hurricanes and the predictable destruction that followed should bring home to some the notion that things are really far more complex than we ever suspected, and that at present we seem to operate beyond our ability to plan and implement effectively, or even to conceive what needs to be done given certain circumstances. We are, in my opinion, lagging woefully behind in the business of linking knowledge with action.

The ossification of the knowledge enterprise

The second factor requiring more sophisticated conceptualization in context of the imperative for useful knowledge for sustainable development is the ossification of our knowledge enterprise. This ossification urgently requires our attention. I choose the term “ossification” carefully and consider it the most accurate characterization of our knowledge enterprise: “ossified” means bone-like and rigid. Just imagine the calcium deposits and the decalcification that will be required. While we all agree that sustainability is absolutely critical and that we must integrate knowledge and action, we lack progress because our knowledge enterprise remains ossified, particularly in our universities. And while no doubt there is much inspired teaching and research underway throughout our academic institutions, these efforts made not a bit of difference in the case of Katrina.

The academic knowledge enterprise suffers from ossification because we operate according to arbitrary and obsolete design limits, particularly within our universities. We could even term these inherent limitations “design flaws.” Among these flaws is insufficient differentiation among universities, and a social organization underpinning the organization of knowledge so rigid that it sometimes resembles devotion to a cult. Speaking as a university president, former provost, and professor, I have never encountered people more dogmatic than my fellow faculty members. Their dogmatism set in during their disciplinary training and acculturation, and the outcome is a social space that most find perfectly comfortable. While an unequivocally rigid social system might be appropriate in some contexts, knowledge production and scientific inquiry and artistic creativity require anything but rigidity.

The ossification of the knowledge enterprise is paradoxically a consequence of our pursuit of the unknown—our exclusive fixation on the discovery of the unknown. For thousands of years we have become increasingly focused on rewarding the discovery of the unknown pursued to the highest possible level of reductionism. This is not to say

that we do not want to pursue new knowledge, but to ask whether discovery should be the only practice rewarded. And to question whether discovery should be the single practice rewarded at the highest possible levels. Prestige will always attach to the pursuit of the unknown, but I would argue that we must reprioritize our practices and rethink our assumptions if we wish to address problems like sustainability. While there will always be unknowns that must become known, and there are many scholars engaged in the pursuit of these unknowns, there are also many important “knowns” that require assessment and assimilation and implementation. We sometimes require synthesis and not further analytical isolation.

As a consequence of our exclusive focus on discovery, we encourage and tolerate what I term “delimiting tools” or “unconnectibility practices.” Among these impediments to progress are the unimaginable language barriers that have formed between disciplines. Each discipline seemingly lacks the impetus to develop a formal language to make itself comprehensible to other disciplines. We lack the capacity to link the social sciences and the natural sciences in any meaningful way and on a scale necessary to attack issues like sustainability. We have not developed the means for chemists to talk to political scientists, and for political scientists to talk to earth scientists, and for earth scientists to talk to engineers. While we have made significant advances in establishing crossdisciplinary linkages in other areas such as medicine and public health, we have yet to integrate anything as broad-based and scientifically complex as sustainability.

The ossification of the knowledge enterprise is derivative of our failure to update American science policy, the broad outlines of which were set forth following World War II by Vannevar Bush in the manifesto *Science: The Endless Frontier*. At the time the mandate given to the scientific enterprise to assume accountability for national security, economic development, and healthcare was critical to the advancement of academic research, but in my view the correlation between scientific research and societal progress has always been too simplistic. The assumption that scientific research will inevitably foster optimal outcomes has been invalidated time and again. I would argue that it sometimes becomes necessary to specify a desired outcome, and nowhere more so than in an arena as complex as sustainable development. Toward this end I would recommend that we generate a science and technology roadmap for sustainability that would fill the current void.

Our hubris and inherent limitations as a species

The third factor requiring further conceptualization if we are to advance useful knowledge for sustainable development is somewhat more abstruse and will perhaps be disturbing to some. I would argue that as a species we operate with a set of inherent limitations that we do not even recognize and with which we have yet to be reconciled. These limitations could be parsed and defined in many different ways, and my point is not to lament our inherent limitations but to argue that we must no longer continue to

define our problem as external to ourselves—as limits imposed by nature and the environment. Our limitations are cognitive, intellectual, philosophical, sociobiological, socioeconomic, technological, and epistemological. The overarching framework for inquiry and discourse going forward should be the limits of human knowledge acquisition and integration, and the limits of knowledge application through organized societal action. This then is a call for the recognition of the limits of our collective intelligence and knowledge.

As a species we maintain astonishing hubris in the face of our inherent limitations. We assume that with sufficient knowledge we will eventually be able to solve any problem, but it is obvious to me that we have inherent cognitive limitations as a species that we do not even begin to address. We are limited not only by our own intellectual and philosophical constructs, but also by the social organization of our cultural institutions, including our colleges and universities. Sustainability will require cooperation on a global scale, yet our social structures and institutional designs are restrictive and narrow and inwardly focused. How do we cooperate on a global scale when we can barely cooperate in a school district to determine a curriculum? The example may be simplistic but at scale it is the same process that would allow us to advance toward sustainability.

But our inherent limitations are not only cognitive. We are also limited in our ability to conduct ourselves socially, especially when we consider the long-term aggregate impact of our individual actions. How do we anticipate or account for the costs and risks incurred over the long term by our collective behavior? We all operate out of self-interest and cannot know the effects of our individual actions on the larger systems in which we are enmeshed. As we pursue our own interests, each of us appears supremely rational to ourselves, yet the collective outcome of our individual actions can be disastrous. Our only option is to accept the inevitability and the limits of individual rationality, and to take it into account in formulating public policy and collective action. We do not have any economic models or tools or mechanisms to help us address the irrationality of our behavior.

The sociology of our knowledge enterprise remains focused on the relatively simple question of understanding nature. We are driven to understand nature at its most fundamental level as if that of itself is the only process by which knowledge will be derived and from which decisions will be made and through which outcomes will be secured. It is the same question that Socrates, Plato, and Aristotle laid out for us. It is the project to understand nature at its most atavistic level. That is a simple question when compared to the more complicated and challenging and perhaps meaningful question of how to understand nature with a purpose. In the context of sustainability, what is our purpose in understanding nature? Is it to learn how to live in harmony with nature or to exploit it more efficiently as we have during the past four hundred years of organized science? What is the objective and how might that affect how we do science?

While it would be superfluous for me to parse every dimension of our inherent limitations, I would argue that we cannot ignore human nature. And despite our best intentions the outcomes of our actions will likely fall short of our expectations unless we begin to take our hubris into account. Yet there is absolutely no a priori reason to expect that what we *can* know is what we most *need* to know. Science focuses only on questions that *can* be answered. We need to do some serious thinking about how we determine what in fact it is that we most need to know.

These three factors—the centrality of sustainability as an organizing problem of fundamental importance to humanity, the ossification of our knowledge enterprises, and our inherent limitations as a species—require further conceptualization. We must also look systematically at the organizational constraints that limit our ability to take action for sustainable development. At bottom we face an organizational problem that will require the redesign of our institutions.

Organizational constraints limit our ability to take action for sustainable development

We must recognize the organizational constraints that limit our ability to take action toward sustainable development. First, we need to focus on increasing outcome-driven science, but not in lieu of or at the expense of purely curiosity-driven science. I am not suggesting that we turn our backs on four hundred years of scientific accomplishment as if it has been mistaken. Our scientific enterprise has not been misguided but rather merely insufficient, incomplete, and unsophisticated. A new focus on outcome-driven science would suggest an attempt to understand and live in harmony with nature rather than our current project to exploit it. I guarantee that the scientific agenda is different given the outcome that you define.

Second, we need to rethink the design of our knowledge enterprises so that outcome driven science can complement general curiosity-driven science, or science for the sake of science. Many institutions attempt this but not at scale and not focused in the way required by sustainability. I will consider the redesign of our knowledge enterprises in a moment.

Third, we need to restructure the social construct options in which academics work. On the basis of my decades in the academy—six years as president of ASU, and eleven or twelve years before that at Columbia, most recently as one of the provosts, and many years before that at Iowa State and other institutions—I am prepared to say that one of the most conservative organizational structures imaginable anywhere in the world is the academy. Our colleges and universities are filled with liberal idealists who share a vision of a better world but are no more willing to change the organization of their institutions than slow-moving snails. I sometimes think the ice shelves of Antarctica will crack off and melt into the sea and Miami will be flooded to a depth of twenty

meters before we can change a single department at some of our great universities. The world is moving and the climate is changing and things are happening much faster than many academics and administrators in our universities realize.

Lastly, what is needed is the development of language and tools to enhance science-based decision-making and communication between the natural and the social sciences. I do not want to overstate this, but the situation is unbelievably broken and getting worse. The ability to communicate between scientists who understand nature—especially those who want to use that knowledge for some sort of outcome—and decision-makers, particularly politicians who make critical policy decisions, is simply not working.

Moving toward sustainability requires institutional redesign

We cannot advance toward sustainable development until we undertake the institutional redesign of our knowledge enterprises at multiple levels. A thoroughgoing redesign of institutions at all levels is critical: colleges, schools, departments, centers, institutes, and ultimately the entire knowledge enterprise. Further, we must encourage differentiation between our knowledge enterprises: each university must establish its own unique and differentiated intellectual agenda. As it now stands, most of our universities are so fundamentally alike as to be interchangeable. I have often wondered why we must have five hundred universities all attempting to accomplish exactly the same thing in exactly the same way. Conventional wisdom suggests that all universities must model themselves on a prototype established by a handful of elite research universities in the late nineteenth century, but there is no reason why every university must strive to become a center for humanist scholarship and world-class science, engineering, and medical research. Every institution simply cannot accomplish all of these objectives. Such lack of differentiation encourages the formation and perpetuation of arbitrary and demeaning hierarchies. Some institutions are able to emulate the putative gold standard more successfully than others, and those that cannot are relegated to the second and third tiers in the rankings.

To redesign an institution requires what I term “organizational genetic engineering.” This means resetting the organizational framework for the entire knowledge enterprise. Administrators and scholars responsible for academic leadership must develop some basic appreciation for both the genetic code of universities as a thousand-year-old institutional form and the distinct traits of their own particular institution. Research universities are complex institutions charged with both teaching and discovery, and the hallmarks of their genetic code include such core principles as academic freedom and a commitment to such practices as scientific method. But each institution must conceptualize its own identity and determine its own intellectual agenda based on its unique history, location, and constituencies. Why does this particular university exist in

the first place and what is it attempting to achieve? What are its principles and values that supersede all else?

A recently appointed president of a university announced he was going to make that institution the very best in some given field. There is nothing remarkable about such striving for excellence, but the objective to be the very best often supplants the articulation of a specific mission, purpose, and set of objectives for an institution. The articulation of an institutional vision is in my experience the chief motivation and mechanism required to move from knowledge to action. Similarly, a clearly articulated vision is required at each level of the university—colleges, schools, departments, institutes, or centers.

At Arizona State University we have taken the genetic code of the academy and are commingling that ancient tradition with our differentiated model: the New American University. There are many ways to parse the concept of the New American University, but in brief our objective is to reconceptualize and transform a large public university *and* to establish a new paradigm for public higher education through the creation of a prototype solution-focused institution that combines the highest level of academic excellence, inclusiveness to as broad a demographic as possible, and maximum societal impact. We hope to produce a unique genetic code with eight “design aspirations.” Reduced to their essential terms, these guidelines enjoin the academic community to (1) embrace the cultural, socioeconomic, and physical setting of the institution; (2) become a force for societal transformation; (3) pursue a culture of academic enterprise and knowledge entrepreneurship; (4) conduct use-inspired research; (5) focus on the individual in a milieu of intellectual and cultural diversity; (6) transcend disciplinary limitations in pursuit of intellectual fusion; (7) socially embed the university, thereby advancing social enterprise development through direct engagement; and (8) advance global engagement. The restructuring of ASU is taking place in the context of the design aspirations of the New American University. In effect we are offering an intellectually based, sound, meaningful, and socially purposed set of additions to the existing genetic code.

For example, we generally refer to our first design aspiration as “leveraging place.” Because we are not in medieval Europe or colonial New England we embrace our setting in twenty-first century Arizona to address the needs of our region as well as global society. Chief among these needs, both regionally and globally, is sustainability. Knowledge and outcomes related to sustainability must be framed in terms of specific geographies. With its semi-arid climate, fragile topography, and rapid urbanization, few settings could be more challenging than metropolitan Phoenix. Our second design aspiration is “societal transformation,” with which we register our intent to engage society directly. If our objective is to transform society we must actually assume partial responsibility for society. We cannot just talk about sustainability, but we must actually practice sustainability. As signatories of the American College and University

Presidents Climate Commitment (ACUPCC), a consortium of more than five hundred public and private colleges and universities dedicated to achieving climate neutrality for their campuses, we reaffirm that addressing climate change cannot be a mere intellectual exercise. As chair of the steering committee, I join with all of the signatories in advancing this collaborative effort to achieve a more balanced relationship with our natural environment.

Our design aspiration calling for “use-inspired research” is an effort to redress the assumption that curiosity-driven research, generally termed “fundamental,” is of a higher order and more important than research predicated on application. “Academic enterprise” represents our effort to reconceptualize a large public university as an enterprise—agile, competitive, adaptable, and responsive to the changing needs both of our constituencies and global society alike. Generally associated with the private sector, “enterprise” is a concept sometimes wholly lacking in discussions about higher education. Enterprise and the entrepreneurial academic culture that such an orientation instills encourage creativity and innovation with intellectual capital—the primary asset of every college and university. With the spirit of academic enterprise guiding universities, the complex array of tasks with which universities are charged—teaching, discovery, creativity, and innovation—have maximal potential to advance.

Our “focus on the individual” is in part an effort to redress the exclusionary practices of leading universities. Almost without exception these institutions tend to be *exclusive*—that is to say, they define their excellence based on exclusion. It is generally taken for granted that there are two types of universities: those that focus on academic excellence and discovery, and those that focus on access—providing a base level of higher education. Institutions that focus on academic excellence generally admit only the finest students, many of whom come from privileged socioeconomic backgrounds and have enjoyed undeniable advantages. All others are expected to attend less competitive schools. In terms of societal outcomes, this implicit calculation is not only shortsighted but may in the long run be a fatal error. In response to demographic pressures and because we believe that the university can best accommodate the needs of the region by facilitating the broadest possible distribution of its teaching, research, and community service, we plan to increase enrollment from the current level of 63,000 students to over 95,000 by 2020, thus providing expanded educational opportunities—both on-campus and online—to qualified students.

Perhaps most directly relevant to the advancement of useful knowledge for sustainable development is our design aspiration of “intellectual fusion.” In an effort to advance the fusion of academic disciplines we have conceptualized and launched fourteen new interdisciplinary schools, including the School of Global Studies, the School of Human Evolution and Social Change, the School of Materials, and the School of Earth and Space Exploration. Although we are first and foremost committed to educating the students of Arizona, we are equally a cutting-edge discovery organization, focused on contributing

to regional economic development through enhanced research and academic programs, including major interdisciplinary research initiatives such as the Biodesign Institute. Biodesign is biologically inspired engineering and seeks to mimic and harness the elegance of natural processes to confront specific challenges, with a focus on preventing and curing disease, overcoming the pain and limitations of injury, renewing and sustaining our environment, and securing a safer world. In a perfect exemplar of intellectual fusion, to accelerate the pace of discovery the institute merges formerly distinct fields of research, including biology, chemistry, physics, medicine, agriculture, environmental science, electronics, materials, and computing.

At ASU our design aspirations undergird our institutional commitment to sustainability. And we have restructured our academic organization towards that end as well. We have established the Global Institute of Sustainability (GIOS), a university-wide network organization with over five hundred faculty members involved in different aspects of education and research. We have launched the School of Sustainability, the first of its kind in the world, which currently offers masters' and Ph.D. degrees in sustainability, and which will soon be offering undergraduate degrees as well. The school is educating a new generation of leaders through collaborative, transdisciplinary, and problem-oriented training that addresses the environmental, economic, and social challenges of the twenty-first century. Teaching and research in the school seeks adaptive solutions to such issues as rapid urbanization, water quality and scarcity, habitat transformations and the loss of biodiversity, and the development of sustainable energy, materials, and technologies.

Toward an integration of knowledge and action

While it would be outside the scope of this discussion for me to parse each of the design aspirations more fully, suffice it to say that if we are to integrate knowledge with action we must devote time and effort to institutional design. I would argue that we can no longer just continue to fuel the existing designs and practices of the academy. These have not put us on a path to sustainability. Secondly, we need to develop the middleware to produce a sustainable interface between the software of science and the hardware of policy decisions. Thirdly, and I want to say this very carefully, we must move science to mature to the broader question of understanding nature so as to enable sustainability. We are not yet on that path, and this meeting is an important effort toward that end.

This may be heresy but I would argue that universities must control the compulsion to advance knowledge for the sake of knowledge and start thinking about our collective well-being. The role of the academy must be broader than just the generation of scientific knowledge. Policy decisions require more than just science. Universities must lead the way in discerning linkages between science and decision-making. We must bring stakeholders to the table to discuss our collective survival. Global climate change

and ecosystem collapse, to take but two examples, represent challenges incommensurate with our historic approach to planning and problem solving. But in order to establish an appropriate framework for understanding and action, I would argue that we must not only focus on external limitations, but also acknowledge our seeming inability to communicate among ourselves the knowledge we already possess and to act on it and execute. Unless we rethink our institutions and embrace sustainability as a new organizing principle, our universities will be as removed from the frontlines of change as the most remote monasteries. It is time for universities to recognize their moral responsibilities, both for the knowledge they produce and to the communities in which they exist. As anyone familiar with the development of the atomic bomb will know, when the first device was tested, on July 16, 1945, some of the physicists involved fell to the ground and wept. In the academy we assume that we are only responsible for producing knowledge, but no longer can we afford to assign that responsibility to others.

It is appropriate that we are having this discussion as one in a series of colloquia that honor Arthur Sackler. As someone whose mastery of disciplines spanned the natural sciences and humanities and arts, he recalls the polymaths of the Renaissance, and our effort to advance sustainability should be inspired by his breadth. I have long valued a statement he once made that is apropos to this colloquium: "It is clear that bridges must be built to unite peoples in mutual respect and reciprocal esteem in a shared striving for great common goals. I believe that the arts, sciences and humanities can best create those bridges of understanding essential for a world in which all people can link their aspirations to achieve their potentials and the abundances now possible to assure for all the blessings of peace." Such "bridges of understanding" must indeed be built—bridges between disciplines and between institutions and between nations. And sustainability would certainly be one of the "great common goals" that Dr. Sackler specified, and its realization will indeed require "mutual respect and reciprocal esteem," and in a very real sense without it we place the "blessings of peace" that we seek in jeopardy.