From Results in the Lab to Results on the Ground
Summary and Synthesis of the Invited Panel Discussion
Hosted by the Global Solutions Summit
At the Nobel Prize Summit: Our Planet Our Future

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This note summarizes the panel discussion hosted by the Global Solutions Summit at the 2021 Nobel Prize Summit. I have limited the note, for the most part, to a summary of what the panelists said during the panel discussion. Due to time constraints, the panelists were able to touch only briefly on several issues that merit further in-depth discussion. For example, what are the best mechanisms for organizing the research and deployment ecosystem around a problem-first quest for solutions? How can we resolve the tension between top-down problem definition and the need, in many cases, for bottom-up, community-based implementation? What specific policies and programs would facilitate the transition from a technology- push to a market-pull paradigm? What happens when optimal technical solutions collide with cultural norms, superstitions, religious values, and other non-technical factors that may have more impact on what does and does not get adopted than scientific and engineering excellence? As the panelists, along with many others, have noted, discovering pragmatic answers to these questions will be an essential step toward securing our planet and our future.

I. Introduction

The Nobel Prize Foundation and the National Academy of Sciences invited the Global Solutions Summit (GSS) to host a panel discussion around the theme, "From Results in the Lab to Results on the Ground" in conjunction with the first Nobel Prize Summit: Our Planet, Our Future. The three-day Nobel Prize Summit brought together Nobel Prize laureates, scientists, policy makers, business leaders, and youth leaders to explore the question: What can be achieved in this decade to put the world on a path to a more sustainable, more prosperous future for all of humanity?"[1]

The Summit organizers asked the GSS panel to explore one facet of this multidimensional challenge: How can the scientific community more efficiently transform results in the lab into financially, operationally, and environmentally sustainable results on the ground. Although scientific advances in the lab have been, and will continue to be, indispensable for addressing the urgent problems confronting our planet and our future, the journey from mind to market, to use Ramesh Mashelkar's phrase, is neither smooth nor assured. On the contrary, it is long and uncertain, littered with potholes and obstacles. As

[1] https://www.nobelprize.org/events/nobel-prize-summit/2021

UN Secretary-General António Guterres observed in his Foreword to the Global Sustainable Development Report 2019, despite the increased affordability and ubiquity of new scientific innovations and "despite considerable efforts these past four years, we are not on track to achieve the Sustainable Development Goals by 2030."

What accounts for this confluence of scientific abundance and insufficient progress on the ground? All too often, research results sit idly in the lab, generating no tangible benefits for anyone. As Dr. Akinwumi Adesina, President of the African Development Bank, explained in a speech to the UN Food and Agricultural Organization in Rome, "Technologies to achieve Africa's green revolution exist. For the most part, they are all just sitting on the shelves."

Are these problems inherent in the process of scientific inquiry -- a process in which scientists focus on advancing the frontiers of knowledge, leaving the tasks of inventing, and deploying practical applications to engineers, business managers, manufacturers, NGOs, foundations, suppliers, community organizers, entrepreneurs, and financiers? Or is it possible to tweak the research and deployment paradigm to enhance the quality of scientific research while, at the same time, smoothing the path from mind to market?

Speaking from slightly different vantage points and professional experiences, all three panelists[2] – Maurizio Vecchione, Ramesh Mashelkar, and Theresa Kotanchek – agreed that the research community will need to revise the prevailing "mind to market" paradigm in order to generate the breakthrough disruptive innovations, or moonshots,[3] that will "put the world on a path to a more sustainable, more prosperous future for all." Specifically, the panelists agreed that:

- Scientists should organize a larger share of their research around a mission-oriented quest for moonshot solutions to global problems.
- Not only will this problem-first approach improve the quality of scientific research, but it will also forge a closer bond between results in the lab and results on the ground. This will result in a faster and smoother path to market, one that leaves fewer inventions sitting idly on the wrong side of the valley of death.[4]
- Disruptive scientific solutions to moonshot problems can become a treasure trove of high-impact research and business opportunities that are both good for the planet and good for business -- a mechanism for doing well by doing good and creating unicorns[5] with impact.

[2] A video of the panel discussion is available here. The panelists' PowerPoint slides are available here.
[3] The MacMillan Dictionary defines moonshot thinking as "a type of thinking that aims to achieve something that is generally believed to be impossible. Moonshot thinking motivates teams to think big by framing problems as solvable and encouraging 'anything is possible' dialogues around how to solve the challenge."
[4] According to an analysis by one of the leading Silicon Valley venture capital firms, VCs receive approximately 4000 funding proposals each year, fund approximately 200, or 5%, of the proposals in the hope that 15 of the funded start-ups will evolve into the stellar, successful businesses that generate nearly all of the VC industry's returns. The VC model emerging from this technology-push or science-first approach effectively ignores 95% of the scientific results emerging from research laboratories. This approach increases the time, expense, and risk of translating results in the lab to results on the ground, stranding many promising scientific discoveries on the wrong side of the valley of death.
[5] According to Investopedia, "Unicorn is the term used in the venture capital industry to describe a startup company with a value of over $1 billion."

- However, a serious impediment to translating moonshot thinking into moonshot results is the relative scarcity of coordination mechanisms. The current spate of well-intentioned research and deployment initiatives does not add up to a coherent research and deployment strategy. Someone needs to align mission-oriented, interdisciplinary, convergent research around a quest for solutions to well-defined problems; someone needs to organize individual deployment initiatives around a mission-oriented deployment strategy; and someone needs to organize a mechanism for passing the baton from the scientists conducting the convergent mission-oriented research to the non-scientists in the deployment ecosystem who will convert those research results into goods and services that will be deployed in the market. This remains a yawning void on the road from mind to market. Policies, programs, and mechanisms for filling this void should be a high priority for policy makers.

II. Summary of Presentations

A. Maurizio Vecchione: Convergent Research for Moonshot Solutions

Drawing on his experience leading Global Good's collaboration with Bill Gates and Innovative Ventures "to tackle some of humanity's toughest problems through the power of invention," and serving as the Chief Innovation Officer of the Terasaki Institute for Biomedical Innovation whose mission is to "invent and foster practical solutions that restores or enhances the health of individuals," Maurizio Vecchione asserted that, "The problems encapsulated by the SDGs are planetary in scale, they affect all of us. Solving them will require scientific, technological, business, and execution moonshots" which, in turn, will require at least three fundamental shifts in the business-as-usual approach to research, commercialization, and deployment.

1. Interdisciplinary Convergent Technologies.

Vecchione, along with the other panelists, agreed that disciplinary silos will have to give way to a more interdisciplinary approach to knowledge creation and problem solving. "The biggest revolution, Vecchione explained, is the "interdisciplinary revolution in the nature of problems and solutions…. Instead of thinking in terms of silos and classic disciplines, increasingly we are experiencing the convergence of science into an integrative process that will unleash solutions to moonshot problems in an unprecedented way."

Vecchione explained, "we are at the dawn of the bioeconomy, defined by the convergence of engineering, biology, mathematics, computer science, thermal behavior, genomic sequencing, and biomechanics." In terms of problems related to global health, this convergence provides a "deeper understanding of biological systems and an uncharted opportunity" to generate "integrative" biology-based moonshot solutions to planetary and societal problems.

The impact of convergent technologies extends far beyond Vecchione's global health examples. Smart(er) agriculture in both developed and developing countries is poised to combine such convergent technologies as (i) drones; (ii) sensors to monitor soil conditions, weeds, and crop maturity; (iii) robots to pick weeds, spray crops, apply fertilizer, and harvest crops; (iv) synthetic biology; (v) new materials for smart packaging, preservation and storage; (vi) connectivity (ICT, IoT, mobile money, fintech financial services); (vii) controlled environmental agriculture including vertical farming and horticulture; (viii) high quality enhanced seed; (ix)enhanced genetics including cloud biology; (x) nanotechnology and advanced materials; and (xi) 3D printing of cells, food, machinery and structures.[6]

Similarly, smart(er) factories, including those operated by second and third tier suppliers in developing countries, will combine AI, machine learning, Open-Source software, robotics, 3D printing, cloud computing, big data analytics as well as numerous other new materials and frontier technologies.[7] Even problems as seemingly mundane as the provision of affordable potable water in thousands of urban areas and rural village will involve such convergent technologies as (i) new materials and nano-filters for water purification; (ii) solar and wind power, batteries, and inverters to operate the purification and distribution systems in areas without access to grid power; (iii) sensors and the internet of things to monitor water quality; (iv) mobile banking and fintech to handle customer payments for water and corporate finance; and perhaps (v) water ATMs or kiosks to handle customer sales and distribution.

2. A Problem-First Approach.

Current research efforts will undoubtedly advance individual technologies vital for global health, smarter agriculture, smarter factories, and potable water, as well as numerous other SDGs. But, Vecchione asserts, pursuing curiosity-drive research in the vague hope that the research findings might one day help to solve some unspecified problem will be far less effective and efficient than strategically organizing multi-disciplinary research around the deliberate quest for a solution to a well-defined moonshot problem. This observation prompted Vecchione to ask, "how do we foster convergent scientific research? How do we converge chemistry, engineering, physics, thermal behavior, genomic sequencing, biomechanics, and other allied disciplines into a product that ultimately does something useful for the planet?" Moonshots, he explained, "come from these interdisciplinary activities."

The answer according to Vecchione is "to define problems at the research level that ultimately translate into solutions. Problem definition and impact assessment become critical factors in what is ultimately a successful, fundable translational model." In practical terms, this entails (i) defining a problem; (ii) identifying technology gaps; (iii) identifying technology platforms and research pathways for filling those gaps; and finally (iv) packaging the solutions into a financially viable moonshot product or service. Or,

[6] For a more detailed discussion of these frontier technology opportunities see, Fred Davies and Banning Garrett, Connecting Farm, City, and Technology to Transform Urban Food Ecosystems for the Developing World, Global Federation of Competitiveness Councils, 2019. Available at: https://docs.wixstatic.com/ugd/f344ed_2a423f9a4453415f91c8ec944a2a1af3.pdf.

[7] Peter Diamandis, MD, "The Four Converging Technologies Giving Rise to the Spatial Web," available at https://singularityhub.com/2019/09/20/the-technologies-giving-rise-to-the-spatial-web/ . A high level overview of these smart factory issues is available at Alfred Watkins, "Building the Capacity to Adapt, Adopt, Deploy, and Use Frontier Technologies in Low Income Countries," Background Paper prepared for UNTAD TIR 2021, available here.

as Vecchione summed it up, the key to success requires "highly curated problems focused around highly defined impact metrics."

Organization and Metrics.

This is easier said than done. Someone must decide which problem is worth pursuing and which metrics are the best measure of success. Someone must organize and coordinate these disparate strands of research around a highly curated problem. And someone must develop a strategy for bringing the results to market. That someone can be an institution like Global Good or the Terasaki Institute for Biomedical Innovation, a venture capital firm such as AdAstral[8]which Vecchione now leads and whose aim is to "bring transformational technologies to market," a large corporation like Dow Chemical Asia, where Theresa Kotanchek served as CTO, or some other public or private sector institution. But if nobody takes charge, the requisite organization and coordination will not emerge spontaneously which is why so many promising research results currently fail to see the light of day beyond publication or patent filing.

With respect to metrics, Vecchione focused on the public health metric[9] that he employs in his global health work – Disability Adjusted Life Years, or DALYs. According to the World Health Organization's Global Health Observatory, "One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population."

In theory, it should be possible to rank solutions to global health problems based on the DALYs they help to avert. According to Vecchione, "If you can deliver the highest number of DALY reductions at the lowest cost, you by definition have a disruptive innovation that will scale, that will have financial success and enormous impact." Moreover, Vecchione maintains, "If you curate the high impact, problem first approach to planetary and human issues, the private sector will have interest and resources" to finance these moonshots. "The solutions that get successfully commercialized," he concluded, "are solutions to problems."

B. Ramesh Mashelkar: Gandhian Moonshots for the Bottom of the Pyramid

Vecchione emphasized the importance of convergent, translational research in discovering moonshot solutions to well-defined problems. Ramesh Mashelkar complemented Vecchione's analysis with a discussion of the importance of convergent innovation – the process of bundling new and existing technologies into disruptive moonshot products designed explicitly to meet the needs of the billions of people at the bottom of the pyramid. Mashelkar's motivating question was, "moonshots for whom? and

[8] Under Vecchione's leadership, AdAstral proposes to define a set of problems, organize convergent research to discover cutting edge solutions to those problems, and incubate, finance, and launch new ventures to commercialize those cutting-edge solutions. In other words, AdAstral's solution to the organization and coordination puzzle by vertically integrating these diverse tasks under one roof.

[9] Different metrics will be required to evaluate the relative efficacy of such non-global health problems as food security and agriculture, potable water, off-grid, renewable energy, climate change, urban mobility, and smart manufacturing, among others.

his answer was that "true inclusive innovation brings access equality despite income inequality." Mashelkar calls this approach "Gandhian Engineering."

Gandhian engineering, Mashelkar explained, does not refer to the design and production of low-tech, low quality, low performance, low-priced products for billions of poor people in developing countries. Just the opposite. It is a call for scientists and engineers to harness interdisciplinary, cutting edge, science, engineering, design, and business models to the cause of inventing, producing, and deploying affordable, world-class products for the billions of people at the bottom of the pyramid. These goods, Mashelkar explained, must satisfy the "Much More for Much Less for Many More" (or M-L-M) criteria.[10] In other words, they must deliver:

- **Much More (performance)** embodied in products whose quality **equals or exceeds** that of goods and services consumed by the global middle class.
- **For Much Less (money)**. Not a 10% price reduction but a 10X or greater price reduction compared to comparable products currently marketed to the global middle class. The goal, according to Mashelkar, is nothing less than "radical affordability" and "affordable excellence" so that
- **Many More (people)**, primarily the billions of people at the so-called "bottom of the pyramid," can benefit from these innovations. Focusing on the billions of people at the bottom of the pyramid is not a feel-good humanitarian objective to salve the conscience of over-indulged wealthy consumers. Based on current demographic trends, virtually all the population growth over the next several decades will take place in what is today considered to be the developing world. In the wake of these demographic shifts, "the bottom of the pyramid will become the largest slice of the pyramid and the needs of developing world will be tantamount to the needs of the world."[11]

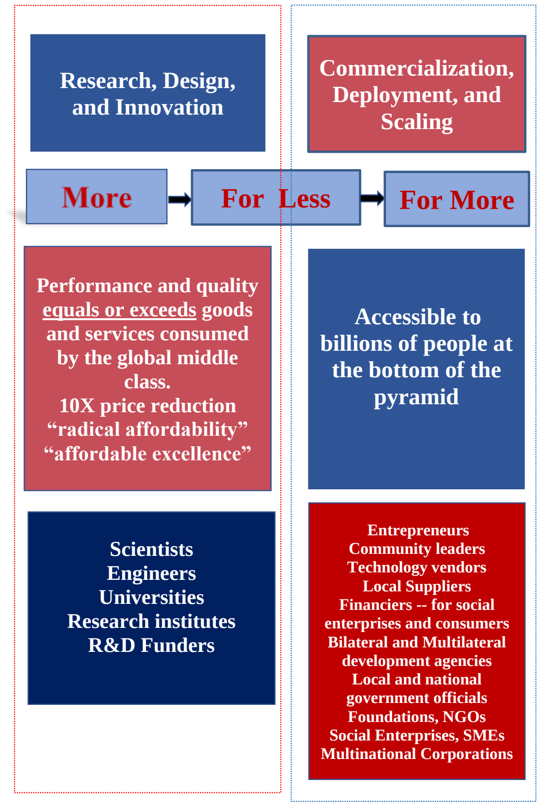
According to Mashelkar, meeting these needs in an operationally, financially, socially, and environmentally sustainable and equitable manner is the 21st Century's moonshot challenge. Fortunately, Mashelkar explained, products that satisfy these moonshot criteria already exist. Health care examples that Mashelkar cited[12] include:

- A ventilator whose price is 1% of the cost of high-end ventilators.
- An ICU bed that is 10X cheaper than existing ICU beds.
- A portable, wireless, accurate, non-invasive, cloud connected, instantaneous breast cancer screening device that provide breast cancer screens at a cost $1 per screen.
- A $30 high quality cataract surgery process.

[10] A comprehensive discussion of MLM is available in C.K. Prahalad and R.A. Mashelkar, "Innovation's Holy Grail." Havard Business Review, July-August, 2010 available at: https://hbr.org/2010/07/innovations-holy-grail.
[11] Presentation by Maurizio Vecchione at the 2019 Global Solutions Summit at UN Headquarters in New York City. A summary of the proceedings is available here.
[12] These examples are only the tip of inclusive technology iceberg. Dozens of additional development solutions spanning the entire range of technologies and SDGs are potentially available thanks to support from the Anjani Mashelkar Foundation, Grand Challenges Canada, USAID's Grand Challenges for Development, the National Innovation Foundation – India which specializing in grassroots innovation, Innovations in Healthcare dedicated to improving "access to affordable, quality care for people who need it most", IEEE Empowering a Billion Lives which focuses on developing new strategies "to scale energy access solutions 1000x", Feed the Future/Partnering for Innovation which "builds partnerships with agribusinesses to help them sell new products and services to smallholder farmers," and Mission Innovation "working to accelerate clean energy innovation."

- A $25 incubator for newborns that requires no electricity and has no moving parts. In effect, it brings the incubator to newborns scattered in remote villages rather than requiring mothers and infants to travel to distant hospitals.

Figure 1. More For Less For More



What explains the success of these innovations, and others like them? According to Mashelkar, assured success is a product of "ASSURED" innovation[13] which stands for innovations that are: (i) **A**ffordable; (ii)**scalable**; (iii) **S**ustainable – economic, operational, environmental, and social; (iv) **U**niversal – or user friendly; (v) **R**apidly deployable; (vi) **E**xcellent – high performance, affordable excellence; not dumbed down products; and (vii) **D**istinctive.

To achieve assured success during the More for Less or M-L stage of research, design, and innovation, scientists and engineers must produce innovative goods and services characterized by **A**ffordable **E**xcellence. However, as Figure 1 illustrates, affordable excellence is merely the first step along the much longer journey from mind to market. To complete the journey, these scientists and engineers must pass the baton to the stakeholders in the so-called deployment ecosystem who take charge during the Less for More or L-M stage of commercialization, deployment, and scaling.

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[13] A more complete discussion of ASSURED Innovation, including case studies failed deployment programs that did not satisfy one or more of the ASSURED criteria, is available at Mashelkar, R A. From Leapfrogging to Pole-vaulting. Penguin Random House India Private Limited. Kindle Edition.

These stakeholders, who are mostly non-scientists, include entrepreneurs, community leaders, foundations, NGOs, equipment vendors, logistics experts, financiers, government officials, social enterprises, small local companies, large multinational corporations, and local universities (especially business and engineering faculties), among others.

Their tasks include such non-scientific activities as building a for-profit or not-for-profit businesses around specific technologies to provide an essential good or service (potable water, roof-top solar, etc.), developing and scaling sustainable business models, organizing supply chains, training skilled technicians to perform essential installation, operation, and maintenance tasks, developing community outreach programs, organizing marketing strategies, organizing and arranging payment and billing systems, and determining how to finance these operations.

Their goal is the conversion of affordably excellent technological breakthroughs into goods and services that are **S**calable, **S**ustainable, **U**ser Friendly, **R**apid, and **D**istinctive. As Mashelkar warns, failure along any one of these dimensions is a signal that a prospective moonshot is destined for market failure.[14]

Unfortunately, at present, failure is all too frequent. In some cases, failure is the result of faulty or deficient commercialization, deployment, and scaling strategies. The remedy in this case is applying the lessons of experience from these failures to the next round of deployment attempts. But in many other cases, failure is due to structural deficiencies in the mind to market pathway. In principle, the transition from ASSURED research, design, and innovation to ASSURED commercialization, deployment, and scaling should follow logically and inexorably from one to the other. But in the real world, there is nothing inexorable or inevitable about this process even when scientists, engineers, and innovators are mobilizing their efforts to produce affordably excellent ASSURED innovations.

Two culprits are primarily responsible for these structural failures. First, there is no mechanism to reliably pass the baton from the scientists and others involved in research, design, and innovation to the non-scientists who will take the lead in commercialization, deployment, and scaling. This is another manifestation of the so-called valley of death.

Second, in some locales, critical pieces of this deployment ecosystem are missing entirely. In other locales, many of the constituent elements of a vibrant and effective deployment ecosystem already exist, but they are fragmented and disconnected. Where the ecosystem is fragmented and disconnected, someone must take responsibility for organizing the pieces into an effective, efficient, and coherent ecosystem that empowers all the stakeholders in the deployment process to find each other, join forces, and get the job done. Where many critical pieces are missing entirely, someone must create the necessary ecosystem from scratch before the deployment process can start. In either case, these organizational tasks are expensive and beyond the limited logistical and administrative capacity of many of the companies, social enterprises NGOs, start-ups, and SMEs involved in the deployment process.

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[14] For examples of scientifically excellent products that failed in the downstream, deployment end of the pipeline because the failed to meet the ASSURED criteria see Mashelkar, R A. From Leapfrogging to Pole-vaulting. Penguin Random House India Private Limited. Kindle Edition.

C. Theresa Kotanchek: Accelerating Successful Translation

At the end of the day, even the best convergent, interdisciplinary research leading to the best Gandhian engineered product can flounder on the path from mind to market. Drawing on her experience as Chief Technology Officer of Dow Chemical China and Global Director of Corporate R&D at Dow Chemical, Theresa Kotanchek argues that a successful journey requires a combination of scientific expertise, organizational expertise, and a multidisciplinary mind-set capable of integrating science and non-science variables.

According to Kotanchek, the starting point for successfully navigating the mind to market journey is a customer centric/market-pull approach, as opposed to the more typical technology-push approach. A market pull approach, she explained, starts by identifying (i) the needs of the market (or the problem, in Vecchione's terminology); (ii) the primary customers for that product; (iii) the application requirements – how the customer intends to use that product; and (iv) the material fundamentals – the production and distribution requirements, the technology and raw material requirements, the supply chain issues, and other pertinent nuts and bolts variables. This contrasts with the more traditional technology-push approach in which research and product development begin before anyone has defined a problem, tested the problem definition hypothesis against customer needs and preferences, and evaluated the requirements for deploying that solution in the market. As a result, the technology push approach means that "you don't have clarity over any of the key items. This causes considerable uncertainty as you push into the marketplace…. Knowing market and application requirements upfront is absolutely critical. It is an accelerant for reducing the time, cost and risk" of bringing a new product to market, she explains.

The next step in the market-pull approach, according to Kotanchek, is identifying the key accelerators and inhibitors for each phase of the design, develop, manufacture, and deploy cycle. Well-honed strategies for enhancing the accelerators and dampening the inhibitors will reduce development time, cost, and risk. These accelerators might include strategies for (i) identifying target customers and essential partners; (ii) employing expert systems and models to understand the linkages between material requirements and manufacturing costs; (iii) ensuring the availability of prototyping and production facilities; (iv) engaging customers throughout the entire cycle; (v) developing the capacity to identify and strategies to mitigate technology, market, product, regulatory and financial risks; and (vi) building the capacity to execute an integrated readiness plan including raw material sourcing, supply chain and logistics, a viable business and financial model, workforce training, and strategies for scaling and expansion.

Kotanchek summarizes this in terms of five readiness levels: Customer Readiness, Technology Readiness, Manufacturing Readiness, Supply Chain Readiness, and Business Readiness. The challenge, and a key determinant of the ultimate success of bringing a product from the lab to the market is building the capacity to identify gaps in each portion of the readiness chain and, most importantly, to utilize partnerships to overcome the major bottlenecks.

Perhaps most importantly, she notes that many of these readiness items are only tangentially related to scientific research. Yet these non-research tasks hold a near veto power over whether breakthrough scientific results will end up having a tangible impact on the global problems of our planet, our future outlined by the Nobel Prize Summit committee.

Thus, although scientific research is an indispensable tool for solving these problems, it is not the only indispensable tool or essential skill. Equally important, Kotanchek explained, is a recognition that successful innovation operates at intersections of cultures and disciplines. Successful innovators, therefore, must have the capacity to leverage extensive internal and external networks that integrate diverse stakeholders -- customers, suppliers, entrepreneurs, National Laboratories, universities, students, community organizers and leaders, etc. – and accommodate such non-science research factors as culture, values, ethics, trust, leadership, history, politics, superstition, local customs, and social structures.

Thus, Kotanchek concludes, in addition to depth and breadth of research expertise, the following skills and characters traits will be essential for surmounting the challenges confronting "our planet, our future":

- Cross cultural sensitivity: the ability to decipher the values of others.
- Cultural humility: the ability to see one's own values as no better or worse than someone else's.
- Proactive problem-solving orientation: the conviction that issues can be resolved.
- Personal flexibility: the ability to adopt responses and approaches as needed.
- Negotiation skills: the ability to explore differences creatively.
- Interpersonal and cross-cultural tact: the ability to work diplomatically with others.
- Visioning skills: the ability to envision options that others cannot see and to then articulate how to implement that option.
- Business acumen: the ability to identify, assess and articulate the potential value of unmet needs.
- The ability to understand the value of intellectual assets and hidden assets, not just published intellectual property.
- Strong strategic partnering relationship skills
- The ability to identify, define, and establish win-win partnerships.

We ignore these traits at our peril – and the planet's as well.