The comments and deliberations of all participants are deemed very important by the Foundation For the Future. While every attempt has been made to preserve the accuracy of dialogue in the seminar sessions, it is impossible to guarantee that no errors or omissions were made in the course of transcribing and editing the live-session recordings. All participants were afforded the opportunity prior to publication to review and amend their comments recorded in this document.

The goal in publishing the proceedings of the seminar is to encourage human minds to ponder issues that may shape humanity's future.

Printed copies of this publication are available from the Foundation For the Future. Contact the Foundation for details.
December 2007

Dear Readers:

I am very pleased to present to you the proceedings from our Humanity 3000 seminar “Crossroads for Planet Earth,” held in April 2006.

The Foundation For the Future was established with the mission to increase and diffuse knowledge concerning the long-term future of humanity. Our Humanity 3000 Program focuses specifically on the thousand-year future, starting with the basic question: “Where does humanity go from here?” This seminar gathered some of the world’s brightest minds from three continents to assess and place in perspective issues related to resources, climate change, population, the biosphere, and other key areas affecting the future of the Earth.

This publication is a comprehensive record of the “Crossroads for Planet Earth” seminar. I hope you will enjoy reading these discussions about the crucial nature of the challenges and the opportunities now facing humans and the Earth going forward in this millennium.

Sincerely,

Walter Kistler
Co-founder and President
“Crossroads for Planet Earth”

George Musser

Natarajan Ishwaran

P.C. Kesavan

David R. Montgomery

David Wasdell addresses a point during a fishbowl discussion on "Learning and Education."
Participants at Work

David Wasdell  W. Wayt Gibbs  William H. Calvin

Michael A. Treder  Paul Polak

Natarajan Ishwaran comments on the massive loss of biodiversity facing the planet.
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The Foundation For the Future wishes to acknowledge the following persons for making the Humanity 3000 “Crossroads for Planet Earth” seminar a success:

The Humanity 3000 Organizing Committee, for their foresight and guidance in planning and organizing the Humanity 3000 Program. These members include Clement Bezold, Joseph Coates, Brian Fagan, Barbara Marx Hubbard, Sohail Inayatullah, Charles Johnston, Graham T.T. Molitor, Siro Polo Padolech, and Allen Tough.

The nine participants, whose multidisciplinary expertise and inspirational leadership formed the substance of the seminar and whose contributions will be valued well into the future. These participants and their affiliations are named on Page xvii of this document.

The staff of the Foundation For the Future, for their dedication and commitment to ensure that event planning and facilitation resulted in a smooth and memorable experience for all involved. This staff includes Kathy Carr, Special Programs Manager; Jean Gilbertson, Public Relations and Publications Manager; Jeff Holdsworth, Creative Director and IT Manager; Tom Price, Executive Assistant; and Mary Stroh, Executive Assistant.

David Rapka, for capturing the entire seminar on videotape.

Rebecca Mayse, certified real-time court reporter, for providing transcripts of the seminar.

Bill Wright, for extensive photographic coverage.

Madhuri Hosford, for editing and text preparation for the proceedings document.

Gordon Swanson, for book production.

The Trustees and Executive Director of the Foundation, for reposing their trust and confidence in all of us.

Sesh Velamoor  Donna Hines
Deputy Director, Programs  Deputy Director, Administration
Introduction

Under its mission to increase and diffuse knowledge concerning humanity’s long-term future, the Foundation For the Future conducts an ongoing Humanity 3000 Program, convening workshops and seminars on an annual basis and an international symposium every five years. The fundamental objective of the Program is to bring together prominent thought leaders from around the world in a multidisciplinary framework to engage in a dynamic exchange about issues that are most likely to have a significant impact on humanity one thousand years into the future.

The “Crossroads for Planet Earth” seminar held on April 6–8, 2006, followed five previous Humanity 3000 seminars; knowledge workshops on the status of humanity’s search for extraterrestrial intelligence, nanotechnology, and the future of humans in space; and two bidecadal symposia. At five-year intervals, the symposia gather scholars and experts from around the world to review and reassess critical factors identified in preceding symposia and seminars as representing the most crucial threats, opportunities, and emergent priorities that may have a significant impact on the long-term future of humanity.

The inspiration for “Crossroads for Planet Earth” seminar began with the September 2005 publication of a special issue of Scientific American magazine. The focus of that issue was “Planet at the Crossroads.” Nine participants gathered for this seminar to explore the future-focused perspectives represented in that issue and to confer about the factors deemed most critical facing the long-term future of Planet Earth.

The Foundation’s goal is not to create a vision or develop a decisive set of guidelines for the future, nor does the Foundation advocate any particular cause or position. Rather, its effort is to create forums for scholarly discussions about the future and to distribute the results and records of those discussions widely in the anticipation that an informed, bottom-up process of choice and decision-making will affect the long-term future.

This document provides the transcripts of the nine “Crossroads for Planet Earth” seminar presentations and all plenary and small-group dialogic sessions. Proceedings of previous Humanity 3000 events may be downloaded from the Foundation’s website (futurefoundation.org/publications).
Summarized below are the contents of each section and appendix of “Crossroads for Planet Earth” Seminar Proceedings.

SECTION 1 summarizes the seminar, providing details on background and purposes, design and process, selection of participants, and key outcomes.

SECTION 2 contains statements prepared by participants before the seminar, describing their view of the most critical priorities facing the planet going forward into the future.

SECTION 3 provides transcripts of the keynote speeches, presentations, and all dialogic sessions of the seminar.

APPENDIX 1 contains the seminar agenda, including key activities from the opening reception to a group dinner following the closing remarks.

APPENDIX 2 provides biographical information on the participants in the seminar, along with partial bibliographies of the participants’ recent, relevant publications.

APPENDIX 3 lists observers present at the seminar.

APPENDIX 4 includes two PowerPoint presentations given at the seminar by Bob Citron: “The Human Journey on Planet Earth” and “The Human Impact on Planet Earth.”
List of Participants

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Author and Neurobiologist  
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Pittsburgh, PA USA

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P.C. Kesavan  
Homi Bhabha Professor  
M.S. Swaminathan Research Foundation  
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Founder and President  
International Development Enterprises  
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Michael A. Treder  
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David Wasdell  
Director  
Meridian Programme  
London, England UNITED KINGDOM
This summary provides an overview of “Crossroads for Planet Earth,” Foundation For the Future’s Humanity 3000 seminar held in April 2006 at the Foundation building in Bellevue, Washington USA. The seminar was documented by video footage and still photography, in addition to this published proceedings document.

Background and Purpose

Humanity 3000, an international seminar and symposium series, is one of the major program components of the Foundation For the Future. In the spring of 1998, the Foundation formed the Humanity 3000 Organizing Committee, composed of scientists, scholars, educators, and futurists from North America, Europe, and Australia. This committee provided guidance to the Foundation in the areas of program design, participant selection, and venue. Sesh Velamoor, Deputy Director, Programs, integrated the work of the Organizing Committee into the initial seminar and symposium format, and Humanity 3000 was formally launched in 1999.

The purpose of the Humanity 3000 series is to convene some of the world’s most prominent scholars and scientific experts representing a wide range of worldviews to assess the current state of humanity and to identify the most significant factors likely to affect human life a thousand years into the future. Humanity 3000 events provide an unbiased forum for the free exchange of ideas and the expression of creative and contemplative thought as participants debate the factors affecting the future of our species.

The Foundation For the Future convenes Humanity 3000 annual seminars, bidecadal symposia, and periodic smaller workshops that provide a knowledge base for seminar and symposia participants to review the history of cultural, scientific, and technological trends as they consider the question: “Where does humanity go from here?”

Humanity 3000 events emphasize the understanding of not only the key physical, biological, and social scientific discoveries that may affect humanity’s thousand-year journey into the future, but also how the scientific view integrates into the whole. Participants identify and explore these key factors, map the situation (past and present), and attempt to outline the future trajectory of each factor, as currently understood, in view of foreseeable future problems and opportunities.

Seminar Goal

In September 2005, a special issue of Scientific American, “Planet at the Crossroads,” featured a series of extensive essays by various scholars and experts addressing topics such as climate change, resource consumption, population, and other key areas represented in the global debate on the long-term sustainability of Planet Earth and the survivability of humanity. The “Crossroads for Planet Earth” seminar brought together Scientific American scholars with additional voices from the United States and abroad for a dynamic, face-to-face exchange in which participants explored issues to enhance the general public’s understanding of this most important debate. A primary goal of the seminar was to identify the specific issues and priorities deemed most critical to the long-term future of the planet as humanity faces decisions of monumental consequence.

Participants

An international panel of nine distinguished scholars, researchers, analysts, and experts participated in the seminar, representing a broad diversity of perspectives on issues of planetary sustainability such as climate science, environmental policy, global poverty, and emerging technology.
Seminar Design and Process

Prior to the seminar, participants were asked to develop and submit statements identifying the three most critical priorities facing the planet going forward into the future. These statements, along with brief participant bios, were made available to all participants before the seminar commenced.

The seminar agenda was a blend of presentations, plenary discussion sessions, small groups of predetermined participant composition, and time for more casual conversations. Following the keynote and seminar presentations, the participants worked in two small groups, with each group focused on identifying priorities for Planet Earth for the next thousand years.

Each small group presented its findings to the full group of participants, where discussion ensued until the entire group reached overall agreement regarding the three most critical factors going forward: (1) planetary sustainability and interconnectedness, (2) learning, education, and building resilience and the ability to respond, and (3) technological innovation and its impact on the planet.

The plenary session of participants then generated a consensus to select two of the three critical factors as topics for fishbowl discussions. Full transcripts of all presentations and dialogue sessions are included in this document.

Speakers

Foundation Executive Director Bob Citron set the stage for the seminar by presenting the film Cosmic Origins: From Big Bang to Humankind. Seminar participants then delivered two keynote presentations and seven papers, addressing key subjects within the larger topic of “Crossroads for Planet Earth.”

“Facing Bifurcation: Crossroads in Context,” the first keynote address, was presented by David Waddell, Director of the Meridian Programme in the UK. P.C. Kesavan, Homi Bhabha Chair and professor at the M.S. Swaminathan Research Foundation in Tamil Nadu, India, presented the second keynote, “Crossroads for Planet Earth: Harnessing Science and Technology for Reconciling Human Security and Environmental Protection.”


Small Groups

Participants were preassigned to two small working groups to discuss and prioritize the most critical issues facing the planet in the next thousand years. Group leaders reported the groups’ conclusions to the plenary session. The full group of participants reviewed the findings of both small groups, arriving at consensus on two topics to address in the fishbowl discussions.

Fishbowl Discussions

The last afternoon of the seminar included two fishbowl sessions, each of which consisted of a small number of participants in the center of the room discussing one of the most critical issues facing the planet going forward, while the remainder of the group observed and subsequently added their own commentary at the end.

Fishbowl participants self-selected which of two topics identified earlier in small group conversations to address. Fishbowl 1 discussed the goal, “planetary sustainability and interconnectedness,” and Fishbowl 2 discussed the method, “learning, education, and building resilience and the ability to respond.”

Walter P. Kistler Book Award and Ceremony

A featured event at the beginning of the “Crossroads for Planet Earth” seminar was a reception and the awarding of the fourth annual Walter P. Kistler Book Award, to which all seminar participants were invited on the evening of Thursday, April 6, 2006. Created by the Foundation’s benefactor, Walter Kistler, the Walter P. Kistler Book Award is presented annually to recognize authors of science-based books that significantly increase the knowledge and understanding of the public regarding subjects that will shape the future of our species.

The 2006 Walter P. Kistler Book Award was presented to Dr. William H. Calvin, author, neurobiologist, and professor emeritus in the Department
of Psychiatry and Behavioral Sciences at the University of Washington School of Medicine. Dr. Calvin was honored for his book A Brain for All Seasons: Human Evolution and Abrupt Climate Change, which addresses the broad sweep of hominid history and the likely impacts to it of abrupt climate change.

**Participant Evaluations**

At the close of the seminar, participants completed and returned to the Foundation evaluation forms. The Foundation welcomes feedback and suggestions to improve and make the Humanity 3000 Program and process as rewarding as possible.
Participant Statements

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David R. Montgomery  15
Paul Polak  17
Michael A. Treder  19
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If humanity on Planet Earth wants to stay in business, it needs to address some of the dynamics of our situation, such as:

Slip Locally, Crash Globally

The very concrete version of this is illustrated by the mega-tsunami generated by an unstable hillside falling into the ocean on some mid-ocean volcanic island – say, La Palma in the Canaries. Europe gets hit first. The wave, taller than most buildings in Washington, D.C., would reach the East Coast of the United States about nine hours later. Locally it would be far worse than New Orleans 2005, and it would impact the whole East Coast from Newfoundland to Brazil.

While one can imagine tackling this with a massive Earth-stabilization project, the growing power of the occasional malicious individual shows a more difficult version. The standard example is the computer virus, but think biotech. The Japanese 1996 sarin-in-the-subways incident and the 2001 anthrax packages show how individuals and small groups can attempt to shut down whole countries. Soon the rare, malicious-but-knowledgeable individual will pose a threat much like that unstable hillside in mid-ocean.

Terrorists don’t (yet) aspire to occupy their targets. They hope that an impact in the right place (the David-and-Goliath tactic) will collapse us to the point that we will then disappear in a downward spiral of famine and disease, flushed – or at least so weak that a takeover becomes likely.

Out-driving Our Headlights

The faster you travel, the greater the chances of a fatal spinout when you hit a big pothole. Avoiding the pothole depends on shortening your reaction time: faster reflexes through practice and vigilance, headlights that reach farther, and so forth. The pace of change is now accelerating. Most problems associated with rapid change are due to one process being faster than some interacting process. It’s the relative speeds that matter, not the absolute speed. Some things are nimble (say, technology) and others are ponderous (reaching consensus about course corrections). When you hear “fast,” always ask, “Faster than what?” Remember that more than two speeds may be involved, as in the old joke about the two guys being chased by a bear. (Punch line: “You don’t have to run faster than the bear, only faster than the other guy.”)

Designing for Bounceback

Sensible precautions can fail for many reasons (as in the failure of leadership for New Orleans). We must realize the nature of the game we are forced to play, and design for bounceback independent of the source of the impact. We’ve already done it for the Internet. Without central direction, it automatically routes traffic around disruptions, whatever their cause. Our electrical grids – now a standing invitation to terrorists – badly need such a redesign so that they, too, can reconfigure themselves quickly. The same thing applies to our food and fuel distribution.

And we need to design and debug a standby crisis economy. If the economics of this reordering are not debugged in advance, all else will fail. Market forces, which often efficiently handle reordering on longer timescales, cannot handle abrupt impacts in time, nor fund the overcapacity needed.

There are just too many directions – mega-tsunami, terrorists, pandemics, economic panics, drought – from which we could be pushed hard. We need the resilience to right ourselves quickly, before we pass the tipping point and collapse into a spiral of civil disorder, disease, and death. Panic can speed a collapse, and so our citizens need to be confident, ahead of time, that we have the well-tested resources to bounce back.
Define the three most critical priorities/characteristics facing the planet going forward into the future.

1. Engineering better ways for humanity to produce and use energy

Sometime between now and mid-century, production of conventional crude oil and natural gas will peak and begin an inexorable decline. This event has the potential to shake global economies to their foundations and to lead powerful nations into conflicts over the dwindling resources. Greater understanding of the contribution of greenhouse emissions to global change seems likely to exacerbate the problem, by making other fossil fuels largely unacceptable as substitutes.

We currently lack the basic technology, infrastructure, economic incentives, and political consensus required to shift global energy production and use patterns to the degree that we ultimately must.

2. Increasing land use efficiency and restraining land conversion

Improvements in agricultural efficiency, energy production, and increasing urbanization allowed partial reforestation in the 20th century of many regions that had been denuded by subsistence farming in prior centuries. In the United States and other rich nations, however, this trend is reversing as growing infrastructure and technology enable city workers to move to low-density exurban housing. As human population grows in size and wealth, the pressure for increasing per capita housing and shopping space threatens to divide ecosystems into unstable patchworks.

Humanity must become more frugal with the land that it occupies if there is to be any hope of retaining the full variety of Earth’s ecosystems into the next century.

3. Widening the scope and horizon of economics and politics

Many of the long-term problems that today seem so intractable originated with political and economic decisions that seemed rational—even wise—when assessed over the four- to ten-year perspective routinely taken in business and government, but those decisions have produced unwanted consequences over the course of generations. Massive subsidies for highway construction, industrial agriculture, coal mining, and oil drilling, etc., have removed much of the self-correcting economic and political pressure that should have pushed the highest-consuming democracies onto more sustainable paths long ago.

This is the result both of structural flaws in political and business governance systems and in the inadequacy of science and economics to estimate persuasively the future costs of present decisions. In order to solve today’s global, long-term problems and to avoid creating new ones, political leaders need to find ways to make long-term assessments an essential part of policy-making. And economists need to find ways to harness the essential acquisitive and competitive aspects of human nature, and the efficient risk-management behaviors afforded by markets, to the service of ecological preservation, climate mitigation, energy security, global health, and other pressing needs.
Define the three most critical priorities/characteristics facing the planet going forward into the future.

In my view the three most important challenges for the future centre around what I consider to be the single most important problem for the new millennium that dawned only six years ago: designing, developing, and sustaining context-specific equations between what are currently two major overlapping, yet distinct, spheres of human endeavours: conservation and development.

In the domain I call conservation, I include all human endeavours to create more space and opportunities for biodiversity at biosphere, landscape, ecosystem, species, and genetic levels. Development, in my vocabulary, encompasses all of humankind's efforts to promote economic productivity, employment, and other social well-being essentials, and cultural innovation and creativity.

I articulate the three challenges in the following way:

1. Collate and collect information, data, experience, and knowledge needed for improving survival and enrichment options for biodiversity in an increasing range of ecological, social, and cultural spaces.

2. Promote economic productivity, employment generation, and cultural expressions and adaptations that experiment and enhance a better accommodation between human populations and in-situ communities of plants, animals, and micro-organisms.

3. Network and link throughout the world human communities that commit themselves to a biosphere mission, and enable and equip them to influence global diplomatic and political agendas in support of achieving their goals and objectives.
Define the three most critical priorities/characteristics facing the planet going forward into the future.

1. Technological push without a balancing ethical pull
2. Co-existence of an unsustainable lifestyle on the part of a billion, and unacceptable poverty on the part of another billion of the human family
3. Achieving harmony with nature and with each other

The human/nature relationship can be improved through ecotechnological and knowledge empowerment of the resource-poor, largely illiterate, and unskilled rural communities in the developing countries. Ecotechnologies are the result of blending of frontier technologies with traditional knowledge and ecological prudence, so that there is a pro-nature, pro-poor, pro-women orientation to technology development and dissemination for the rural areas. The Planet Earth frequently turns violent, and extreme geo-physical and hydro-meteorological disasters are inflicted upon humankind and other forms of life. Therefore, there is an urgent need to promote resilience of the vulnerable communities. Resilience to extreme natural disasters requires the integration of disaster preparedness and management strategies with sustainable development.

Harmony among humans cannot be effectively achieved so long as unsustainable lifestyle and unacceptable poverty coexist. Peace and hunger are mutually exclusive. The fate of the people on our Planet Earth is ecologically entwined, irrespective of political and geographic boundaries. Equally important is the “unity in diversity.” This is possible only when intolerance towards diverse social systems, cultural ethos, and religious faiths is totally abolished from the depths of human hearts.

The rapidly advancing frontier technologies (e.g., genomics, proteomics, modern information and communication, and nanotechnologies) can provide uncommon opportunities for a sustainable human future rooted in the principles of ecology and gender and social equity only if a strong ethical push is applied. Without it, there would result a “technological apartheid” on the one hand, and exploitative use and exhaustion of the Earth’s natural resources, on the other. The “Green Revolution” (i.e., exploitative agriculture) needs to be transformed into an “Ever-green Revolution” to achieve productivity in perpetuity without causing undue degradation of the ecological foundations of agriculture. The human/nature relationship is also stressed by the accumulating burden of the non-degradable and only slowly degradable technological by-products and their waste. Poverty and environmental degradation form a vicious spiral.
David R. Montgomery

Define the three most critical priorities/characteristics facing the planet going forward into the future.

Soil erosion, biodiversity, and sustainable agriculture.
The first and most critical priority we face is finding practical solutions to poverty, especially among the 1.1 billion people in the world living on less than a dollar a day. Of these poorest of the poor, some 800 million make their primary living from small farms of one acre or less. Since the rural poor often lack access to the benefits available from industrialization, the logical first step to bringing them out of poverty is to find ways to increase the income they earn from farming. This requires nothing less than four revolutions to end poverty – revolutions in water, agriculture, markets, and design – all centered on increasing income from one-acre farms.

Second, we face the challenge of feeding an additional 3 billion people by the year 2050 without comparable expansion in the amount of land and water devoted to agriculture, and we must do so without causing irreparable damage to the planet. Water is key to boosting farm production and alleviating poverty, as nearly 1,000 liters of water are needed to grow just one kilogram of grain. We must store more water for irrigation and manage the supply we have more effectively.

Third, we must strive to maintain the population balance of our planet by stabilizing global population growth to a rate that can be supported by the Earth's limited resources.
Define the three most critical priorities/characteristics facing the planet going forward into the future.

1. Surviving entry into the nanotech era

Sooner than any other emerging technology, molecular manufacturing – an advanced form of nanotechnology – will provide spectacular opportunities and also pose grave dangers. Vast parallel arrays of precise molecular tools using inexpensive, readily available feedstock and operating under automated control inside a nanofactory will build advanced, high-performance products of all sizes and in virtually any quantity. Molecular manufacturing clearly offers wonderful benefits for humanity. But it also comes with severe risks, some that could be globally catastrophic and possibly even terminal.

To keep the worst-case scenarios from occurring, it will be necessary somehow to control or limit use of the technology. The Center for Responsible Nanotechnology’s analyses indicate that unless adequate defenses can be prepared against nano-built weapons that are intended to be ultimately destructive, the number of actors trying to possess such weapons must be strictly minimized. Preventing full-scale war is essential, as is avoiding vicious cycles that spiral down into massive oppression or even global genocide.

Ruinous runaway processes – economic, climatic, social, and political – must be guarded against, and any proposed solutions carefully scrutinized to avoid making things worse. A great deal more study will be required before we have sufficient knowledge and understanding to assure the survival and well-being of the human race in the era of nanotechnology.

2. Expanding our habitats

Today humanity has but one home. We cannot survive for long anywhere beyond our planet without making use of its resources. But what if catastrophe strikes, rendering Earth uninhabitable? This might occur in the form of a major asteroid impact, a global plague, a complete ecological collapse, massive volcanism, a devastating blast of cosmic radiation, or any of several forms of warfare. Although no one can say for sure when such a disaster might strike, the chances that something will happen are well above zero, and thus we must be prepared.

Within the next 50 to 100 years, or even sooner, we will have developed the technology to create comfortable, sustainable habitats off the Planet Earth. Whether these are space stations, hollowed-out asteroids, settlements on Luna, Mars, Titan, Ganymede, or somewhere else, it is imperative that we spread out in order to reduce the risk of species extinction.

3. Maintaining freedom with post-human diversity

Great progress has been made during the past few centuries in guaranteeing freedom to ever-larger fractions of humanity. But as we approach the crossroads of powerful converging technologies, the possibility of human enhancement – and even transcension – will lead to unprecedented challenges. The combination of nanomedicine, genetic engineering, neurotechnology, informatics, and robotics offers the potential for development of superhuman intelligence and/or non-human superintelligence.

Will these augmented, hybrid, or completely manufactured beings view “natural” humans as worthy of their respect? What was once the stuff of science fiction is rapidly heading toward reality. We must anticipate and prepare for the existence of various non-equivalent classes of post-human descendants.
Define the three most critical priorities/characteristics facing the planet going forward into the future.

1. Ecology

From a terra-centric perspective, the planet is in crisis. Within its biosphere has emerged a species that has evolved the capacity to overwhelm the negative feedback mechanisms of its environment, the immune system of the planet. Its population has reached plague proportions and is set to double once more. The drive to sustain exponential increase in resource-use per capita is stripping the geo-biosphere of assets and driving an accelerating cascade of other species into extinction. Waste production is choking the global commons and polluting every planetary system. Above all, its insatiable hunger for energy has resulted in the discovery, combustion, and re-release of the fossil carbon deposits buried by the planet in its effective response to previous periods of catastrophic overheating. *Homo Replicans* has now precipitated an extreme event of runaway climate change, similar in intensity to the last great extinction during the so-called “Palaeocene-Eocene Thermal Maximum.” The most critical task facing the planet is therefore to regain control of its ecology by all means at its disposal.

2. Psychology

Quite apart from the task of restraining the reproduction rate of the human species and reducing its population and consumption to more sustainable levels, the planet also faces the problem of species-specific psychopathology. As cranial diameter evolved to accommodate the enlarging brain, parturition became universally traumatic. Survival demanded increasing prematurity, but psychological damage became endemic. The species now presents in a condition of collective post-traumatic-stress-disorder. There is a fractal response of splitting, or idealisation, between good and evil, projected into every facet of behaviour. Intensely psychotic defences and delusional defence reinforcement mechanisms are collectively elevated to the realm of religion. In some cultures children are further subjected to ritual genital mutilation, so intensifying the collective psychosis. Individuals and out-groups that do not conform are treated as enemies and become the target of annihilatory aggression. Fixation just prior to peak trauma engenders denial of birth and consequent perseveration of utopian foetal assumptions. There is an irrational addiction to unlimited exponential growth and the accumulation of wealth. The environment is treated as spatially unlimited, as an infinite source of energy and material, and as a sink with infinite capacity for waste-disposal. Any encounter with limits to growth triggers this foetal civilisation into a paroxysm of col- lusional denial, rising anxiety, and acting-out of the titanic struggle of birth. If the planet is to move forward into a future of sustainable symbiosis with this species, it will have to find the means to resolve its psychopathology.

3. Technology

The Industrial Revolution enabled this strange biota to harness external power as an extension of muscle. Now, the cybernetic revolution has enabled it to harness external power as an extension of mind. Hyper-exponential growth is expanding to include not only physical and material reality, but also to encompass information, information-processing, communication, research, and application. Technological outcome of this emergent trend, coupled with the psychological dysfunctionality noted above, combine to constitute unprecedented threats not only internal to the species itself, but also to its planetary environment and all other dependent life-forms. From a planetary perspective, technological development is ambiguous. Given the required resolution of psychopathology, and the emergence of value systems...
and behaviour congruent with sustainable symbiosis, human technology and the progressive merging of artificial intelligence, man and machine, could be consistent with long-term planetary well-being.

However, even if the first two challenges could be successfully overcome, the planet would do well to be wary of *Homo Technans* for the foreseeable future.
The Humanity 3000 seminar “Crossroads for Planet Earth,” held April 6–8, 2006, convened a forum of nine distinguished experts in multiple disciplines including biodiversity, nanotechnology, natural resources management and conservation, landscape evolution, human society and complex human systems, harnessing science and technology for human welfare, and ending poverty for rural poor throughout the world.

A primary goal of the seminar was to identify, prioritize, and arrive at a consensus on the most critical issues with significant implications for the long-term future of the planet.

During two days of meetings, the participants met in plenary sessions to hear two keynote addresses and presentations of seven papers, followed by small-group sessions where participants explored the factors most critical to the future of the planet. Following are the transcripts of the presentations and discussion sessions.
Introductory Session

FOUNDATION OFFICERS: Walter Kistler
Bob Citron

FACILITATOR: Sesh Velamoor

PARTICIPANTS: Plenary Session

The opening session provided an overview of the purpose of the Foundation For the Future, the format of this “Crossroads for Planet Earth” seminar, and self-introductions of seminar participants.

KISTLER: Good morning, ladies and gentlemen. I’d like to welcome you here. We’re very happy that all of you have made the effort to join us for this meeting. This should be a very interesting meeting for you since it covers a wide range of topics and ideas, all connected in some way with our future. I hope those who participated in last night’s events enjoyed the evening and had a good rest, and that you are ready for an interesting meeting today. I wish you all good luck and that everything goes well. Thank you.

Our whole purpose is to … capture the thinking of the best minds on the planet in specific fields related to humanity’s long-term future on Planet Earth.

CITRON: Thanks, Walter. I’d also like to welcome you on behalf of Walter and the Foundation. We’re looking forward to two intensive days of discussion and debate about issues concerning the long-term future.

The Foundation was started ten years ago this year. It was the concept of Walter Kistler, who had been talking with me about it for a number of years before we actually established the Foundation. About four or five years ago Walter was generous enough to endow the Foundation in perpetuity. We now have a permanent endowment, which will last for centuries and, we hope, for millennia. We actually operate with the earnings from the endowment, so we don’t have to go out and seek funding; we have our own funding.

It was Walter’s intention from the very beginning to look at the long-term future of humanity, because he had some serious concerns about several things happening concurrently. You should know that the Foundation has no agenda and no point of view. We bring together scholars three or four, sometimes five times a year in groups of typically 10 to 20 scholars, but we have had nearly 70 participants in some meetings. Some groups we hold here at the Foundation; others we host at a hotel.

Our whole purpose is to get the latest information and capture the thinking of the best minds on the planet in specific fields related to humanity’s long-term future on Planet Earth. We videotape and audiotape all of our meetings and sessions, then transcribe and publish the results. We now have over 500 hours of videotape of several dozen seminars like this one. You can see in our library a few dozen publications from previously produced seminars and workshops. This is an open forum, so we request that participants in each of our meetings express their ideas candidly and fully, thinking outside the box for the long term.

… in making the effort to think about the thousand-year future, scholars discover insights into their thinking about the present and the near-term future.

People say, “You can’t think about a thousand-year future,” and, in fact, that’s true. But in making the effort to think about the thousand-year future, scholars discover insights into their thinking about the present and the near-term future. By “near term,” I mean the next couple of centuries, not the next couple of decades.
The other thing to keep in mind is that the Foundation takes no action on the findings of these meetings and seminars. We just publish and disseminate globally the results of what you talk about. We're here to get your best ideas about the significant problems facing the long-term future. A thousand years from now, there will be discussions about the next thousand-year future. The only variation will be that the people will be different. This will be an iterative process that will go on generation after generation.

About five years ago we made a film based on the mural in the Foundation For the Future building entrance. The mural traces the origin of the universe to the present day and into the future. In order to think about the long-term future we have to look back into the past to learn, “Where did we come from?” “How did we get here?” “Where are we now?” And, “What are our likely prospects to survive for millennia?” So we commissioned a mural, and we made a 15-minute movie – produced by a PBS NOVA filmmaker – based on the concepts we originated. We like to start our meetings with this movie because it puts everything into context in terms of where we've been, where we are now, and where we're going.

[Film is shown: Cosmic Origins: From Big Bang to Humankind.]

... if there is consensus ... that the planet is at a crossroads, we hope to discover three or four of the more important factors we need to pay attention to.

SESH VELAMOOR (FACILITATOR): Thank you, Bob. If any of you want a copy of that video, you're quite welcome. We’d be happy to give you copies to share with others.

The inspiration for this seminar, thanks to George Musser and Wayt Gibbs, started with an issue of Scientific American in September 2005. The focus of that issue was “Planet at the Crossroads.” Some seven or eight individuals presented detailed points of view about various topics related to the future. We have two objectives for this seminar. First, in a free exchange of expertise and disciplines we will explore those eight future-focused points of view – most of which we believe will be represented here, along with a couple more – to see if the ideas presented can be integrated into a multidisciplinary context. Second, if there is consensus or agreement that the planet is at a crossroads, we hope to discover three or four of the more important factors we need to pay attention to.

Tomorrow the presentations will change into a conversation format to facilitate that process. First, of course, we’d like to know who you are and we’d like for others to know who you are. So let’s begin by each giving a brief one-minute introduction of ourselves.

David, would you like to start?

WASDELL: I'm David Wasdell. I'm a polymath; I range over various disciplines. For the last 20-odd years as the Director of the Unit for Research into Changing Institutions, I've been exploring how human systems respond to rapid transition under conditions of high stress and low resource. That feels about where we're heading.

My main ambition ... is to use ... international processes, many of them in the political and diplomatic arenas, to bring benefits to ... human and other life.

ISHWARAN: Thank you, good morning. My full name is Natarajan Ishwaran. Most people call me “Ish.” I started life as a biologist. Now I am an international civil servant, as some people like to call us. My main ambition, at least what I try to do, is to use United Nations and international processes, many of them in the political and diplomatic arenas, to bring benefits to land use, conservation, and changes in land use that benefit human and other life.

I'm ... one of the editors of Scientific American ... a thousand years is nothing; I think in terms of 13.7 billion years.

MUSSER: I’m George Musser, one of the editors of Scientific American. I’m basically the astronomy editor. I’ve somehow gotten myself involved in sustainable development issues as well. One of the things I most liked about the video we just saw was Project Orion, traveling to the next star with nuclear pulses going
off every moment. When I was growing up I always thought that was the way to go to the stars, and I still hope we can do that. Even a thousand years is nothing; I think in terms of 13.7 billion years. I hope I can contribute to this session somehow. I feel somewhat humbled and flattered to be here among such a distinguished audience, and I’m happy to be here.

GIBBS: My name is Wayt Gibbs. I’m Senior Writer at Scientific American. Like George, I feel under-qualified for this group, but I’ll do my best. I specialize at the magazine as a dedicated features writer for science and technology in areas that raise social issues, which are hard for people in the field themselves to cover, or are under intense debate, or are subject to controversy. I try to approach topics from a fairly skeptical and open-minded point of view. Part of that involves sometimes considering “far out” or unpopular ideas. The article I wrote for this special issue had to do with setting priorities. That’s certainly an area for which there is no consensus, yet. I hope that we can have a good discussion about what those priorities ought to be going ahead.

TREDER: Good morning. My name is Mike Tredrer. I’m from the Center for Responsible Nanotechnology. My background is quite diverse. I don’t have an advanced degree. In my life I’ve done many different things. I’ve been a truck driver, a salesman, a radio station manager, and a telecommunications firm marketing manager. I’ve had a lot of experiences and lived in many places and, over the course of my lifetime, I’ve taught myself in many, many fields. I consider myself a generalist. In the last five years or so, I’ve specifically focused on nanotechnology as the single emerging technology that will have the greatest impact, both positive and negative, on humanity within the next few decades. It’s the factor I think we need to pay the most attention to. I’ll tell you more about that later.

KESAVAN: My name is P.C. Kesavan. You can call me “P.C.” I started my professional career as a university teacher in Canada. Then I went back to India to start the School of Life Sciences at Jawaharlal University at New Delhi. There, for different reasons, I set up a School of Radiobiology – radiation effects on biological systems. One of my motivations was that India has very high natural background radiation, and that also we needed radiation technology for food preservation, electricity, and other purposes. About two decades later, in 1993, I joined the Department of Atomic Energy. In 1999 I was appointed Homi Bhabha Professor at the M.S. Swaminathan Research Foundation, a foundation to work toward harnessing science and technology to link the livelihood and security of millions of rural people with the conservation of biodiversity. I am happy to be here sharing my experiences with you. Thank you.

MONTGOMERY: I’m David Montgomery. I’m the Director of the Quaternary Research Center at the University of Washington. I’m a geologist by training and the Quaternary is the period of geologic time that we live in. The Center focuses on the connection between humans, their environment, and other species – whole ecosystems. I’m mostly focused on landscape evolution. Looking at that has brought me to the idea that a thousand years is a very small piece of time. It’s very nice to be asked to participate in this group and think about those kinds of time scales because that is what I tend to do – most people don’t.

For the last couple years I’ve been studying how societies affect the landscape – soils in particular – and how that feeds the success or failure of human societies. It’s something that I think is absolutely fundamental – foundational, if you’ll pardon the term – to
both our past and our future. As a geologist, today I’ll share with you a lot of my thoughts about the past, and hopefully we can discuss the relevance of those topics for the future.

POLAK: I’m Paul Polak. The article I wrote for the special issue was on water and agriculture. I’m a psychiatrist, although I see myself as an entrepreneur. For the last 25 years I’ve worked on finding practical solutions for the majority of the people all over the world, who are poor. As a psychiatrist, I focused for 20 years on the social and environmental context of mental illness. As an entrepreneur, I was able to fairly rapidly lose large amounts of money. But I also made enough money in other pursuits to be self-sufficient, so 25 years ago I started working on global poverty. From the first I decided the only way to do this effectively was to learn in detail about the specific context of poverty. I set a threshold goal of interviewing at least 100 small farmers a year in their own context, walking with them through their farms. I bring to this meeting the viewpoints of the some 3,000 small farmers in the world whom I’ve interviewed over the past 25 years.

FACILITATOR: Thank you, everyone. As you can see, this group brings an incredible diversity of expertise and perspective. We appreciate your being here and look forward to your participation in the seminar.
Presentations

To provide a common base of shared information for seminar participants and to add to the Foundation's knowledge base of speeches, nine presentations were invited for the “Crossroads for Planet Earth” seminar, including two keynote addresses and seven presentations of papers delivered on the first day of the seminar.

FACILITATOR: Sesh Velamoor
PARTICIPANTS: Plenary Session

Each of you has either a captive or a not-so-captive audience that will benefit from being influenced by your input and all that happens in these meetings.

SESH VELAMOOR (FACILITATOR): The mission of the Foundation is to increase and diffuse knowledge concerning issues for the long-term future. One of the ways we do that is to make the proceedings available to the general public to inform them about the choices and the decisions they make.

One other thing that happens – and we hope this will happen during this seminar – is the fact that you, as participants, are listening to each other, which, I believe, subtly changes the way you think about the issues you think about. Each of you has either a captive or a not-so-captive audience that will benefit from being influenced by your input and all that happens in these meetings. In these and many different ways we try to meet that mission of the Foundation.

The Foundation For the Future doesn't have an agenda. We are not interested in taking some course of action or influencing what someone else should or shouldn't do. In this or any other Foundation seminar, you'll find that Walter Kistler, for instance, or Bob Citron – unless they get really emotional about something – will not intervene and say something that might represent their point of view. If they do offer their point of view, they're asked to qualify and state that their comments represent not the Foundation's point of view but their own.

The Foundation has arranged for two keynote addresses and seven additional speeches on crucial aspects of our larger topic, “Crossroads for Planet Earth.”

The Foundation has arranged for two keynote addresses and seven additional speeches on crucial aspects of our larger topic, “Crossroads for Planet Earth.” Today, the first keynote address you will hear is from David Wasdell, Director of the Unit for Research into Changing Institutions, on “Facing Bifurcation: Crossroads in Context.” P.C. Kesavan, Homi Bhabha Chair and professor at the M.S. Swaminathan Research Foundation, will deliver the second keynote talk on “Crossroads for Planet Earth: Harnessing Science and Technology for Reconciling Human Security and Environmental Protection.”

“The Climax of Humanity” will be the subject presented by George Musser, Staff Editor of Scientific American. Dr. William H. Calvin, University of Washington School of Medicine professor emeritus, will address the question, “When Climate Flips, Will Civilization Bounce Back?”

Natarajan Ishwaran, Director of the Division of Ecological and Earth Sciences, UNESCO, will tell us about “Biosphere Futures,” followed by “The Big Potential of Small Farms” presented by Paul Polak, psychiatrist, entrepreneur, and founder and President of International Development Enterprises, an organization that has ended poverty for more than 12 million rural poor people throughout the world.

“How Should We Set Priorities?” will be the ques-
tion addressed by W. Wayt Gibbs, Senior Writer for Scientific American. David R. Montgomery, a geologist by training and Director of the Quaternary Research Center at the University of Washington, will describe, “Dirt: The Erosion of Civilizations,” and Michael A. Treder from the Center for Responsible Nanotechnology will speak on “Nanotech Manufacturing: Driving Toward a Crossroads – and a Crisis.” Each speaker will have approximately 45 minutes to deliver his speech and take questions from the floor.
“Facing Bifurcation: Crossroads in Context”

Presentation by David Wasdell

David Wasdell is International Coordinator of the Meridian Programme and Founder and Director of the Unit for Research into Changing Institutions, a registered charitable trust in the United Kingdom. With degrees in mathematics, physics, and theology, Wasdell has used a multidisciplinary approach over the last 20 years to research the psychodynamics of how complex human systems respond to rapid transition under conditions of high stress and low resource. For more information on the Meridian Programme and for access to Wasdell’s more than 90 articles and papers, please visit www.meridian.org.uk.

... we have reached a tipping point, or bifurcation, in the Earth system as a whole.

WASDELL: Thank you very much for the invitation and for the joy of sharing among peers in a context in which learning together is more important than scoring points. That is a joy, let me tell you.

We meet at a time in which the complex adaptive systems of Planet Earth are facing the impingement of a species whose population explosion, exponential resource use, accelerating technological development, unrestrained pollution, and dysfunctional behavior have combined to overstep the conditions of sustainability. It is the argument of this presentation that we have reached a tipping point, or bifurcation, in the Earth system as a whole. That’s different from the chattering or subsystem tipping points that we’ve seen being referred to elsewhere. The navigation of this bifurcation sets the initial conditions not just for the next millennium, but for the future of life on Earth.

The issue of feedback threshold ... has urgent implications for current strategic decision-making and, indeed, for the whole world community.

What is a bifurcation? Brian Walker, the Australian founder of the Resilience Alliance, offers a landscape showing the tipping point along ridge-top lines rising above sunken attractor basins of complex equilibria. As negative feedbacks yield to positive feedbacks, system behavior moves up to the ridge and leaves its familiar stability before plunging into the containment of an alternative state. The issue of feedback threshold, then, is now the most critical agenda of research. It has urgent implications for current strategic decision-making and, indeed, for the whole world community. It is, therefore, to the conceptual analysis of that global level that we must now turn our attention as a first step in exploring the possible existence of a tipping point or bifurcation in the macro system itself.

We start simple and build up. We begin by assembling the basic elements that drive climate change. Global geothermal heating, the radioactive-driven decay and energy, is added for completeness, though its order is much smaller than the other issues involved. In practice, we can ignore it in the analysis. An increase in CO₂ emissions and methane concentration drive global heating, which leads to rising temperature. Then we can add in other anthropogenic greenhouse gases together with increase in concentration of water vapor, vapor trails, particulate aerosols, albedo effects, and finally the complex contribution of cloud systems. That completes the set of drivers of climate change.

Taken together, the elements drive radiative forcing away from equilibrium, generating global heating
which, in turn, leads to an increase in average global temperature, albeit subject to complex subsystem energy distribution dynamics, endothermic damping, thermal inertia, and consequential time-delays. That’s the standard model of climate change. Interacting with that model are the accelerating effects of feedback dynamics to which we now turn.

Six major categories of feedback process can now be identified in addition to the geothermal feedback, which, as I said, is of a lower order of significance. Nonlinear relationships link the feedback drivers and their target systems. For instance, certain systems are driven by increased carbon dioxide concentration, and drive increase in carbon dioxide concentration. That is a positive-linked feedback loop. There are several items within each of these categories. All other feedback categories are driven by rise in temperature and, therefore, come into action only as greenhouse gas-driven global heating begins to take effect. We can then complete the conceptual analysis by overlaying the complex adaptive feedback system on the standard climate change model. We have no time this morning to look at the various subsystem categories of feedback and specific feedback mechanisms. Those who are interested can explore the material in-depth on the Meridian website [www.meridian.org.uk/Resources/Global%20Dynamics/TippingPoint/index.htm]. This material is full of active links, so that we can look at categories, explore feedbacks, and extrapolate those into different mechanisms. We can bring out subsystems, explore their feedback dynamics, and so on. Today, we focus on these issues. The background work is for later.

Feedbacks not only affect the specific functions on which they operate; their output also changes the driver conditions for other feedbacks which, in turn, reinforce the driver of the initial mechanism. Nearly all the systems known to affect climate change are now in positive feedback. Each feedback mechanism accelerates its own specific process. As a whole, the complex adaptive system consists of an interactive set of mutually reinforcing subsystems, and this accelerates the acceleration of climate change. Therefore, it constitutes a second-order feedback system. The inclusion of the complex feedback system in our study of the cumulative effects of greenhouse gas emissions leads to a fundamental shift in our understanding of the dynamics of climate change. The development calls into question the inadequate assumptions underlying all current strategic approaches to the control of global warming. It is as significant as the original recognition that human emissions from the combustion of fossil fuels could, in fact, lead to potentially dangerous levels of climate change.

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Our world climate responds as a complex, adaptive system in which small interventions … can precipitate large, nonlinear effects with long time-delays.

Our world climate responds as a complex, adaptive system in which small interventions – greenhouse gas emissions – can precipitate large, nonlinear effects with long time-delays. So much for the model. Let’s look at its behavior over time. We should focus particularly on its systems dynamics, its equilibrium states, and its tipping points. And then I’ll go on to build a topological landscape on which the crossroads facing Planet Earth can be more clearly seen. The origin of this one [referring to slide] is from William Rudiman’s paper published some time ago in *Scientific American* [March 2005].

Cores drilled in the Antarctic and Greenland ice sheets have provided evidence about the Earth’s past climate, including changes in the concentrations of greenhouse gases, vis-à-vis three-kilometer long ice cores retrieved from Vostok during the 1990s. The research has been expanded since then, confirming that concentrations of CO₂ and methane rose and fell in a regular pattern – we’re familiar with this – over virtually all of the past 400,000 years. I share this just to indicate how profoundly in sync these increases and decreases in greenhouse gases were with intervals in the intensity of received solar radiation – the Milankovitch cycles. However, changes in global heating or cooling were significantly greater than the small fluctuations in energy arriving from the sun due to the procession, tilt, and wobble in the Earth orbit. Why? Small changes in received solar energy triggered weak positive feedback in the Earth system, whether of heating or cooling. I’m going to note this point because I think this is too good to pass by. Here
[referring to slide] is the chatter of the last two ice ages that we’ve been talking about – the “pump” driving brain development and the “pump” driving populations out of Africa. The shift between the warm wet and the cold dry windy conditions is often set off by the thermohaline switch.

We talked about weak positive feedback in the Earth system, whether of heating or cooling. This amplified the effect of change in solar heating. Cyclical changes in global temperature are the combined result, therefore, of shifts in received solar energy and their amplification by the change in greenhouse effect. Greenhouse gas production and resulting changes in concentration of atmospheric greenhouse gases constitute an inherently unstable equilibrium. From its tipping point, increase in solar heating sets off runaway global warming. Conversely, from the same tipping point, decrease in solar heating sets off runaway global cooling. This unstable equilibrium is contained by the changes in solar heating. As energy received from the sun starts to decrease after reaching its maximum, it provides a more powerful negative feedback that halts and reverses the weaker positive feedback of the biosphere. Runaway global warming is stopped and reversed.

Similarly, at the other end of the cycle, as energy received from the sun starts to increase after reaching its minimum, it again provides a more powerful negative feedback that halts and reverses the weaker positive feedback of the biosphere. Runaway global cooling is stopped and reversed.

The combined effect of these two interacting features results in the stable equilibrium of the illustration. This analysis alerts us to one very significant proviso. Should any intervention occur in this system that neutralizes the damping effect of changes in received solar radiation, then the underlying unstable equilibrium of the biosphere would be exposed without containment. Runaway climate change would proceed without further control. It is precisely such an intervention that has been initiated by the Industrial Revolution.

The impact of extreme events, however, illustrates limits to the stable equilibrium. On more than one occasion cooling feedback loops overwhelmed the homeostasis, precipitating the “Snowball Earth” effect. Slow degradation in the feedback process led to an eventual recovery of the basic equilibrium. On the other side, massive release of CO₂ as a result of major volcanic activity in the Siberian region, for instance, also overwhelmed the homeostasis, setting off positive feedback loops, precipitating runaway global warming and eliminating most life forms, for instance, at the end of the Permian-Jurassic interface. When that central homeostasis, controlled by the damping effects of the negative feedback loops, is disturbed beyond a given range, it is subject to increasingly powerful positive feedback processes, pushing it towards the peak of the unstable equilibrium. It is at that point that the negative and positive feedbacks just balance each other. As positive feedback loops begin to dominate (e.g., post-Industrial Revolution) they move the system beyond the unstable point into accelerating change. That’s a bit repetitive, but I really want to make that point very clear.

Let’s widen the perspective some. These extreme responses are themselves subject to boundaries, creating a wider form of equilibrium, the maintenance of which has enabled the evolution and maintenance of life on this planet in contrast, of course, to conditions on Venus. Eventually, a new equilibrium is achieved – warming and cooling – at some distance from the base position. In these extreme conditions the environment is very hostile to most life forms. The biosphere takes many millions of years to recover once the system has returned to the central equilibrium. Five major extinction events have occurred in geological history. Humanity may have just triggered the sixth.

I offer this look at William Ruddiman’s work [referring to slide] because it shows the more recent onset of the current warm interglacial period. It’s a smaller scale, obviously. Current orbital analysis, however, indicates that we are entering an anomalous 30,000- to 50,000-year extension of the current warm interglacial period, and not starting a descent into the next ice age as he had previously assumed. Human emissions of greenhouse gases began to accumulate in the atmosphere about 8,000 years ago with the onset of agriculture and deforestation. By the start of the Industrial Revolution, the result in global warming of about 0.8 degrees centigrade had almost exactly compensated for the small amount of expected cooling.
Since the start of the Industrial Revolution and the accelerating oxidation of deposits of fossil biomass, the rate of accumulation of atmospheric greenhouse gases has sped up dramatically. The time scale, although appearing slow in relationship to the individual human life span, is some 100 times faster than the geological perturbations of the basic equilibrium. That means adaptation in the natural systems is extremely difficult. Furthermore, both time frame and scale of the change have much more in common with the extreme events that led to the historical overwhelming of the stable equilibrium.

As emissions soared, so the cumulative concentration of atmospheric CO₂ began to rise from its pre-industrial base of 282 parts per million, which we left somewhere around 1840ish, accelerating to the current figure now at 381 and rising by just over 2 parts per million per year, towards its projected value of some 550 parts per million by 2050. That's unless some significant action is taken meanwhile. Global warming – the temperature – has slowly followed suit but with significant time-delay, probably about 60 to 80 years. Since the atmosphere and oceans can take decades to adjust to reach new temperatures – masked, incidentally, by industrial aerosols and damped by endothermic processes – it takes a lot of energy to melt ice or to evaporate water. Temperature increase seen to date probably represents the global warming due to CO₂ levels equivalent to 1930s levels. Some of the most misinforming data sets I've ever seen try to get the scales to match and show that current levels of temperature actually correlate with levels of CO₂. They don't. How we present information can be used to massage public opinion.

I want to look a bit more at radiative forcing. Accumulating greenhouse gases have driven radiative forcing away from equilibrium. When the effects of CO₂ equivalent emissions – those are the other greenhouse gases we produce – are added into the CO₂, then the greenhouse gas concentration now stands at just over 420 parts per million, which is above the level set by the European agencies as the ceiling beyond which we should not go if we are to limit global warming to about two degrees and avoid dangerous climate change. We've passed it. And it's not just the level, but the rate at which we are passing, that is accelerating.

Let's just go back to that for a moment. In 2000, watts per square meter of radiative forcing was at a carbon dioxide concentration of about 360. We're now at 381. If you add in the other greenhouse gases, watts per square meter forcing is probably 2 to 2.4, not the 1.5 on this graph [referring to slide]. Again, this graph is available on the Meridian website.

In geological time, apart from extreme events, thermal equilibrium of the whole Earth system was sustained. Radiative forcing stayed close to zero. The pace and scale of anthropogenic intervention are accelerating radiative forcing away from equilibrium. It is under these conditions that the effects of positive feedback loops in the process must now be taken into account. Please remember that most of the climate-modeling supercomputer runs work best very close to equilibrium. The further away you get from equilibrium, the worse their capacity to deal with feedback processes becomes. In our current situation, increased concentration of greenhouse gases driven by accumulation from human emissions and magnified by the accelerating effect of the set of positive feedback groups is widening the gap between received and emitted energy. Instead of moving naturally towards a restored equilibrium, the radiative forcing is accelerating; indeed, its rate of acceleration is increasing.

Survival of life on Earth requires the restabilizing of geosolar thermal equilibrium at a temperature close enough to the maximum of the warm interglacial periods.

Let's explore. What kind of intervention strategy is required to restabilize equilibrium? Survival of life on Earth requires the restabilizing of geosolar thermal equilibrium at a temperature close enough to the maximum of the warm interglacial periods. As an intervention, that entails the slowing, halting, and reversing of the increase in global heating, followed by a sustained period of global cooling with negative radiative forcing. Eventually, global heating would then need to stabilize close to zero again with a temperature held roughly constant at the new and acceptable thermal equilibrium. The effective achievement of such a strategic intervention would
be possible only if and while the capacity to reduce greenhouse gas concentration outweighed the combined and time-delayed power of the set of positive feedback mechanisms. If those criteria were not met, we would face uncontrollable runaway climate change for the foreseeable future, with catastrophic consequences.

Different feedback categories require different intervention strategies. The very first set, the ones that are driven by increasing concentration of CO₂ and, in turn, raise concentration of CO₂, can drive global heating in a feedback positive mode. But they can be neutralized by stabilizing the CO₂ concentration. That’s not stabilizing emissions; it’s stabilizing concentration. That requires reduction in CO₂ emissions to a rate that can be totally absorbed by the environment. The rate of absorption is degrading as global pollution and other systems go forward. We have a downward slope on what is containable.

The second set of hybrid loops is driven by rising temperature but results in increasing CO₂ concentration. Since there’s a significant time-delay in the stabilizing of global temperature for any given CO₂ concentration, these loops would continue to be active after the point at which the first set had been neutralized. Rising temperature would, therefore, lead to increased CO₂ concentration. That, in turn, would reactivate the first set of feedback loops, which are, themselves, depending on rising CO₂ concentration. The neutralizing of this particular process would depend on significant further reductions in emissions during the period while temperature rise continues and before it has been halted. Five, six, seven decades? More?

The third set of feedback loops is temperature-driven and independent of the CO₂ emission cycle. These continue to drive temperature upwards for as long as temperature is actually increasing. They also set off mechanisms of global heating that are, themselves, subject to long time-delays in reaching their full effect: the albedo effect; the increase in water vapor concentration; the release of methane from thawing permafrost; and, eventually, the release of methane from the clathrate deposits in the shallow ocean areas around the continents. These are the most positive and powerful feedback loops driving the acceleration of global heating. In simple language, “The hotter it gets, the hotter it gets, tiddely pom.” Winnie-the-Pooh has an enormous amount to say on climate change, for those of you who read your classics.

Different feedback categories require different intervention strategies.

It is … imperative to explore the limits of our power to intervene in the complex feedback system.

This set of feedback loops sets in motion an uncontrollable chain reaction with a long, built-in time-delay. Containment of this set of positive feedback loops and their transformation into a containing negative feedback process requires a dramatic reduction in greenhouse gas emissions at the earliest possible point in order to ensure the lowest possible peak of the temperature trajectory. It is not clear whether that window of opportunity is still open. It is, therefore, imperative to explore the limits of our power to intervene in the complex feedback system.

I find it difficult to explain these next concepts, but the chart I’ll use may help. On the vertical access we map the relative power of the negative or damping intervention of reducing CO₂ emissions, and we compare it to the effect of the positive change accelerating feedback processes. At the origin, when greenhouse gas concentration was still virtually undisturbed and environmental absorption of emissions could still handle all we produce, power to contain system disturbance by reducing emissions is total – no problem. As emissions start to exceed environmental reabsorption capacity, greenhouse gas concentration starts to rise. That sets in train eventual time-delayed response of the temperature disturbance. By the time global warming became detectable, positive change-reinforcing feedback loops have already started to play their part. As global heating continues to rise, the power to make a difference in the feedback balance by reducing emissions starts to decline. Eventually, the positive feedback process takes control, and all further effect of emissions reduction is nullified. The critical heating threshold at which this takes place represents the closing of that window of opportunity during which human initiatives to generate negative system-damping interventions are still able to halt
global warming and return it to a stable life-sustaining equilibrium.

The stark implications of that last section are made even clearer if we express the power of the positive feedback system as a fraction of the power of the controlling intervention system. While global heating remains close to the original equilibrium, the value of the ratio is virtually zero. Influence of the positive feedback loops is minimal, and the situation is consistent with the assumptions of current strategic thinking. As global heating starts to rise, the relative power of positive feedback systems begins to climb. The capacity to intervene by reducing greenhouse gas emissions quickly decays. The more powerful the positive feedback loops become, the more massive and costly is the intervention needed to return the system to equilibrium. As the energy exchange approaches the critical threshold, the power ratio between positive feedback and controlling intervention, and the total cost of making any effective intervention reaches a vertical asymptote. In other words, it approaches infinity.

Beyond that critical threshold in global heating there is no further intervention capable of damping the system. The runaway chain reaction of uncontrollable climate change will have been initiated, leading inevitably to the sixth or Anthropocene Extinction Event.

I find this very hard material to put together and even harder to present. But never mind; let’s keep going.

Unrealistic hope also leads to unrealistic action. What we require is the capacity to engage reality and work at the implications. Current strategies assume no limit to the time scale within which it is still possible to intervene effectively. They also deny any degrade in the ability of emissions reduction to control the rate of global heating, however high it becomes. In so doing, they gravely underestimate the power of positive feedback. These are false assumptions, and they place the future of our world in extreme danger.

Unrealistic hope also leads to unrealistic action. What we require is the capacity to engage reality and work at the implications. Current strategies assume no limit to the time scale within which it is still possible to intervene effectively. They also deny any degrade in the ability of emissions reduction to control the rate of global heating, however high it becomes. In so doing, they gravely underestimate the power of positive feedback. These are false assumptions, and they place the future of our world in extreme danger.

The further we move away from the position of unstable equilibrium … the faster the result and the rate of climate change.

We’re now ready to combine the equilibrium topology surface with the critical threshold graph in a single diagram. Pre-industrial accumulation of human-generated greenhouse gases just cancelled out the natural damping negative feedback system, leaving the Earth in balance in a condition of unstable equilibrium. An exponential increase in greenhouse gas concentration driven by the Industrial Revolution then tipped the system over the hill and into the present state of accelerating climate change. The effects of human-generated emissions were amplified by the increasingly powerful set of positive feedback mechanisms, the behavior of which is driven both by increase in CO₂ concentration and by the time-dependent effects of temperature change, summarizing what we’ve just been saying. The further we move away from the position of unstable equilibrium, the more powerful the positive feedback system becomes and the faster the result and the rate of climate change. The vertical asymptote of the critical threshold now rises through the downslope beyond the peak of the unstable equilibrium. And the window of opportunity within which reduction in greenhouse gas emissions is able to contain the process of global heating and return the system to equilibrium lies to the left of that critical threshold. It is not yet clear how close to
that threshold we are in reality, or whether, in fact, it has already been passed. Loss of power to intervene in the system becomes absolute as the asymptote is approached. The closer we come to the threshold, the more massive and costly the required intervention becomes.

Now let’s introduce the dimension of time, running from left to right along the base axis here [referring to the diagram below]. We can then extrapolate the lines of the previous diagram as surfaces going through time within the volume of the resultant three-dimensional space. The equilibrium topology is now represented by the ridge stretching from left to right. Near the front face is the valley area of the stable equilibrium. The surface rises from the valley through the inflection line where the positive feedback loops begin to influence the system, then climbs on up to the unstable equilibrium, the tipping line, of the summit of the ridge where positive and negative feedback processes just cancel each other out. Over the hill the positive feedback loops are dominant, driving runaway global heating and resulting in climate change. That’s the summary transferred into three dimensions.

Every passing year reduces further the window of opportunity within which it is still possible to avoid the chain reaction of uncontrollable runaway climate change.

The vertical asymptotic wall of the critical threshold reaches up through the downward slope on the far side of the ridge. It contains the area within which reduction of greenhouse gas emissions still constitutes an effective intervention able to return the system to a stable equilibrium. As that wall is approached, the power of the intervention decreases rapidly and reduction in emissions required to stabilize the system becomes massive and costly. Now, inactivity is not neutral. Every passing year reduces further the window of opportunity within which it is still possible to avoid the chain reaction of uncontrollable runaway climate change. We are now in the early stages of an extreme disturbance of global climate. There is no naturally occurring negative feedback process in place to contain its effects.

Dennis Meadows said what we have to do is find new negative feedback mechanisms. I said they’re not out there to be found: We actually have to generate them in our own human activity. Strategically, the only option open to us is the replacement of the neutralized damping effect of reduction in received solar energy with an intervention of our own making of sufficient power to overcome the now-active positive feedback process.

Today we are facing a bifurcation in the whole Earth system that places the crossroads for Planet Earth in a new and critical context. Without effective action, we will trigger the Anthropocene Extinction Event. If we look down on the landscape – flatten it out a bit – we see that four ways meet at the present crossroads. The facticity of our historic journey opens into three choices.

The “business as usual” path stretches downwards on the steepening slope, passes through the asymptotic wall, the critical threshold, and descends ever further into the vale of positive feedback, the landscape of runaway climate change.

The current Kyoto strategy … does not reduce greenhouse gas concentration. It merely reduces the rate at which greenhouse gas concentration rises.

The current Kyoto strategy, aimed at slow reduction in the rate of increase in greenhouse gas emissions, or, eventually, decrease in the volume of emissions themselves – even if successful – does not reduce greenhouse gas concentration. It merely reduces the rate at which greenhouse gas concentration rises.

Global heating continues to increase, albeit at a
somewhat reduced rate. Positive feedback processes, particularly the temperature-sensitive ones, are not de-activated but slightly dampened. The projected path through the equilibrium landscape deviates slightly to the right. The descent is slowed but continues, nevertheless, down the slope, away from the ridge, past the critical threshold, and into the domain of runaway climate change.

The sharper and faster the intervention affected, the more hope … we have of averting an otherwise inevitable climate catastrophe of our own making …

The “survival pathway” is the only intervention that can halt that descent, turn it along a contour line, and then make it climb slowly back up and over the ridge. It requires a strategy of sustained reduction in greenhouse gas concentration, stabilizing and reducing the rate of global heating, and initiating a period of global cooling. That scenario will have to be held in place while whatever positive feedback loops are activated in the long period before the rise in global temperature can be halted, reversed, and brought into constant stable equilibrium. The sharper and faster the intervention affected, the more hope – realistic hope – we have of averting an otherwise inevitable climate catastrophe of our own making, the Anthropocene Extinction Event.

To allow powerful vested interests of the social, economic, and political systems to continue to hijack the world and hold it ransom for the sake of short-term profit, political power, and national protectionism, would be an act of collective suicide.

We cannot afford any further delay in effective action. Any procrastination increasingly risks global bankruptcy in financing the needed intervention and massive human suffering in carrying it through to completion. It also threatens our ability to regain control before the system is overwhelmed by positive feedback and drifts into the runaway global warming. To allow powerful vested interests of the social, economic, and political systems to continue to hijack the world and hold it ransom for the sake of short-term profit, political power, and national protectionism, would be an act of collective suicide.

Thank you very much, indeed.

TREDER: Can you put the “survival pathway” – the required intervention steps – into practical terms? What would we really have to ask of Americans and all of Western society, as well as developing societies (India, China, etc.)? How drastic would that lifestyle change actually have to be in practical terms?

WASDELL: Unless we actually understand the shape of this system, we can’t really answer that question. The critical research agenda now is, “Is this appropriate?” “Is this accurate?” “How do we quantify it?” “What’s the time frame we’re facing?” Then you get to, “What are the key intervention strategies that may be needed in order, within that time frame, to achieve this set of objectives?” I think if we abort that difficult analytic process, we would “jump into action now, please!” That would have something to do with our anxiety about it, and we would move away from the key issue of work. I’m sorry to be so blunt there. Of course, there’s a lot of work going on about how to do it and what might be needed. We would probably have a lot of access to some of those scenarios. But what I’m looking at here is a different context for looking at the whole question of climate change, which brings the scenarios into a very, very different set of evaluations economically, socially, and politically. I think that’s all I want to say in terms of detail at the moment.

SESH VELAMOOR (FACILITATOR): Looking at the graph on which you pointed out where CO₂ levels in the 1930s equate – in terms of lags – to what’s happening now, wouldn’t there be a way, since the data is available from the ’30s, even prior, and going forward 10 or 15 years, to see if that correlation is validated?

WASDELL: Yes, it would be possible to see that.

FACILITATOR: The other comment I want to make is that Weather Makers by Tim Flannery is a new book that has just come out.

WASDELL: Yes, he’ll be here next week.

… there has to be a 50% or some such percentage reduction in carbon emissions if we are to take charge and control this issue …

FACILITATOR: He has estimated that there has to be a 50% or some such percentage reduction in carbon emissions if we are to take charge and control this
issue – not decreasing the rate of increase, but a 50% reduction in the overall emissions, something along those lines.

WASDELL: Yes, thank you for that. If you look at the Chevron website and their high-eco-impact advertising, you’ll find buried within their strategy for climate issues a little phrase, “Our goal is to slow the rate of increase of emissions by 2050.” It is exactly as you said.

MONTGOMERY: I guess the question I have is: You’re invoking a runaway positive feedback, but an unstable equilibrium like that – sort of the crest between two wells like you identified in your first graph – in a system that receives external perturbation is inherently unstable and should not exist. You’re basically, as I understand it, invoking Milankovitch forcing to push things back periodically to keep it from running away all the time.

But there are two other negative feedbacks that geologists usually invoke to explain the long term. One is the weathering of rocks, and the other is the fact that as you increase carbon dioxide concentration in the atmosphere, plants take up more. Are those going to occur on time scales relevant to applying your kind of arguments to the future?

WASDELL: Let’s take the first one: the weathering of rock, which is the very slow geological process that takes massive CO₂ out of the atmosphere and sequesters it. That is the main process that has led to the recovery of that central equilibrium after it’s been disturbed in a major way. In terms of the uptake of CO₂ by plants, that depends on how many plants are around. What we’re seeing is the decrease, for instance, in planktonic activity with rising acidity and rising temperature, and also the degradation of plankton shell-forming capacities with rising acidity. The capacity for quite major parts of the biosphere in take up of CO₂ is degrading, and that, itself, is a positive feedback loop. There’s a lot more on that. We don’t have time here to go deeper; there’s a two-day seminar in this thing, at least. I’ll refer you to the website I mentioned earlier where you can go into that presentation and pick out the particular categories, and then burrow down into the specific feedback mechanisms. You’ll find all the ones you’re talking about are there and looked at. Thank you for the question.

MUSSER: Just a follow-up question: What constraints can you put on the position of the threshold from the paleoclimate data? You did suggest that there have been these extreme events historically – the “Snowball Earth” in one direction and the Permian-Triassic in the other. How close are we to the PT, in other words?

WASDELL: I was with Al Gore in London about ten days ago, and I raised some questions in addition to what he’s been looking at in terms of the crisis of positive feedback. He said, “I want to reinforce what David is saying about this.” He also said, “There has been a frisson going through the scientific community in the last six months, and it’s on this particular issue.” The work of James Zachos out of the University of California at Santa Cruz has been hitting some of the understanding for this. It’s come out in the independent research in our country [UK]. He’s been looking at the Paleocene-Eocene Thermal Maximum in great depth. Do have a look at his work; it’s very important stuff. He’s indicating that the current set of climate modeling systems are nowhere near sensitive enough, because the point at which the amount of CO₂ in the atmosphere reaches somewhere on the order of 400 to 440 parts per million triggers all sorts of secondary feedback dynamics that are not addressed. His challenge to our current modeling is that it’s not sensitive enough.

Then we have the American Association for the Advancement of Science Congress in St. Louis in February. A small group of paleoclimatologists, with Ruth Curry for Woods Hole Oceanographic Institution leading among them, also said the same things. They said the models we have from the past are not the chattering and the flip-flops of specific subsystem feedbacks and turning points that occurred during the ice ages, but the macro system changes of the great extinction events. These are the great, historic exemplars for what we have done. The amount of CO₂ we have released is equivalent, in terms of order, to that released in those events. The consequences look like being somewhat similar. We’re changing the exemplar field from the glaciation-interglacial periods to the great extinction events. That just changes the ballpark. I get frizzy goosebumps just thinking about it. Seriously, I think it’s a very, very different ballpark.

Really, your question was, “How seriously can we
take that?” Zachos now wants to put together a major program of systems dynamics analysis of the factors driving the feedback process in the Paleocene Eocene Thermal Maximum. I said to him, “We need now to bring that Paleolithic material into sync with our current attempt to generate systems dynamics analysis of the feedback processes meshing on to our current, rather limited, capacity of global climate modeling systems on the supercomputer runs.”

MUSSER: My question was whether we can cut through the model of uncertainty, go to the historical data, and back out the threshold from that.

FACILITATOR: That’s what I was thinking.

WASDELL: I would say not yet. We’re close. A psychiatrist friend in the middle of the States emailed me the other day saying, “David, I wish I could be a village idiot and not understand a damn thing in what you’re saying.” I really sympathize with that.

POLAK: Could one of you sketch out what a world with a 50% carbon reduction would look like?

FACILITATOR: If I were to present a picture, I think maybe it’s close to your heart in terms of where you are going with this. I go in the winter to a place about 30 or 40 kilometers away from the city of Bangalore, India. It’s a rural area. I think that area represents a 50% reduction – actually, not a 50% reduction – I don’t know that they emit any carbon.

POLAK: Can you say more about it? What’s it look like?

FACILITATOR: It’s a rural environment, except for bicycles and an occasional scooter. People are living in a somewhat self-contained, small farm environment. Nothing has changed over the last 200 years. They do have a television antenna.

Could the Earth sustain 10 billion, or 9 billion people living like they live in that village near Bangalore?

TREDER: Could the Earth sustain 10 billion or 9 billion people living like they live in that village near Bangalore?

WASDELL: If we’re going to look at issues of sustainability, let me just take you back to the last meeting of the Club of Rome in Norfolk, Virginia. Dennis Meadows asked about 80 or 90 people present, “With just as a show of hands, how many of you actually think we can have a smooth landing through this particular crisis, and how many think we will go into a catastrophe and bump?” Just over three-quarters of the room at the Club of Rome were convinced in their own analysis that we could not have a smooth landing. It’s very interesting that in the 30-year update, Dennis Meadows and his group there have missed out the death rate statistics from their graphs. I think they really didn’t want to look at them too much.

I’m not talking about despair. I am talking about reality. It is alarming, but I refuse the title of alarmist. Alarmism is using fear to mobilize action, and it is useless. There are some things that are alarming that we’re facing, but we face them together and we can work on them. I think we need to reword La Marssellaise, for those of you who like French, from Aux armes, citoyens to Au travail, citoyens; from the fight culture (find an enemy and attack it) to the work culture (find a task and get to it!).

ISHWARAN: I have a question for Sesh Velamoor based on the scenario you just said. Is it possible to have a low-emission scenario in a city with only bicycles and trams where there are no gasoline-based transport systems? There’s a second question. You raised some major issues on the relation between science and public decision-making. How do you go about deciding anything on this kind of an issue if the decision-maker has to wait for a better understanding among the community of people in society who are expected to provide knowledge? How do you go about it? Is it better, based on your last set of French sayings, to go towards a work culture, expect people to do whatever they can, muddle through, and find solutions within their context, rather than waiting for a global answer?

WASDELL: Sesh, you have the floor.

FACILITATOR: I think the answer is that, although not quite as effectively as in rural environments, the use of trams, urban transit systems, bicycles, no-car zones in the core city areas, and other such initiatives, will help. I was reading some time ago that urban sprawl into bedroom communities in itself is radiating out and contributing to the phenomenon because it extends so far out. Of course, the answer is yes, these things will reduce CO₂, but I’m not sure they will
approximate or equal the low levels of emissions you might see in a strictly rural environment. David can address this more.

**WASDELL:** I think we do have different cultures to examine. The rural culture is a subsistence farming culture, which will have a better capacity to survive until the inner cities begin to break down. Then the locusts swarm outward and absolutely consume what is there in the rural farming community, so watch that one.

**FACILITATOR:** Right.

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**WASDELL:** There's a naive assumption that people will just sit there and die. They won't. They'll go marauding. However, it's very clear, and I'm absolutely over the moon with joy to be here in Seattle, because the mayor of Seattle has been taking one of the key leads in this country to go towards an effective carbon solution to the problems of climate change as they are currently seen. That initiative is gaining ground and momentum towards critical mass. It's slower here in the States for some reasons, which we know about. It's sharper in other parts of the world. But I think you have a capacity here to lead and show how it can be done to move to a very low-carbon economy and still stay ebullient, growth-oriented, surviving, and at work. If you can't do it, I don't know who can. There is dramatic hope for a low-carbon, high-quality form of life. Whether we can survive with 8, 9, or 10 billion in that situation, I think, is a very moot question. What will the shift look like? Can we buy enough time for the population demography to go through its peak and decline, and still survive without a crash? I don't know.

One last facet of this: the issue about decision-making. At the end of the USSR, the time frame of social change outstripped the capacity of the centralized bureaucracy to manage it. We're facing the same kind of issues here within which our political, economic, and social institutions have a slower time response than the emerging turbulence of the global climate. What kind of decision-making processes are appropriate to enable transition management in this situation? That, for me, is the critical agenda. In my own work, the work we've been looking at in terms of the context of climate change has been engaged because it sets the parameters of social response on the conditions of crisis. That's where my main work has been. I've been talking to my consultants and trustees, and I think dealing with this is an essential set of good-enough answers within which we then have to look and say, “What are the implications for that for how we go about riding this baby?” Watch that space. There's a lot of work on that but it's not the agenda for this seminar.

**FACILITATOR:** In that three-dimensional chart you showed, I just wonder, though, whether pointing to that critical threshold and the arrow going straight to Anthropocene Extinction Event, then, is hyperbole?

**WASDELL:** Unfortunately, no.

**FACILITATOR:** I find it hard to conceive that somehow 6.3 billion people are going to suddenly disappear.

**WASDELL:** Before this work hit the scene at all, Aubrey Meyer – the guy who deals with the Global Commons Institute – wouldn't talk to me on the phone. Eventually he said, “I'm just so depressed. I don't want to talk at all.” I said, “What's the problem?” He said, “I seriously think we're engaging in a scenario of giga death as a species.” I think the information we have today puts that into even more profound context. The head of the British Antarctic Survey Expedition is saying we should have probably between one-half and one billion people as a survival population of a sustainable Earth system.

**FACILITATOR:** Professor Pianca from the University of Texas at Austin might turn out to be right after all. He's making the television news rounds where the talk show hosts are hounding him for the fact that last week he stated in one of his speeches that humanity would be better off losing 5 billion of the 6 billion people that are alive today.

**KESAVAN:** It's been a very interesting discussion. I still feel that there are now two points we have to keep in mind in talking about the “survival pathway.” Already the population is very high. The “survival pathway” is closed, in my opinion. If you go back all the way to Malthusian predictions at the time the global population was only about a billion, even then he was very concerned that the resources were not adequate to support that level. It is the science and technology that have enabled somewhere around 6 billion people
to be able to still produce and get enough food. Now, the point is, if you must stop producing that and if you must also reduce the standard of living, whatever it is, even if you try to mimic the scenario that is obtained near Mysore or Bangalore, India, you would still find that you need enough energy to produce food, and water is being depleted. You have to lift the water from the groundwater levels. I have a feeling that we have already missed the boat, and we are on the extinction path. Would you like to comment on this?

**WASDELL:** Not really, but I may have to. I think the realities in this situation are acute. The issue of food production and sustainability for that population base is also acute. What I don’t want to do is to put the economy, including food production, in the limelight, but to say simply, “What is the context within which the planet faces its crossroads today?” And then work back from that to say, “It’s the economy, stupid!” will never again be a political platform for election. The economy is a totally owned subsidiary of the global ecology.

Now, with all our technical competences and our capacity to see into the future some, it is not beyond the wit of humanity and the brain, augmented by extra-cranial processing capacity, to handle this crisis. That I believe. The question is whether the global system as a whole is already precipitated into that course, in which case, the effects are dramatic. If not, we have a job to do in order to contain the life support system of Apollo 13 and get us back on Earth with the best possible survival chance, and then think about some of the costs of how we did it. I’m sorry if there are economists present, but I want to make that challenge. Writing it off as a cost-benefit analysis is simply no longer possible. That’s not a very good answer to your question. I’m sorry, P.C., but that’s the best I can do.

**KESAVAN:** That’s a good answer. The whole thing brings out that it is a very complex scenario, and there are no simple solutions for it.

**ISHWARAN:** Are we being overwhelmed by the problem by looking at the world as one system? Is it possible to look at smaller systems to fix the problems in isolated or limited spaces?

**WASDELL:** Yes and no. I think we are overwhelmed emotionally and intellectually by looking at the total global system. The introduction to this lecture is literally a whole system approach to the Earth from space as a thermodynamic system, which helps us to look at it in that way. Most of our approaches are piecemeal and subsystems.

When Joachim Schellnhuber and the Potsdam Institute are talking about tipping points, they’re talking about local heat distribution bifurcations and tipping points. They’ve identified nine of them, of which the thermohaline line switch is the most powerful and has the most effect on the globe as a whole. But...
that amount of chatter can shift quite major political, economic, and ecological systems and issues around the world. Its impact on the complexity of the whole system is comparatively limited. It does have some effect, but nowhere near the shift of the tip between glaciation and interglacial warming. And what we've done is about three times that. So what we're looking at is an order of intervention that is twice the order of the shift of the thermohaline switch.

We have to be able to look at the globe as a whole, and then look at the implications in detail at subsistence. Obviously, the response has to be fractal. This is where I'd love to spend much more time in answer to your first question on how we go about making some difference, practically. Fractally, at every point in the world system, every nation, every town, every household, every organization, every business, needs to be taking "response-ability" to deal with this, and then working together to make it happen.

MONTGOMERY: I was wondering if you could clarify for me. It seems like the only evidence that you offered to show that there was, in fact, an unstable equilibrium or a fundamental tipping point was the PT extinction event and the “Snowball Earth.” Am I missing something? Are you positing this? What is the evidence that the mechanism or the style of mechanism you're invoking is actually pertinent, other than the box diagram you showed?

WASDELL: This is where I'm drawing on the discipline of dynamic systems analysis.

MONTGOMERY: Yes, I get that part.

WASDELL: If you look at the processes engaged in climate change, they conform very closely to a nonlinear, complex feedback dynamic, adaptive system.

MONTGOMERY: I get that point, too.

WASDELL: In other words, I'm looking at the diagnosis of the system. I've checked this with the best minds I can find, and at the moment, that's the best solution we can come up with as a conceptual model. In terms of finding illustrations of its activity to validate that....

MONTGOMERY: You can't validate something like that.

WASDELL: It's tough. I don't think you can. What I'm asking people to do is please tell me I'm wrong. I'm engaged in falsification with the best minds we can get to try to crack this. And nobody would be happier if somebody said, “Actually, this is just David's paranoid fantasy. We can go home and smoke as much as we'd like.”

MONTGOMERY: To follow that up, would I be right to characterize that if the magnitude of the positive and negative feedback loops involved in one of your early figures – that's the key – can overwhelm the stability, you may be right. But knowing the magnitude and the strength of those various connections and feedbacks is the whole game of whether or not you simply have an interesting hypothesis or you've really got something we should be terrified of.

WASDELL: And go to work on, in spite of being terrified.

MONTGOMERY: Either way, right?

WASDELL: There are three levels of feedback:

Firstly, weak positive and negative feedbacks operate within the bio-geo-chemisphere. Slightly stronger negative feedback is in the insulation changes of solar radiation.

Secondly, stronger positive feedbacks are precipitated by massive releases of CO₂, like volcanic and so on, of which the Industrial Revolution is on par.

Thirdly, there is the degradation of the negative feedbacks (the destruction of CO₂ sinks), because of the pollution of basic ground systems.

As you go on in time, the relative strength of the containing system degrades and the overwhelming strength of the positive system increases. That, I think, is one of the critical issues to which we need to pay attention.

In the handout there's an agenda for future research. That, I think, is now where we have to put our energy with everything we've got. Parallel to it, we need to come up with strategic responses and action programs because this is going to hit the fan very, very fast indeed.

FACILITATOR: Thank you very much, David. With that, we'll conclude this session.
“Crossroads for Planet Earth: Harnessing Science and Technology for Reconciling Human Security and Environmental Protection”

Presentation by P.C. Kesavan

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… we have people with tremendous capacities for science and technology. That is our strength.

KESAVAN: Good morning, everybody. At the outset, I’d like to thank the Foundation For the Future for enabling my presence here so that I may take back with me food for thought. It’s been a very interesting session; I’m enjoying it.

The M.S. Swaminathan Research Foundation (MSSRF), as the name implies, was set up by Professor M.S. Swaminathan, who put up his own personal money, which he received through various prizes in the amount of about $6 million – not much for the United States but something substantial for India. One of the prizes he won was a World Food Prize that gave him about $2 million.

What is the purpose of the foundation? We know that we, in India, have many advantages as well as disadvantages. Some disadvantages outweigh the advantages. We have a huge population, of which 200 million people live below the poverty line of a dollar a day. We also have enormous biodiversity, which is getting depleted at an alarming rate. A third thing is that we have people with tremendous capacities for science and technology. That is our strength.

The question is: How are we going to combine these varied things together and see to it that there can be an onward march of one-sixth of the humanity of this planet? India has one billion-plus people. We share a dubious distinction with China in being a billion-plus club, of which 200 million people, as I told you, are extremely poor. How are we going to combine our advantages and disadvantages, and move forward? We are convinced that science and technology are the solution.

For instance, 200 years ago Thomas Malthus wrote an essay saying the Earth’s resources would not be able to support the population of the planet, which then was about a billion. Today there are six billion of us, and yet we are able to manage reasonably well. How has this happened? This is because of the advances in genetics, engineering, medicine, and other science and technologies, particularly space exploration and other areas. All these various things will have to be harnessed in order to have a longer lease on existence on this planet for humanity. That is our approach.

Whenever you slash and burn … the entire spectrum – ecotypes, species, organisms, animals, butterflies, insects, and everything – goes with that destruction.

I don’t want to dwell too much on this. I would only like to keep in the back of the mind that we have come a long way. Our ancestors were hunter-gatherers. At the time there was no pollution, there was no degradation of the biodiversity. As we marched on, agriculture was introduced about 8,000–10,000 years ago. But that kind of agriculture, I must caution, is not the
same kind of agriculture that is being practiced today. That was slash and burn: cut off the whole forest area, cultivate for a while, and move on. That is the kind of agriculture they practiced. Whenever you slash and burn, not only do the forest and trees go, but also the entire spectrum – ecotypes, species, organisms, animals, butterflies, insects, and everything – goes with that destruction. That era began a kind of depletion of biodiversity. No doubt, the affected life forms regenerate, but not exactly as they were in their original form.

Then, if you go back between 2,000–5,000 years ago, I think that was the beginning of what we consider today as social institutions and geographical distinctions on this planet. Political/cultural/religious systems started forming and farming activities spread across the Earth. Then came the Industrial Revolution with the invention of the steam engine. At the time, as has been pointed out by a number of distinguished speakers here, carbon dioxide in the atmosphere was about 280 parts per million.

As we advanced, the discovery of the Mendelian principles of inheritance in the mid-1860s was a very important thing. That really offset Malthusian predictions to a great extent, because humans could use the principles of genetics in improving the yield, and also the quality aspects of a number of crop plants, and so on. At that time the atmosphere contained about 315 parts per million of carbon dioxide.

Somewhere in 1945, you know what happened with the detonation of atomic bombs over Hiroshima and Nagasaki. I always try to look at the positive side of everything. Even the atomic bomb detonations have given us tremendous knowledge. I am basically a radiation biologist. I’ve been representing my country in Vienna in the United Nations Scientific Committee on the Effects of Atomic Radiation. I can tell you that ionizing radiation has failed to produce any mutations in humans. Also, it cannot induce cancer but it can contribute to the advancement of carcinogenic lesions if somebody already has them. That is the thing that many do not know.

India, until about 1966, had a kind of what they call “ship to mouth” existence. India’s food production was abysmally poor; therefore, we had to get PL 480 food [Public Law 480, the US global food aid program under the Agricultural Trade Development and Assistance Act of 1954]. Only when the ship arrived would there be food in many houses. That situation changed, thanks to American Nobel Laureate Norman Borlaug and Professor M.S. Swaminathan in India. They brought about the Green Revolution. In 1967 India’s population was about 400 million, and our food production was abysmally poor at 40 million tons. Today the human population has gone up by two-and-a-half times to reach 1 billion, and food production has increased to about 200 million tons. That is clearly a five-fold increase in food production; however, it does not mean that everybody has enough food to eat. There may be food security at the national level. We have 50 million tons of buffer stock; fine. But at the household level there is no food security; namely, there is no money in the pocket to buy food, which is true for several million poor people.

Since the dawn of agriculture and the Industrial Revolution, our environment has been affected by development. The carbon dioxide level today is about 380 parts per million. I would like to quickly go over how the rise of genomics, proteomics, space, the Internet, nanotechnologies, etc., is coming to the aid of humanity from 1980 onwards to the present. If we can only use them properly, I think there is a way to

… at the household level … there is no money in the pocket to buy food, which is true for several million poor people.
go forward.

I want to say one thing more. Professor Swaminathan, I mentioned, along with Borlaug, was responsible for India’s Green Revolution ushered in during 1967–68. That same year he was also very concerned about the environmental impact of the Green Revolution in terms of developing only one or two high-yielding varieties of wheat and rice. At that time the yield increases occurred because of the discovery of what they called Norin, dwarfing genes. These genes make plants remain short, but without any decrease in the grain-bearing panicles – the yield. These plants, therefore, have different idiotypes that allow them to take up a lot of nutrients and water, resulting in grain productivity, provided the basic elements such as sunlight and other elements are there. The dwarf plants bearing large numbers of grains do not bend under their weight.

That kind of agriculture created crop plants tailored to make use of the inputs. These are all chemical inputs. Or, in other words, this Green Revolution is highly chemistry-based. Naturally, there are a number of different pests accompanying the luxuriant growth. In order to fight them, enormous amounts of insecticides had to be applied to combat the pests, fungi, diseases, etc. Then intensive cultivation also involved pumping out the groundwater to irrigate the fields. All these resulted in environmental concerns that Dr. M.S. Swaminathan himself addressed in various seminars. He felt that the unscientific tapping of the groundwater and rapid replacement of diverse, locally adapted varieties with one or two high-yielding strains in large, contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened in the case of the Irish potato famine. One of the factors in the Irish potato famine, as you know, was the blight disease. Considering all of this, his conclusion was that instead of having a great future in agricultural prosperity, we may run into an era of agricultural disaster.

As was predicted 40 years ago, today we find 40% of the world’s agricultural land is now seriously degraded.

As was predicted 40 years ago, today we find 40% of the world’s agricultural land is now seriously degraded. That’s an area of about 2 billion acres. Regarding soil degradation, David Montgomery, a geologist, offers an excellent lecture; I totally agree with his information. Soil degradation has a significant adverse effect on the productivity of 16% of the world’s agricultural land. Tillage and agrochemicals pollute water and damage soil structure and biodiversity. Irrigation is increasing; water supply is decreasing.

In this seminar, Dr. Polak points out how we have to conserve water, an absolutely appropriate thing. Rivers are drying up, and aquifers are lower in agricultural areas.

If you look at developing countries, the agricultural requirement – the growing demand for water – is shooting up. This is an area of concern. Developing countries – China, for instance, also India – will require enormous increases in their agricultural productivity. But where will it come from if there is no water?

In 1972, four years after Dr. Swaminathan raised concerns about the adverse environmental effects of the Green Revolution, there was the World Conference on Human Environment. Mrs. Indira Gandhi was then the Prime Minister of India. She led the Indian delegation at this meeting. The first thing she said was, “We must know that poverty is the greatest polluter. So long as poverty persists, there cannot be any harmony between humankind and Nature. You cannot tell a hungry man not to cut the trees, not to destroy the biodiversity. To him bread is God.”

At this conference, the vicious spiral between poverty and environmental degradation was identified as a cause of major concern, as was the fact that developmental activities should be in harmony with ecological ground rules. The World Commission on Environment and Development was set up with the then Norwegian Prime Minister, Gro Harlem Brundtland, as Chairperson of that meeting. She brought forth the report, “Our Common Future” [1987]. In a brilliant way, she dealt with a number of different things.

She spoke of ecological concerns: the growing damage to life support systems, which consist of land, water, forests, biodiversity, and the atmosphere. Then she addressed the social concerns: increasing poverty; social inequity; feminization of poverty; particularly in
India, which I’ll deal with as I go along; rapid growth of the population; explosive technological development coupled with high rates of unemployment; computers taking away many jobs, people say, in the developing countries, including India; jobless economic growth; and, regardless of political frontiers and geographical distinctions, the fact that the fate of humankind is ecologically entwined with these things.

… the average number of people dying per reported disaster in a high-level developed country is 22.5, and in a very low-level developing country it is 1,052.

In India we have very frequent occurrences of geophysical disasters – mainly earthquakes – and also hydro-meteorological events – cyclones, drought, floods, etc. The contrast between developing countries and developed countries in terms of their resilience to cope with disasters is important. For example, the average number of people dying per reported disaster in a high-level developed country is 22.5, and in a very low-level developing country it is 1,052. In India the number of deaths would be probably about 145 or so. This shows that all types of development – technological as well as social and cultural – contribute to a country’s resilience. Vulnerability to natural disasters has a social dimension.

If I may say, without being misunderstood, in the recent earthquake incident in the northern part of India adjoining Pakistan, there were more deaths in Pakistan, where the rehabilitation is still not effective. In India, there were fewer deaths and the rehabilitation has been completed because of higher levels of development and a democratic system of governance.

After the tsunami hit India, Indonesia, Thailand, and many countries, I was asked to go and study the effects in Andaman and Nicobar, a union territory of India. The southernmost part of Nicobar is only 110 kilometers from the epicentre of the earthquake in Banda Aceh, Northern Sumatra. The whole island had been completely devastated. There have been geological changes in Andaman and Nicobar: the northern part has gone up by about 1.9 meters and the southern part has sunk 1.6 meters to 4.0 meters in various places. Post-tsunami analyses of past development activities enabled me to understand the need to integrate sustainable management of resources with disaster preparedness to achieve enhanced resilience of the vulnerable communities.

Today for countries in the developing world, particularly India, and so on, we have to bring together several different aspects. One is that sustainable development is the key. You have to manage the resources carefully so that, as I mentioned, humanity can have a little longer lease on existence. Then you have the negative aspect of poverty and hunger, and vulnerability to natural disasters, then environmental degradation and climate change. All these things form a kind of vicious spiral. So the question is: How are we going to break this vicious spiral?

Subsistence farming, by nature, does not generate adequate income … and women bear the consequences of poverty, the “feminization of poverty.”

I also take into account three important things. One is the Bruntland Commission report that I mentioned, “Our Common Future.” A second thing is Norman Myers’ concept of “environmental refugees.” Norman Myers, a very famous British thinker, has dealt with this problem. India is composed of about 600,000 villages. The men in the villages move into the cities to eke out a living. In so doing, they leave their women behind – young women and old parents. The women now have to take on the responsibilities of managing subsistence farming. Subsistence farming, by nature, does not generate adequate income; it does not produce any wealth. So the villagers remain poor, and women bear the consequences of poverty, the “feminization of poverty.”

The third thing is the Ever-green Revolution; this is very important. Professor Swaminathan, in the last ten years or so, is keen to transform the Green Revolution into the Ever-green Revolution. The Ever-green Revolution aims at productivity in perpetuity with conservation of ecological foundations of agriculture, unlike the Green Revolution.

Breaking the vicious spiral between poverty and environmental degradation involves the following steps. One is promoting sustainable development, development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Second is linking ecological security and livelihood security. We have done it in one place, in Orissa, which is the central origin of rice on this planet. That
has been very successful. The tribal people, who had never traveled even by bus, were flown on flights facilitated by MSSRF to Johannesburg, South Africa, where they won awards for their success.

The key to sustainable development in the developing countries, we believe, involves developing ecotechnologies. We believe that frontier technologies should be blended with traditional knowledge and the ecological prudence of the tribal and rural people to provide a pro-Nature, pro-poor, pro-women orientation to technology development, dissemination of information, and knowledge empowerment of the semi-literate, resource-poor, rural communities. In India this is what we want to do in about 600,000 villages.

Instead of a “don’t” ecology, our approach is a “do” ecology, which means the creation of new eco-jobs. You are part of Nature; you can’t exploit it.

Instead of a “don’t” ecology, our approach is a “do” ecology, which means the creation of new eco-jobs. You are part of Nature; you can’t exploit it. Nature provides for the needs of humankind, not for the greed of humankind; keep that in mind. Knowledge explosion initiated by digital, space, biotechnology, and nanotechnology revolutions provide uncommon opportunities for solving several problems and alleviation of poverty. In the ecotechnology revolution, as I mentioned, we blend frontier technologies – which include information/communication technology, biotechnology, nanotechnology, space technology, and nuclear energy – with traditional knowledge. These then become ecotechnologies, with the pro-Nature, pro-poor, pro-women orientation. Ecotechnologies also involve concurrent attention to ecology, energy, equity, economics, employment, and ethics. These ecotechnologies are in action in M.S. Swaminathan Research Foundation’s “biovillages.”

What is a biovillage? Normally, villages in India have not been dynamic. When the people in the villages get up in the morning, they wonder what they will do for the rest of the day, because they don’t have anything. So we have to transform them into a vibrant society. How do you do it? You do two things. One is to teach them the natural resource conservation and enhancement. If you have fish around there, or if you have some bananas, that is the natural resource, which is also renewable, so let us build on it.

Conservation efforts of the people should be linked with their sustainable livelihoods. They don’t have any money; they don’t have livelihoods, and that’s why they are below poverty level and unable to buy food in the shops. We need to develop on-farm, non-farm, and also marine-based ecoenterprises in the coastal villages. These various on-farm ecoenterprises offer diversification and value addition, and they’re also market-driven. They generate income for the rural self-help groups for women and men.

The biovillages integrate natural resources management, conservation of arable land, prevention of erosion, soil health (a very important aspect that has been completely ignored in many parts of India), wasteland reclamation, water conservation management, etc. Integrated pest management, integrated nutrient supply, and improved post-harvest technology are also given due attention.

Instead of a “don’t” ecology, our approach is a “do” ecology, which means the creation of new eco-jobs. You are part of Nature; you can’t exploit it.

It is not like feeding a fish to a hungry man … This process teaches him how to catch fish so that he’ll always have some food.

Each biovillage has a knowledge centre attached to it. “Knowledge” means knowing how to do a certain thing. We make the people stand on their own feet. It is not like feeding a fish to a hungry man; he will return hungry the next day. This process teaches him how to catch fish so that he’ll always have some food.

The biocentres are service centres of the biovillages. The rural people are largely unskilled, uneducated, largely illiterate, and have no resources. How are you going to teach them technology? That has to be by the process of learning by doing, actually doing the work. If you come to India, you’ll find that there are expert auto mechanics who have not studied automobile engineering but who have learned by doing.

I’ll give you some of the ecoenterprise examples, including village fishermen who didn’t know the value of the mud crab. A mud crab that weighs 2.5 kilos is worth, in the place where it is caught in India, about $5–$6, or about 200–300 rupees. In Japan this crab would fetch $50. This is exactly the kind of value this has; these people were ignoring this. Our intervention consists of telling them how to scientifically produce bigger mud crabs and how to market them.

Similarly, we trained villagers to culture prawns. When the farmers in the Andamans said, “The salin-
ity is too much here. How are we going to contain this to raise a rice crop?" We told them, "If you produce ten kilos of rice, you will get only 200 rupees – about $5 – whereas if you dig and raise mud crabs, you will get maybe 15 times more." In places where rice is cultivated, as you know, pollution from the rice straw is a problem. In Punjab, it is common to burn rice stubble in the field because they want to raise the next crop of wheat. Burning the stubble adds to carbon dioxide and greenhouse gases in the atmosphere. We told them how the rice straw can be used for culturing oyster mushrooms. This is value addition using rice straw.

The third thing is, as I told you, the transformation of the Green Revolution to the Ever-green Revolution. The Ever-green Revolution requires a number of different things that we call biological software. One type of biological software is the vermiform compost. The earthworm produces the best manure in the world. This was, again, being ignored in a country where adequate temperatures, moisture, etc., are available in the soil. We taught them how to do it.

Best of all is the example of the Trichogramma egg parasitoid production. We don't want to use chemical insecticides to manage pests in the agricultural field, so we use the enemies of the enemy as our friends. Fortunately, in the biological world you have tiny wasps. These tiny wasps lay eggs upon the other insect pests and destroy them. How do you then use this? We thought that women who have no land and no livelihood can be empowered through techniracy [imparting new technical skills through learning by doing] to produce these. Small cards are laden with tens of thousands of those tiny parasitoid eggs. These are stapled to the leaves of crops in the field. The parasite wasps get released from the eggs, and they go out and attack the pest. Two illiterate women mastered this technology and came to Alexandria, Egypt, to win a prize.

Another example is the backyard ornamental fish culture. In Singapore, Japan, and other places they are crazy about ornamental (colored) fish: yellow, green, and orange, etc. Raising them doesn't require much investment or much skill, either. With training in how to culture ornamental fish, these women are able to generate some income.

Another thing is that in many parts of India, banana plants are a nuisance in the sense that people don't know how to manage the waste; the plant fiber chokes the rivers and canal systems. Also, the fiber rots and facilitates breeding of houseflies, mosquitoes, etc. The technology here converts the banana fiber into recyclable boards and paper, which are now exported to the United States, Japan, and other countries. These women who were without any livelihood today have a fantastic opportunity to generate a handsome income.

Now, I come to the biodiversity aspect. India and all the countries within 22 degrees to the north and south of the equator are blessed with a great deal of biodiversity, which is under enormous threat. These places are the biodiversity “hot spots.” The strategy should be how to link the ecological security or the biodiversity conservation with the livelihood security of the people. Today, in the globalized world, even the huts in India have televisions. They see how Americans and Western Europeans live; they want to have that kind of life. If this happens at all, the remaining biodiversity will be finished.

We don't want that to happen; therefore, Professor Swaminathan came up with an idea of what are called community-managed gene, seed, water, and food security banks. These are banks with a difference. Banks deal with money. We don't deal with money; we deal with agricultural crops, their seeds, and a variety of related necessities. For example, as I mentioned, the Koraput region of Orissa in India is the central origin of rice. At one point, more than 70 years ago, the British set up the Central Rice Institute at a place nearby because they were very impressed with the enormous varieties or variants of rice. With the Green Revolution coming in, the farmers preferred to cultivate only two or three high-yielding varieties of rice that would be commercially suitable, and they started ignoring a number of different, useful variant forms of rice. This is alarming; already we have lost so much. There are books on the lost crops of North America, the lost crops of South America, the lost crops of Africa, the lost crops of India – there are a series of lost crops.

Our goal was to prevent any further genetic depletion, so we set up Community Gene Banks. We have a cryogenic facility at MSSRF. Valuable landraces and
indigenous varieties of the farmers’ crops are preserved in cold storage ex-situ and in farmers’ fields in-situ. These valuable genes include those with drought and disease resistance, salinity tolerance, etc. Conserving precious genes in landraces is important because biodiversity is the feedstock of biotechnology.

Our idea of a gene-to-seed bank is to conserve seeds for emergencies. If there is another disaster, the farmers will still be able to raise the next crop.

Following the 1999 super cyclone, many farmers in India lost seed material for sowing in the next season. Our idea of a gene-to-seed bank is to conserve seeds for emergencies. If there is another disaster, the farmers will still be able to raise the next crop.

The Community Water Bank is very important; as Dr. Polak mentioned, fresh water is very crucial. The Community Grain Bank has another advantage; this I’m going to link with disaster management. For example, when disasters occur in India, first the people are absolutely without any help. They literally starve for two to three days until helicopters drop food.

This grim situation need not be there if we build the grain banks at the grassroots level, at the village level, and empower the women there. Women are empowered to manage these community banks. Particularly in developing countries, if women are not empowered, then those countries will never become developed.

I’m convinced that women should be given the responsibility to manage these grain banks because if there is any emergency, they know how to deal with it. They know the hungry people, and they will give them food and other things. Rural families can also borrow grain on loan and return it with some additional quantities as interest.

Encouraged by our ecotechnology enterprises, the organizers of the World Summit on Sustainable Development in Johannesburg asked our foundation to develop a database of ecoenterprises. We provided a database of about 700 ecoenterprises.

I want to now compare and contrast some situations between this most developed country in the world, the United States, and India. In the USA, there are about 900,000 farming families. In India we have 110 million. The average size of the US farm is about 200 hectares [one hectare of land equals 10,000 square meters], and the average Indian farm is about 2 hectares. Farmers make up less than 2% of the US workforce, while Indian farmers make up 64% of the workforce. The US farmers’ contribution to GDP (Gross Domestic Product) is 1.7%, while Indian farmers contribute 25% to the GDP.

If we take, for example, milk production, it also brings forth another important point, namely factory farming or mass production, vis-à-vis production by the masses. Today, India is Number 1 in the world in milk production. We produce about 90 million tons of milk, but it takes 90 million people – 75 million women and 15 million men – to do it. The USA is Number 2 with 69 million tons of milk produced, and it takes only 0.2 million (200,000) people. This compares production by the masses versus mass production. The economics that flow out of this comparison are totally different. We must go for job-led economic growth – it is possible – whereas, it’s very easy in the United States to have jobless economic growth. There’s a difference between the two models.

In the Ever-green Revolution, the goal is productivity in perpetuity without accompanying ecological harm.

I want to talk to you about transforming the Green Revolution into the Ever-green Revolution. The Green Revolution had a commodity-focused paradigm, with improvement in crop productivity as the goal. The Green Revolution could cause harm to the ecological foundation (soil, water, and biodiversity) of agriculture. In the Ever-green Revolution, the goal is productivity in perpetuity without accompanying ecological harm. Not only do you want to have enough for your generation, but also you’ve got to ensure that succeeding generations have a fair share of productivity.

If you want to look at it from that point of view, the production gains of today should not erode the prospects for the future; therefore, you have to have this approach of integrated natural resources, management-centric, and mixed organic farming with the low external input and sustainable agriculture for small farms. I found that Professor E.O. Wilson has been associated with the Foundation For the Future. I’m happy to quote him with regard to what he has said about Dr. Swaminathan’s concept and model of
the Ever-green Revolution. I quote from his famous book, *The Future of Life*: “The problem before us is how to feed billions of new mouths over the next several decades and save the rest of life at the same time, without being trapped in a Faustian bargain that threatens freedom and security. No one knows the exact solution to this dilemma. The benefit should come from an Ever-green Revolution.”

Organic agriculture complements the Ever-green Revolution. The shift is from chemistry to biology. There will be less chemistry and more biology, whether you are dealing with soil fertility or soil health, or managing pests or nutrients. Your choices have to be biological so they are eco-friendly. For soil health, these are the biological software components: vermiculture, biofertilizers, stem nodulating, and green manure crop, the *Sesbania rostrata* from Australia that initially had a problem of photo-periodic sensitivity. Through induced mutation breeding, we obtained a mutant that is insensitive to day length (photo-neutral). It can be grown anytime in between two crops to fix nitrogen in the soil.

The next topic is knowledge empowerment. As I told you, in India most of the villagers, rural people, and tribal people had no clue about what was happening just 50 miles away. Sesh Velamoor will agree with me that people in his village wouldn't know what is happening in Bangalore, which is probably 50 miles away. Recently, this situation has changed very rapidly. Today when we talk about the Ever-green Revolution and ecoenterprises, which are knowledge-intensive, the rural people absorb these concepts quickly and also make the best use of them.

We turn to space technology. India, fortunately, has a good space organization. Our foundation is collaborating with the space research organization. The idea is to provide the rural people with time and locale-specific, value-added, demand-driven information. I’ll come to the definition of the demand-driven information in a minute. This information deals with various components such as meteorological, early warnings, sea wave height, community-based disaster preparedness and mitigation, market prices for local commodities, poverty-alleviation schemes, micro credit for micro enterprises, education, health care, employment, etc.

Establishing Village Knowledge Centres may require a wired-wireless hybrid technology if there are no adequate telephones in a remote hamlet. India has a little over 600,000 villages. Today all the villages have telephones. We also install solar panels to ensure uninterrupted power supply. Through this connectivity we are trying to connect every single village to provide locale-specific, demand-driven information.

In doing so, we follow the “Antyodaya” approach. I won’t talk about the Antyodaya approach now, but I will come to that in the conclusion. Our satellite provides information to the people in various villages on the Tamil Nadu coast. The information includes tele-agriculture, tele-fisheries in the coastal regions in the Bay of Bengal, tele-medicine, tele-health, and tele-education. The coastal areas we serve are in the places hit hardest by the tsunami, areas that were devastated completely and are now, by and large, back to normal.

Our Village Knowledge Centres that put computers in common places are bridging the digital divide.

Our Village Knowledge Centres that put computers in common places are bridging the digital divide. You’ll find that in some of the villages of India, there is still a caste system. But we decided that if a village should have a computer-based knowledge centre, it should provide a common place that has no exclusion on caste basis. Everybody should be included.

Secondly, we provide the training particularly to women, because our goal is to empower women. Many of these women have studied only up to 7th class or 8th standard. They are quite good in the Tamil language – they can read. Their English is very marginal. Techniracy is responsible for providing them computer literacy. They can access the Internet and participate in video conferences; they can make PowerPoint slides.

One supporter who took a lot of interest in our program was Dr. Bruce Alberts, who was until recently the president of the US National Academy of Sciences. He has written and lectured about MSS-RF’s Village Knowledge Centres. He has also donated some money to start one Village Knowledge Centre.
What are the attributes of these knowledge centres? These women can provide all kinds of time- and locale-specific knowledge that is required: When should you sow crops? If rain fails, what crops should be sown? If you don't have enough water for rice, can you shift to millet, or peanuts, or something like that? What if your plants have diseases – what do you do? These women answer, “Oh, don’t worry.” They connect you immediately to an agricultural research institution and get you the advice for what exactly is to be done to save the crops from pests and diseases.

The US Naval Base puts out data on the conditions of seas all over the world. We download that kind of information and, with the latitude and longitude, we inform the fishermen in disaster-prone areas about what the sea wave heights will be where they plan sailing in their catamaran – a country raft – for fishing. This information has been responsible for saving the lives of many fishermen.

Our organization of information communication enables knowledge flow from lab-to-land and land-to-lab. In every village this is the kind of structure we plan to establish.

The Antyodaya approach means that development is based on attention to the poorest and weakest individuals and groups. The philosophy centres on including the excluded, reaching the unreached, and voicing the voiceless in technological skill and knowledge empowerment.

Women in biodiversity have played a great role. If we still have some agro-biodiversity in India, it is largely because of the women.

Women in biodiversity have played a great role. If we still have some agro-biodiversity in India, it is largely because of the women. By embracing, or hugging the trees to prevent deforestation [the Chipko movement], women have prevented the felling of trees by men. Women are also involved in the community gene and seed banks, which I’ve already dealt with.

Nature, in regions along the coast of southern India, helps protect humans against natural disasters. Mangrove species reduced the velocity of the tsunami waves and saved some villages. In areas where the trees were not there, the damages were far more severe. Wherever the mangroves were growing along the coast, the devastating effects of the tsunami were greatly reduced. This information was published by Danielson et al 2005 [Science 310: 643].

The last part of my talk is about bioprospecting and biotechnology. We talked about the salinity of the soil. As the sea level rises, the coastal soil and water sources will become salinized. If that happens, we can't do anything to foster agriculture. We also have to develop less water-thirsty crops in view of the growing shortage of fresh water. Using rDNA technology, we have taken the genes for salinity tolerance from one of the mangrove species that grows in the coastal saline soils. This species has the genes for salt tolerance. We have put those genes into rice through genetic engineering. This rice is capable of growing in saline soil containing up to 150 millimeters of salinity.

Notwithstanding all these advances, there is still a growing problem of hunger. The FAO [Food and Agriculture Organization of the United Nations] admitted they could not halve the number of hungry people in this world as expected, yet this war against hunger has to go on.

We have in the 21st century the challenge of expanding inequities, including inequity at birth; low birth weight children are a pity.

We have in the 21st century the challenge of expanding inequities, including inequity at birth; low birth weight children are a pity. The inequities of adult life include illiteracy, malnutrition, unemployment, and gender bias. The intergenerational inequities include loss of biodiversity and, more important, climate change. The United States, right from the beginning, has been concerned with some of these global problems. President Franklin D. Roosevelt, at a meeting conducted between May 18th and June 3rd, 1943, said: “This conference, meeting in the midst of the greatest war ever waged, and in full confidence of victory, has considered world problems of food and agriculture, and declares its belief that the goal of freedom from wants of food, suitable and adequate for the health and strength of all peoples, can be achieved.”

In another meeting, President Roosevelt went on to support Gandhi’s Antyodaya, the principle of attending to the weakest and the poorest of humanity. He said: “The test of our progress is not whether we add more to the abundance of those who have much; it is whether we provide enough for those who have little.”

We have in the 21st century the challenge of expanding inequities, including inequity at birth; low birth weight children are a pity.
President Eisenhower was not lagging far behind. On war and peace, this is what he had to say: “Every gun that is made, every warship launched, every rocket signifies, in the final sense, a theft from those who are hungry and are not fed, from those who are cold and not clothed. The world in arms is not spending money alone. It is spending the sweat of its laborers, the genius of its scientists, and the hopes of its children.”

Finally, these are the six Es at the crossroads for Planet Earth: ecology, equity, economics, energy, employment, and ethics. All of these must be attended to. I am also very fond of Freeman J. Dyson, author of The Sun, the Genome, and the Internet. In his book he talks about the hopes for our planet. We can add solar power to bring energy to the most remote areas of third-world countries; the Internet to provide demand-driven information; and genomics for healthier life. These three may help in restoring the economic and human vitality of village cultures devalued and dislocated by the global market.

Professor Harvey Brooks of Harvard University put it very appropriately: “We find ourselves at a unique moment in human history on the planet, a time not only of unprecedented problems but also of unprecedented opportunities. We are thus in a time of transition, a transition leading towards either catastrophe and social disintegration or towards a sustainably growing human society.” That is exactly the crossroads we face.

There are mainly three civilization paradigms to talk about: human-human and human-Nature relationships can be strengthened, in my view, through ecotechnologies. But the human-God paradigm is a more complex one. Although the love of Nature and love of fellow creatures are implicit in ecoenterprises, the basic tenets of various belief systems are masked by widely contrasting rituals.

There is a need for an ethical pull to the technological push as we face these challenges. I do see that genomics, proteomics, and nanotechnology can provide uncommon opportunities for a sustainable human future rooted in the principles of ecology, gender, and social equity only if we apply a strong ethical pull to the technological push.

Thank you very much.

FACILITATOR: And thank you, Dr. Kesavan, for your presentation.
George Musser is a Staff Editor for Scientific American magazine. While Musser’s primary focus is space science, he also writes articles that provide a historical perspective for the complexities human societies face as they attempt to embrace sustainable development. Musser states, “… a thousand years is nothing; I think in terms of 13.7 billion years.” Musser coordinated the single-topic issue “Crossroads for Planet Earth” (September 2005), which won a Global Media Award presented by the Population Institute. For more information about Scientific American, please visit www.sciam.com.

How can we think about the next 50 years... in a way that lends itself not to apathy or to throwing up our hands in despair, but to action?

MUSSER: I see my role here as providing some context as well, so I think my talk follows nicely from the film about the past 160,000 years of human migration over the entire planet. I’m not going to be saying anything that’s terribly novel or original, especially for this audience here. In fact, I may say something that you know is actively wrong, so be sure to tell me if I do that at some point.

I was really struck at Bill Calvin’s talk last night by the boy who got up and asked, “Is there a hopeful spin you can put on the future, or are we just looking down the barrel at a lot of threats that we, as a species, face?” That gets back to some of the themes we were trying to develop in this special issue of Scientific American, which is the raison d’être of this session. How can we think about the next 50 years especially – but going beyond that as well – in a way that lends itself not to apathy or to throwing up our hands in despair, but to action? I don’t know if everyone saw salon.com this past Tuesday; there was an essay by Kevin Sweeney on how global warming and climate change have been portrayed to the public. He was actually riffing off a talk that Al Gore goes around the country giving.

... fear isn't the way to get people motivated. You really need to show people hope, as well.

Al Gore prances back and forth on stage, showing graphs of carbon dioxide and increased temperature. Then, at the very end, he gives a couple of minutes about what to do. Kevin, in the essay, describes how that’s a little imbalanced. People, by and large these days, recognize that there are problems out there. Obviously, there’s a contingent of people who don’t. The question for most people, though, is what to do. How do we understand these problems in a way that lends itself to our actually doing something about them? He argued that fear isn’t the way to get people motivated. You really need to show people hope, as well. In conceiving this special issue, we tried to bring that sense of hope and opportunity to the whole discussion of environmental questions about sustainable development and economic questions as well. We’re trying to reframe the discussion of sustainable development.

You read a lot of these articles – in fact, we’ve written articles in the magazine ourselves – giving long lists of problems. We get overwhelmed at a point. There are just so many problems; they’re all said to be priority Number 1; we need to tackle every single priority at once. Obviously, we can’t do that. The other commonality in a lot of discussions is the talk of sacrifice. We’re all told that we have to give up something; we have to give up the standard of living that we have. People react against that. Perhaps that’s behind a lot of the
skepticism of global warming science; it backwashes from people's unwillingness to do anything about it.

What I’ll try to present today is an overarching framework for systematizing the next 50 years—the different issues that humanity faces. I’ll try to be pragmatic with a very problem-solving approach, identifying both problems and opportunities. I think the opportunities are really crucial for business. I went to a session at Columbia University last week, “State of the Planet 2006.” It’s from one of Jeff Sachs’ events [http://www.earth.columbia.edu/about/director/index.html] that he does every couple of years. What struck me about it was the number of business people that were there. These are the companies and the entrepreneurs; they’re the people who actually will do the things we’re talking about doing. But they won’t do it if they don’t see self-interest or don’t see opportunities involved in it. Before I jump into the rest of the presentation I wanted to get some other disclaimers out of the way.

I’ll be using the word “unique” to describe our period in human history. I think it is unique, but I think every period of human history thinks it’s unique in some way or another. I’ll try to describe the ways our period of history is unique, perhaps objectively unique. That’s not to say other periods aren’t unique in some other way. I’ll paint a very broad brush. There are a lot of issues that I’m just sweeping under the table or just showing in a very low-resolution way. I’m not even going to address a number of issues at all.

I think there are three big trends that are all converging and intertwining with one another: demography, economics, and questions of environmental sustainability. A lot of these ideas are, again, not unique to our discussion in the special issue. E.O. Wilson, Bill McKibben, Stuart Hart, and a lot of other people have talked about this; I’ve tried to synthesize their perspectives.

First of all, start with demography. There are a lot of transitions occurring demographically, and there are a number of sub-transitions underneath the larger ones. The broad trend, and the transition the world faces globally now, is that we’ve reached a kind of an inflection point. The demographic projections of the future from the United Nations [UN] show a middle range leveling off to about 9 billion people by mid-century. There’s a huge range of uncertainty; actually, this range reflects a 0.5 plus or minus variation in fertility rates. It’s not a huge difference in human behavior that results in a huge number of people either being on the planet or not. Nonetheless, we do seem to be at, in most projections, a turning point in the human population.

I’m at the Foundation For the Future; I have to look at this on a very long time scale. If you plot population growth from 8000 BC to AD 8000, there is a huge spike representing the current growth rate of the human population globally. We’re at a very interesting point in human history, even over the past 160,000 years when the human population was largely stable, with a slight increase. Then we see another huge spike that’s really associated with the Industrial Revolution and the centuries just prior to that. We’re just on the rightward part of that spike.

I was born in 1965. Actually, that point [referring to slide] where the trend peaks is roughly the late 1960s. For the first time in my life, I think I was actually ahead of a trend in society. I think the population growth rate was about 2% at that peak, and now it’s down to half that level.

Again, going back to the theme of uncertainty, the width of a little spike in population growth actually results in gigantic changes in the number of people who will be living on the planet by the time we restabilize toward the end of the century, assuming we do restabilize. Looking at a very long-term perspective, three different projections from the UN going out to the year 2300 show such a range of population growth that it runs off the page. Even the projection for 2250 has an enormous range. Just as an aside, there’s actually a very interesting set of other issues occurring about 2150 where, in a lot of the scenarios, the population growth rate is driven by increases in life expectancy beyond that point, rather than changes in fertility. It’s assumed in these models that fertility basically stabilizes around replacement value around 2150, and after that, there’s a slight upward increase in population just due to the fact that people are living longer.

In looking at population growth, I break things down into the West and the rest of the world. If you look with a very broad brush at trends for North America, Europe, and Japan and then Asia and Africa, the leveling out that has occurred, or very nearly occurred,
in the developing countries is the very same pattern seen in the rest of the world. I recently visited Mexico, where the fertility rate has gone from, I think, seven children per woman in 1970, to two today. In the space of 30 years, Mexico has reached a developed-country demographic fertility profile. Obviously, there's still a huge bulge of people who need to work through the population pyramid. But it isn't just the West – the developed countries – that's seeing this demographic transition to lower fertility.

Underneath the economic transitions there are a number of sub-transitions. The Economist magazine showed last year that the developing countries’ share of the world GDP – on purchasing power parity – passed that of the developed world. That takes us back to the way things were prior to the early part of the 20th century. The economies of the world are coming back into relative proportions, which we haven't seen since the 18th century.

Here's an interesting sub-transition that I think is important for the business community; otherwise, we don't think about this topic much. A Goldman Sachs projection of the world economy over the next 250 years ranks the absolute size of the economies from the United States, being the world's largest economy, then Japan, Germany, and going down, showing the GDP per capita of those countries. The basic message is that big countries are the richest countries. That will not be the case in 2050. The largest economies will be middle income. China and the United States are still up there, but then India is also projected to be there. That has big implications for business opportunities and for the diffusion of technology around the world.

The Millennium Ecosystem Assessment Synthesis Report provides information that describes part of what's driving the economic transition. Basically it shows three different industries that dominate the economy: agriculture, manufacturing, or services. Over time, agriculture decreases into a relative fraction of the economy; manufacturing increases and then decreases; and then the service economy slides up again. The developing world – a good portion of China and India – are somewhere in this stage, or coming out of this early stage. This will actually shade into the final of the transitions I'll get into, which is environmental. This is crucial to understanding what's happening environmentally as well.

Before I get into the environment, I have to give a couple of disclaimers. The growth of the world economy today is concentrated in East Asia. Obviously, there are huge disparities in the world. Africa is not doing so well; it's actually regressed even in GDP per capita over the past 30 years. Back in the ’70s and
‘60s there was such a sense of hope about the growth of economies around the world, and today that optimism is really concentrated on East Asia. But that’s incredible. What’s happening in China; what’s happening in India; what’s happening to the tigers in Asia – it’s really just remarkable in terms of the amount of growth we’re seeing with the potential for lifting people out of poverty.

… there are classes of truly global problems, such as global warming, that, in a sense, are understandable only on a global scale.

What I mean by this environmental transition is that problems – environmental issues – that used to be localized are becoming globalized. And second, there are classes of truly global problems, such as global warming, that, in a sense, are understandable only on a global scale. Fossil fuel emissions over time show a sharp rising trend. The IPCC [Intergovernmental Panel on Climate Change] projections show fossil fuel emissions doubling over the next 50 years to the point that the land and oceans can no longer effectively absorb carbon in most of the scenarios that have been developed. I think that rate of growth probably could be disputed a little bit, but the point is that the amount of carbon taken up by the biosphere and the oceans is less than the amount we’re continuing to put out, so the situation is unsustainable.

I have a really cool movie that didn’t quite work out in a PowerPoint presentation. The movie shows Japanese long-line catches of large predatory fish. The catches and the yields are shown in color-coded imagery. The Japanese fleets were really concentrated in the Pacific but spread worldwide. The movie shows how, as the fleet covered more areas and experienced high fishery yields, you see this kind of wave front spreading out where the high-yield areas spread out around the world, followed by low yields coming behind them, showing a depletion of the large predatory fish around the oceans.

Here’s one of the transitions that has occurred environmentally. I’ve plotted reforestation, showing carbon emissions due to land use change in North America, China, and the tropical Americas. Today, North America, or the United States in particular, is taking up carbon from the atmosphere due to a net reforestation, as opposed to what happened in the 19th century where we had a net deforestation putting carbon into the air. We’ve gone through a transition in our land use patterns, such that we’re now taking up carbon.

That’s beginning to occur in China. We’ve actually just crossed over the net carbon intake part of this. In fact, in the earlier graph I showed the decrease in agriculture’s proportion of the Chinese economy. There are suggestions that this transition is occurring – although there are just a couple of data points – in the tropical Americas as well.

… we’re going through a set of changes on the planet … and we’re trying to understand those changes and work with them, rather than throwing up our hands.

Let’s talk about three different classes of transitions: demographic, economic, and environmental. I’m using the word “transitions” a lot because I want to develop a metaphor and an understanding of world issues that get away from the downward spiral. I’m trying to replace the downward spiral metaphor with a transition metaphor. You see, we’re going through a set of changes on the planet – some of which are good; some of which are bad – and we’re trying to understand those changes and work with them, rather than throwing up our hands. Again, think back to what the boy asked yesterday about whether we have a hopeful future or not.

I want to try to draw three broad conclusions from that transitional paradigm or transitional framework I’ve developed. One will involve tipping points; one will involve a sense of what will happen after 2050, or 2100, or whatever that date is when the transitions have really played themselves out; and finally, a kind of reintegration of disciplines that haven’t talked to each other that much and only now are beginning to reengage with themselves.

Now, when we talk about tipping points, we usually talk about them in a negative way. I want to suggest there are also positive tipping points that are occurring, such as ones to do with energy use. From the late Victorian period to today the growth rate of the US economy went up for a six-fold increase in our GDP – in constant dollars, I believe. Before the Second World War we steadily put out more carbon – a disproportionate growth in carbon compared to growth of the GDP. After that, however, in the latter
half of the 20th century, we’ve actually been doing better. We’ve put out less carbon per unit of GDP. The Department of Energy has assessed that carbon intensity has decreased by a factor of more than two during this post-war period.

There’s a lot going on here: part is decarbonization of energy sources, getting away from coal, oil, and natural gas; part is more efficiency; part is outsourcing of manufacturing to other countries. Nonetheless, there’s been a transition and there is an ongoing transition in our energy use. The point is, we’re getting richer but we’re not putting out carbon at the same pace as we get richer. That’s good. That is a hopeful sign.

... if a given unit of economic output required necessarily a given unit of carbon output, we would be in very, very serious trouble ...

If that were not the case, if a given unit of economic output required necessarily a given unit of carbon output, we would be in very, very serious trouble, because then to stop the growth of carbon emissions we would have to fight against people’s self-interest. That is just very hard to do. We would really have to have a wholesale shift in social values in society. People would have to give up their lifestyles to save the climate. And maybe they still will, but this gives us a potential of reconciling those two. Otherwise, we really are in trouble.

At the Columbia University symposium I went to a few weeks ago, there was a talk by Steve Koonin of British Petroleum (BP). He made similar points to this about carbon intensity. The decrease in carbon intensity – the decrease in the emissions per unit of GDP – isn’t enough to help us get out of the situation that we’re in. The population is projected to go up, and energy use is going up as well. So what we really would need, when we put those two together by 2050, is a four-fold decrease in carbon intensity from what we have today.

People are driving 16% more in the United States, so you’ve got this net worsening of a problem.

That isn’t really out of the ballpark. We’ve had a factor of two over 50 years; we need a factor of four over 50 years. I’m an astronomer; a factor of two, a factor of four, it’s all the same to me. A factor of ten is what gets more interesting. That factor of four and the factor of two are reconcilable in the following way. Koonin gave an example of the internal combustion engine efficiency. It’s actually gone up 23% over the past 30 years. Car engines are 23% better in their fuel economy. But, interestingly, gas consumption, oil consumption for transportation, has gone up 11%. We’ve had a 23% decrease in the carbon intensity, yet we still use more gas. The reason is that, A) Cars are heavier, so you get an 18%, according to these figures, decrease because cars are heavier; and B) People are driving 16% more in the United States, so you’ve got this net worsening of a problem.

But, public policy can steer things. And this is something my colleague, Wayt Gibbs, will get into later. In other words, the efficiency gains aren’t enough, but they do give the potential of getting where you need to go. Policy then comes in and makes sure that the increases in efficiency are translated into decreases in consumption. That’s a long way of getting into it, but this is basically hopeful.

I’ll just touch on something that I won’t even really go into. David Wasdell, and then Bill Calvin, will talk about this topic more: the nonlinearities in the transitions obviously cut both ways. You’ve got an improvement in energy and a potential for staving off devastating greenhouse effects. But you’ve got transitions and nonlinearities in the climate system as well. This is an awkward juxtaposition.

The IPCC projects what will happen in the next 300 years. It looks as if … Greenland’s going to melt; that’s bad.

Temperature in Antarctica is measured by ice cores over the past 400,000 years. Data taken from these discoveries tells us about the maximum warm-
ing trends back in the previous interglacial when Greenland was melted. The IPCC projects what will happen in the next 300 years. It looks as if we’re going to rise above that red line, and Greenland’s going to melt; that’s bad. But I won’t even go into that any more because I’m sure other speakers will.

I wanted to mention a couple of other transitions and nonlinearities that will help us. Developing countries don’t have to follow the same mode of development that the current developed world did. They can do things differently; they can leapfrog. That’s already happening. China has obviously brought down its birth rate faster than what happened naturally in the United States and in Europe. That’s not just because of one-child policies; that’s also because of carrots that were offered. In Mexico, as I mentioned, and Iran, a good chunk of the developing world has had a decrease in fertility.

The point is that the trajectory of development and the trajectory of transitions that have occurred can change. Again, that’s a pressure point that we have; that’s a tipping point that can work in our favor. I think the particular pressure points are really China and India. They’re so large, so dominant, that whatever standards they set for technology and patterns of behavior and patterns of development they adopt really will become the default global standards, not just for the developing world, but for the developed world as well.

Stuart Hart published *Capitalism at the Crossroads* earlier this year, and he argues that sustainable technologies, fuel efficiency, and so forth can really gain a foothold in the developed world because they would have to push out some other players in the market, yet they can make it in the developing world because they’re coming into a void, developing a market from scratch.

Second, this whole paradigm of transitions I talked about earlier is also the light at the end of the tunnel, the bottleneck that E.O. Wilson talks about as an approach to thinking about the next 50 years. Earlier, I used the example of video games when I gave a talk about this. When you play a video game and you’re being attacked by different monsters, or extraterres-

If we’re able to navigate these challenges, we can develop a sustainable economy, with a roughly stable population.

That’s not a hopeful message. People have to know that there’s a goal to work toward, a specific end point. I’m suggesting an end point can be seen in the latter part of this century. If we’re able to navigate these challenges, we can develop a sustainable economy, with a roughly stable population. The economy can continue to grow after that, but the growth will come from productivity increases rather than from input increases or population increases. It’s a hopeful sign. A bottleneck has another side to it. If you squeeze through a bottleneck, you can get through it. That’s one of the messages I think we need to be giving, for instance, to the boy who raised this point yesterday.

Fifty years isn’t that far away. It’s well within infrastructure investment decisions. It’s well within planning for my daughter’s – well, maybe not my daughter’s, but my granddaughter’s – education and my retirement. These are all decisions we are making today. So fifty years is not that far off, certainly not to an astronomer, or even to someone who deals with human migration.

This brings me to the three transitions – demographic, environmental, and economic – that are intertwined; they’re really all the same thing occurring. They’re all really, as I said before, the story arc of the Industrial Revolution playing itself out, spreading worldwide. Economic development obviously feeds into population; population feeds into economic development; health feeds into economic development; environment feeds into health. They’re all connected, and that really requires an integrated approach to understanding the problems.
... working on one problem can worsen another. We really need to recognize those tradeoffs and deal with them in an integrated way.

There are synergies there, helping us to understand and deal with environmental and economic inequities and helping with the demographic transition, speeding it up. Conversely, however, working on one problem can worsen another. We really need to recognize those tradeoffs and deal with them in an integrated way.

The time of dealing with economic development and environmental questions separately, really, I think, is actually already over; if it's not, it certainly should be. We'll be seeing interdisciplinary panels like the one we have today. Businesses and aid groups, like the ones I talked about last week at Columbia University, are all coming together. The epiphany that needs to occur, though, is not any longer really in academia or in business or the aid group community; it needs to spread more into Washington, into our public policymaking. Our President talks about not dealing with global warming because doing so will hurt the economy. The obvious response is that we need to deal with global warming because the economy will be hurt if we don't. The two aren't in opposition. That's the message I think we need to start conveying, and I'm trying to convey it in my own work at Scientific American.

And finally, I just want to wrap up with this point. The common denominator in all these discussions is human beings, human welfare. Why do we care about the environment? Why do we care about animals, plants? We care about them inasmuch as they meet our own needs and desires. We start from those first principles and work up to how to deal with the world's issues; that has to be our starting point. We can't say that preserving a butterfly is good and should take precedence over other human needs. It needs to be factored into those human needs and included in the tradeoffs that we're making.

Now, let me get into this a little bit. The Millennium Ecosystem Assessment Synthesis Report puts a dollar amount on the value of different ecosystems. It's trying to identify, in this case, a common denominator, a common currency.

We need to move to this kind of paradigm of putting everything in terms of human welfare …

A wetland: It's worth more undeveloped than it is developed, at least in one model from Canada. A forest: In dollar terms, you're better off keeping a forest – forget about the whole question of forests and their intrinsic value – than turning it into small farms in this particular area in Cameroon. That may not be the case everywhere, but these are the kinds of calculations I think need to be made day-in and day-out in land use decisions, in any kind of environmental decision. We need to move to this kind of paradigm of putting everything in terms of human welfare and try to adjudicate these tradeoffs that need to be made in the world today.

Thanks very much for your attention.

SESH VELOMOOR (FACILITATOR): Thank you, George. We'll now have a brief question-and-answer period.

TREDER: In the earlier part of your talk, you spoke of looking at human population growth, and whether it will go up or down or stabilize. Do you think it's worth, in looking at those population figures, the extremes of either way, and their economic, environmental, and so on, impacts, to consider nonhuman or posthuman population growth? That is, whether machine intelligences or cyborgs or genetically augmented humans are a diversity of the Homo sapien species, and should those things be taken into account within a time frame if we're talking about one hundred or, certainly, one thousand years?

MUSSER: That's a really interesting question; I'll have to think about it. Those projections out to 2300 for population are pretty iffy, as is reflected in the uncertainty. And you've just added another big uncertainty. The UNDP [United Nations Development Programme], when preparing those projections, had a whole series of essays from people basically arguing, “You shouldn't have made these projections at all,” leaving aside the question of where Homo sapiens is going in the context you've described. The projections to 2050 are better because they mostly involve people already alive and the behavior of those people: Do they have 1.5 kids fewer or more than the baseline projection? Past 2100, it's quite likely we'll have to deal
with machine intelligence, as you say, and maybe even before that. I don’t go as far as Ray Kurzweil [http://www.kurzweilai.net/meme/frame.html?main=/articles/art0635.html] would, but we should talk about that more; that’s a good question.

POLAK: What do you think are the main factors that will determine whether population on that graph will go up, stabilize, or go down?

MUSser: This is a discussion I’ve had with Joel Cohen, the demographer, a lot. I asked him, “How do demographers project fertility? What goes into these projections? What goes into these models?” He basically said, “It’s a guess. We’re extrapolating observed patterns that we have today.”

He asked me, “Why did you decide to have the number of children you decided to have?” That’s hard for me to articulate. That’s a decision we all make individually. It goes back to the notion that human decisions are very difficult to characterize. Clearly, though, if the economic side of the equation – the economic transition – isn’t handled well, that will backwash into the demographic in a way that will worsen things. The model is that if economies develop, people will have fewer babies. For whatever reason, that happens.

If a country such as Niger, which I think has the highest population growth today, gets stuck in its current state, it will continue to have a high growth rate. Quite apart from the issue of having people in poverty and the inequity that implies, just demographically, it needs to be moved out of that current state.

POLAK: I totally agree. I believe if you look at the data, the major population growth is in the countries that are the poorest. The likely greatest factor in what will happen to the population is what will happen to the economies, to the poor people, who have the biggest growth rates. Just from practical experience, large families have survival value for people on the edge of survival.

MUSser: Absolutely.

KESAVAN: It’s a very interesting talk, but I am wondering whether we have taken into account several other parameters that are also operating. When one talks about the demographic situation improving by 2050, at the same time, your agriculture has to ensure food security to the people. In doing so, there is another problem. I’m sure Paul Polak may agree with me. Take, for example, India. With the progress of organization, the lifestyle is changing. One would say that more of the American people would have to live like average Chinese or Indian. But what’s happening in India is that more of the average Indians, with the economic boom, are changing their lifestyles to achieve the standards you have. In this kind of scenario, if you take into account all these factors, I’m not too sure that the situation of the decreasing demographic structure would have a favorable impact on the poor Planet Earth. That is my problem. We have to think a little bit more comprehensively about so many other factors. I’m not saying they’re hidden factors; they’re pretty obvious factors. These can be taken into account, and then we’ll have to see how things go.

If the world’s population that does not live the developed country lifestyle were to live at the current lifestyle we have, we’d be in big trouble.

MUSser: Absolutely. That’s sustainable development in a nutshell. If the world’s population that does not live the developed country lifestyle were to live at the current lifestyle we have, we’d be in big trouble. It would be impossible, probably.

CALVIN: Extrapolating trends is an important way of studying this issue and of getting it across to the public. But real sustainability has to include getting through the glitches that occur. Just take one that’s not exotic but fairly familiar, and that’s the matter of droughts that are widespread. The United States – the Midwest and West – has had century-long droughts in 5 of the last 20 centuries. Just on that alone you might say the 21st century has a 25% chance of something like this happening, even without global warming. There are
plenty of glitches of that sort around. Sustainability has to include having the resilience to bounce back out of that, to handle it.

All of the extrapolations that one makes are fine, but if you don’t factor in having the reserve capacity, having the social organization, having the economic planning that will also allow you to get through those periods, from whatever cause, you just fool yourself, in effect, because you think you’re on target in meeting goals when, in fact, you haven’t built the infrastructure that it takes to get through the hard times.

**MUSSER:** Absolutely; there needs to be risk analysis and risk management, in that sense.

… can you move from a fear perspective to a hopeful perspective purely on the basis of data? Is there room for some value discussions?

**ISHWARAN:** I like your idea of looking at things from a hopeful perspective instead of a fear perspective. I think it’s a good shift in perspective. But can you move from a fear perspective to a hopeful perspective purely on the basis of data? Is there room for some value discussions? Someone said that trying to predict the future looking only into the past is like trying to drive a car by looking only in the rearview mirror. That may not work. Somewhere there have to be some discussions about some value systems for the future. What do you think about it?

**MUSSER:** I couldn’t agree more. What I will say is that we have to accept – and here I’m thinking in terms of policy-making – things that can be done, rolling up the sleeves, what you actually do. I think we need to accept that our ability to do things, and I really mean our ability – the people in this room and people like us – is very limited. We need to work with what we’ve got. This is just my perspective – we can debate this later – that by attempting to change values, using our limited ability and limited resources to go after those values, is like pushing on a brick wall. I think we’re better off taking specific measures to address specific policy objectives, such as the cap-and-trade program for greenhouse emissions, making sure that the energy efficiency gains are put into decreasing consumption rather than increasing performance and just driving more. The values have to be there at some level. I tend to suspect, and this just reflects my own philosophical view of human beings, for better or worse, that we’re very situational. I think if the situation changes, the values will change, probably in an unpredictable way, but they will change. Somehow we need to work with our limited policy levers on changing the situation. That’s an imperfect response. I think probably the question of values will come up again and again.

**FACILITATOR:** I guess you’re saying that in terms of values, preemptive setting of agendas or values is not in the cards. We are good at reacting rather than “pro-acting,” particularly when it comes to values. If our circumstance is situational, our behavior will change as a reaction rather than being preemptive.

… people are driven by self-interest or by the situation they’re put into. That’s, I think, where we need to go – at their behaviors.

**MUSSER:** Right. That’s part of it. I guess it depends on what we mean by “values.” It’s a small word with a big meaning. I grew up in a time of environmentalism, talking about admonitions: “Drive less; recycle.” Some people drove less; my parents bought a smaller car. But ultimately, people are driven by self-interest or by the situation they’re put into. That’s, I think, where we need to go – at their behaviors. Not a direct frontal assault on their values, but try to tweak their behaviors at the edges. We need to really accept people as they are, to accept the human-Earth system as it is, and push on the system in the places that we can push.

**FACILITATOR:** Put up little traffic signs that say “Change course,” rather than saying “Road ends, and now you’ve got to go back and do something else.”

**MUSSER:** Yes.

**FACILITATOR:** I have one other question with regard to the carbon efficiencies of the United States. Have you looked at the improvement in carbon efficiencies that may have shifted to another location by virtue of loss of manufacturing?

**MUSSER:** Yes. I alluded to this earlier when I talked about outsourcing. Some of the decrease in emissions is precisely what you can euphemize as a change to a service economy. What this really means is that you’re buying products from a country that’s not as efficient as you are. However – this is something I just saw in, I think, Sci-
ence magazine this past week – there's been a decrease in carbon intensity even in countries such as China, which are the beneficiaries of that outsourcing trend.

I don’t use “outsourcing” pejoratively in the political sense. I’m just using it literally to mean products being made elsewhere. The figure went down a remarkable amount in China. I'm sorry I don’t have the slide here, but I could show a similar plot for almost every country except Brazil. It's remarkable.

MONTGOMERY: It would seem, if your actual goal is to reduce carbon emissions rather than reduce the rate of increase, the necessary criterion is not to change the exponent on the nonlinearities, sort of what fraction you get of carbon for what fraction of GDP increase; it's to change the sign, which is a totally different question. Otherwise, you're just talking about changing the rate of increase.

MUSser: You’re not changing the sign; you're changing your factor. You need to get something that multiplies and gives you less than one. It's not a sign change. It depends on what you're looking at.

MONTGOMERY: As long as you posit a further increase in the GDP, you're still going to have a positive increase, are you not?

MUSser: No. The increase in GDP is offset by a decrease in your carbon intensity. You'll get a net reduction.

FACILITATOR: I think maybe I understand what you're getting at. It's like the FBI reporting crime statistics, saying that crime is going up but it's not going up as fast as it used to.

MONTGOMERY: Right.

MUSser: Maybe I’m misunderstanding; we can talk about it a bit later.

FACILITATOR: Anyone else have one last comment or question?

POLAK: The comparison of “what is” versus “what can be” is not reflected in those examples. Just on the potential for automobiles, the potential exists for a 200-mile-per-gallon car; we're nowhere near that. The potential in terms of energy is vastly greater than what our accomplishments are.

MUSser: Let me rephrase what I was trying to say, and maybe I’ll be more successful this time. If you didn't have this improvement in efficiency, you'd just throw up your hands at that point. This is a necessary, but not sufficient, condition for bringing about your decrease. That's my point.

POLAK: I agree.

TREDER: I think this is related, actually, to Dave Montgomery's question, and Sesh Velamoor's clarification, about things getting worse but they're not getting worse quite as fast. You discussed poverty rates – absolute extreme poverty rates – that have declined over the last 15 or so years, and the optimistic projection that they will continue to decline. My question is, even as the absolute number of persons below poverty rate declines, isn't there such an increase in those who are super wealthy, certainly by comparison to those who are poor, that the gap between the greatest and the least is still expanding? We can see that the poorest are not quite as poor, but the richer are a heck of a lot richer, so the gap is expanding. Is that the case?

POLAK: The BP projection for the next 50 years is a doubling of the world's energy consumption. Doubling. That's amazing.

MUSser: Is there an increase in disparity of wealth in the world today? Yes, I think that's certainly happening, although I don't have the figures for that here. Maybe I can wrap up this discussion by just talking about the question of “getting worse, but at a lesser rate” in two senses.

If I were to show a chart of relative numbers of people in the world living in poverty, you would have seen that number decrease. From 1820, the absolute number would probably go up, and then down again. So there has been a relative improvement for quite a long time in dollar-a-day poverty; that number has been offset by the increase in the world population. So the absolute number of people has gone up. That's what's changed. The decrease in relative poverty is now finally able, given the decrease in population growth rates, to produce a decrease in absolute numbers. There's a case of a sign change in the way that you're saying. That's a similar kind of change that I'm suggesting; I'm hoping – I'm not projecting – that will happen in energy.

Now, to go back to the energy numbers a little bit, the BP projection for the next 50 years is a doubling of the world's energy consumption. Doubling. That's amazing. So another Earth's worth of the use of
energy in the next 50 years will happen. To stabilize it at 550 parts per million (ppm), or whatever number we choose, you really need to reduce your emissions, total emissions, in half. That's where the four-fold improvement in the intensity comes from. If you can improve by a factor of four the aggregate world carbon intensity, you can stabilize it at 550 ppm because you get, again, a turnover occurring like the one for poverty. It's not just a question of things getting worse by a lower rate. Things can get better if the factors you're multiplying in bring you less than 1.0.

FACILITATOR: Thank you very much, George.
“When Climate Flips, Will Civilization Bounce Back?”

Presentation by William H. Calvin

William H. Calvin, Ph.D., is a neurobiologist and professor emeritus at the University of Washington School of Medicine in Seattle. A prolific author, Calvin focuses his research on the likely impacts of abrupt climate change on the evolution of a chimpanzee-like brain into a more human one. His 2002 book, A Brain for All Seasons: Human Evolution and Abrupt Climate Change, won the Phi Beta Kappa Book Award for Science, as well as the 2006 Walter P. Kistler Book Award. For more information on Calvin’s work, please visit http://WilliamCalvin.com and http://Global-Fever.org, the site for Calvin’s next book, Global Fever: How to Treat Climate Change.

CALVIN: I’d like to begin by showing you a “tipping point” – an overturned vehicle – that actually happened about a mile from here to the east, near Bill Gates’s house. This incident occurred because March winds were particularly high that year – in 1999. This garbage truck was coming around a curve, which was not banked in quite right, and a gust of wind flipped him over the top of a Mercedes convertible. The guy survived; he called for help on his cell phone. That shows you the danger of high winds. Basically, most of the gusts of wind just sort of rocked the vehicles. But when you get to the point where the center of gravity extends beyond the line of support, things happen quickly. That's what I mean by “tipping point.”

Discussions of climate change in the past have mostly not had nonlinear features like that in mind. The abrupt climate changes we've been talking about are of the sort where, within five years, you're really in trouble. If you're able to spread those changes out over five hundred years, you could, of course, probably ameliorate quite a few of them.

The analogy in military affairs would be like that of the back-and-forth activities of the front lines of World War I in Belgium and France. Then we saw with World War II the blitzkrieg tactics where basically you get overrun faster than you can react. The whole technique of disrupting supply lines with lightning raids – so that a day later everybody ran out of ammunition and food – shows you the kind of situation we may be facing with some of the abrupt climate changes.

One of the reasons we always thought climate change was gradual was that the Milankovitch drivers – changes in the tilt of the Earth's axis every 40,000-year cycle – are perfectly gradual. So are the changes in the eccentricity of the orbit, and so on, and the time when the closest approach to the sun occurs – currently, January 3rd. Perihelion drifts around the calendar every 25,000 years, roughly. All these are perfectly gradual. You add them all together and you get sort of a forcing function that, particularly from the sunlight up in the high northern latitudes in the summer, predicts a lot of the ice age back and forth movement of the ice sheets.

Furthermore, the climate data looked gradual. A lot of that was because if you core a lake bottom, you're not getting year-by-year layers. They have been disturbed by the worms churning the bottom. They have, in effect, produced a moving average. You know about moving averages from the stock market. I just picked a volatile stock and charted its activity. It was, mind you, a log scale that went from 20 up to 120, and then worked its way down to 4 or 3, and came back up to 20.
Imagine now what this looks like if you filter it with a running average. A one-year stretch of data shows an extremely jagged line of highs and lows. A five-year running average smooths out these volatile changes. That’s the position we’ve been in about climate until we got high time resolution evidence. These have come mostly from the ice cores, though there are a couple of other good sources, as well. It has led to the realization that, as Richard Alley says in this wonderful quote, “Climate is like a drunk – when left alone, it sits; forced to move, it staggers.” And the data looks as if there’s a lot of staggering.

In 1994 I wrote an article for *Scientific American* and included information to show climate drivers. The purpose of including that was to remind readers, as I will you today, that if you’re simply extrapolating, the next ice age won’t start for tens of thousands of years. You really have to ask what the temperature and the humidity in the air will look like and not just ice accumulation. The last warm period ended at 117,000 years really quite abruptly in terms of temperature. After another 30,000 to 40,000 years – around 70,000 years ago – substantial ice buildup began. The climate flipped from what it looks like today into the cool-dry-windy-dusty climate of the ice age, but it jumped back and forth. There were two dozen abrupt climate changes in the last ice age alone. And there was a small, brief, warm-and-wet climate flip 8200 years ago.

These are big changes … You don’t exactly need fur coats in the tropics, but you sure need something for all the drought.

These are big changes. At European latitudes the changes are 7, 10, maybe 15 degrees centigrade in this scenario. In the tropics they’re only 3 to 5 degrees centigrade. You don’t exactly need fur coats in the tropics, but you sure need something for all the drought. The worldwide climate gets a lot dryer. The rain forests shrink down to maybe 25% of what they are today. The entire world really gets into trouble at the same time.

If you look at the neighboring ice core, it shows much the same. You see the period in which humans start becoming behaviorally modern. The creative explosion of art and much finer technology comes in somewhere between 60,000 and 40,000 years. The “out of Africa” scenario Bob Citron covered earlier, in part, occurred also all through that period.

There are periods where the climate jumps up towards warm-and-wet and collapses back down. At times the line showing shifts in climate is just as glitchy as can be, going back and forth. That’s what our ancestors lived through. Then you start seeing the development of agriculture. About 15,000 years ago, temperatures jump up to almost modern levels and then work their way back down in a series of jumps of several degrees centigrade. These would be very troublesome to us today, each one of them. The re-warmings go a lot further in a small period of time. You can pop back up most of the way within five years. That’s what is meant by abrupt.

Other things change with it. The re-warming at 15,000 years also boosted methane production and changed the winds. A proxy for the wind is sea spray in Greenland that cools down the winds and affects Greenland’s temperature patterns.

A global conveyor belt moves heat around the world in a long loop by means of flowing ocean currents. Warm water comes to the surface near the equator and is pushed toward the poles, where it gets cold and sinks. A mid-Atlantic gyre, the Gulf Stream, moves this water along the east coast of the United States. A branch off that loop occurs near Ireland, and then there’s the Norwegian Current, and the Labrador Current in the North Atlantic. In the region above Iceland there’s a particularly effective kind of downwelling where the surface water drops to the ocean floor in giant whirlpools, perhaps 10–15 kilometers across, registered.

The other major downwelling site is over in the Labrador Sea. This is not something you see in every ocean of the world. In fact, only the Mediterranean has a good downwelling loop. But these downwelling sites – high-efficiency, whirlpool-like downwelling sites – are very vulnerable. They’re sort of an automatic flushing mechanism. Cool, dry winds come off Canada, across the North Atlantic, bringing water that’s warmer than usual because of all the heat carried up to the area from the Gulf Stream. These combine to evaporate a lot of moisture from the surface. That
warms the air, cools the water, and leaves the salt behind. The cooling and the salt left behind make the surface water denser than the underlying water, and that’s why it falls. If it just falls and mixes with layers underneath, you don’t get a strong, deep current in quite the same way. But these high-efficiency downwelling sites are what keep the whole thing going. And they’re vulnerable.

Sinking can fail from too much rain. If you dilute the surface water with rain – no salt – then you can drive this down to the point whereby that density-dependent sinking stops because you diluted the surface. More rainfall in the higher latitudes is one of the things you get with global warming. It’s been occurring for forty years already.

**… north-flowing rivers dump a lot of fresh water into the Arctic, so that salinity is about 18% below the average of the other oceans.**

One thing that happens, since the sea surface is a lot cooler now, is that the sea ice can come south quite a ways. That, of course, reflects back out into space sunlight that was otherwise being absorbed by the ocean, cooling things even further (a process known as ice feedbacks). Another source of freshening, or diluting, of this water is the fact that north-flowing rivers dump a lot of fresh water into the Arctic, so that salinity is about 18% below the average of the other oceans. As that’s pushed out into the northern part of the North Atlantic, again, you get the possibility for killing this salty waterfall that normally plunges into the depths of the sea.

Of course, freshwater – melt water – from Greenland, which comes out and layers onto the surface, is a major worry, in part because it can come out in great floods. If you trap melt water in a lake behind an ice dam, the ice dam will eventually be torn apart in a day, and several years’ worth of melt water can come sluicing out. We already know that these two downwelling sites are highly variable. You can see an almost 90% reduction of downwelling in the Greenland Sea during the 1990s. Fortunately, at the same time, Labrador’s downwelling was going strong. You see other decades where one downwelling site is way down but the other one is going strong. We have no idea yet – the data just isn’t there – to know whether they ever fail at the same time. That would be the real worry. The trends are bad enough.

If you look at the salinity of the subsurface water and how much has sunk in the depths of the ocean near the tip of Greenland, 60 degrees north, near Iceland, in the Labrador Sea, and in the Denmark Strait between Iceland and Greenland, you get the picture of what’s going on. Data from 2000 back to 1965 show substantial fluctuations in the salinity and the freshening of these waters, with similar results occurring in other sites. Too much fresh water added to the surface of the northern seas allows warmer, lighter water to flow much farther north than it would otherwise do, acting as a heat pump and melting the delicate ecosystems of the northern Arctic regions.

**… a lot of randomness … will cause the threshold to be exceeded sometime earlier than you ever get to the intersection with straight lines.**

Now, how much time before we reach the threshold for this thing failing? If you take the normal extrapolating-the-past-into-the-future approach, you can imagine figuring this out. Suppose the threshold and salinity are at a certain point. You say, “Ah, well, we’ll extrapolate a line through there, and that will give us a ‘time to failure.’ If the threshold’s further down, we’ll have more years before failure.” That sounds reasonable. It’s the sort of thing we do in science all the time. And, it just won’t cut it. That is to say, this is a stochastic system. There’s a lot of randomness that adds to the steady trends. That will cause the threshold to be exceeded sometime earlier than you ever get to the intersection with straight lines. In math it’s called “first passage time to a diffusing barrier.” It’s an old problem, well studied. I did my Ph.D. thesis using it in 1966.

Tom Stocker’s lab [University of Bern, Switzerland] did a simulation of failure of the North Atlantic Current. After the first thousand years in their model run, at that point they increased the CO₂ gradually for 140 years to reach a level that’s two times the present. They, undoubtedly, tweaked the other parameters of the model to get the thing so it threshold straddled. That’s because there’s so much “noise.”

The noise is what you would get in real life from the El Niños of the world, from the random storm tracks; all those are noise. They combine to make the failure times very different. Stocker’s model shows a collapse that goes all the way down to less than 15% of
present values. Sometimes it goes only halfway down and manages to recover. One hundred superimposed traces are shown, illustrating wide variances in the timing of failures. Furthermore, some of them do manage to recover, but you get these big oscillations.

The other thing you should notice is that the magnitude of the noise signal that you get at the beginning gets greatly amplified as you approach the threshold. In other words, the effect of the El Niños and such factors becomes at least three times greater.

… unless you can forecast the El Niño accurately, you really can’t do a time to failure. You have to act as if it could happen much sooner …

It’s something I saw in spinal motor neurons and had to cope with. This is the kind of thing that makes a prediction so difficult. Even if you know all your parameters, unless you can forecast the El Niño accurately, you really can’t do a time to failure. You have to act as if it could happen much sooner than what a gradual extrapolation will produce.

The second thing I thought I would talk about is a more common kind of abrupt climate change that most people can relate to: drought. Again, it’s something that happens within just three to five years. You realize that you’re in a whole new state of operation. These droughts can last for centuries. This is not something that goes away in six years, like it did for the Dust Bowl.

East African droughts, for example, lasted many decades. In the last 1,100 years, three major droughts shrunk all the big lakes there, including Lake Nakuru. The ice age, in general, was a good time in east Africa, where the lakes were mostly full; there was expansion of the population; and there was consolidation of kingdoms. There would be a whole variety of things taken from history saying that this was a relatively good time, yet there were these three big droughts in the middle of it that lasted on the scale of a century.

By that scale, the Oklahoma Dust Bowl was minor. In 1956 the US Midwest experienced a severe drought. Yet Seattle was actually a little bit wetter than usual; the drought was not a country-wide affair. In 1934, it was not just the West in trouble; only southern Florida had more rain than usual. The rain fell somewhere else, probably out in the oceans. Fortunately, this whole period was 1932 to 1938. That’s why I say it was a relatively minor drought compared to the others.

Now let’s look back at decade-length droughts in the US Plains and the West back over 400 years, from 2000 back to 1600. The 1956 drought didn’t last long enough to count. The Oklahoma Dust Bowl had a substantial drought impact on multiple locations. The previous drought was back in the 1890s. The one before that was just before the Civil War, in the 1850s. The one before that was back at the time roughly when Isaac Newton was contemplating apples. The period around 1665, when droughts were occurring in Europe, was also when the American Midwest and West got into trouble.

Let’s consider widespread droughts that last on a century-long scale. The last 2,000 years of climate records, from tree rings, bathtub rings that lakes leave behind, and skeletal archeological evidence where people lived, show a total of five century-scale droughts. There are some areas, such as North Dakota, where these lasted for 700 years. We can see a number of periods where they’re widespread and last at least a century. This is the basis for what I was saying earlier. Even ignoring global warming, if we were to contemplate what we ought to be ready to handle in the 21st century, this is a 25% or so chance.

If you pick periods in the past that were a bit warmer and less subtle than usual, such as the Medieval Warm Period, that’s where four of the five widespread droughts occurred. If that’s our analogy to our current warming, you would have to say that the chances are more like 80% that we’ll be dealing with some extremes, rather than 25%. This is not good for an urban civilization like ours, where even in a farm state like Iowa, 96% of the people live in the cities. This is a kind of dependence on a just-in-time supply line that we may not be able to afford, given the ease with which you could probably disrupt this whole thing.

We’re perturbing the climate in big ways, raising the chances that our efficient, just-in-time agriculture could get caught in a climate whiplash.

We’re perturbing the climate in big ways, raising the chances that our efficient, just-in-time agriculture could get caught in a climate whiplash. That would be what would kill a lot of people, basically through famine, long before a change in temperature or anything
like that gave them trouble. The general principle in worrying about these kinds of effects, as I say, is time. If we had 500 years to adapt, it would be very different from a situation where we had to do something in five years. The world is just full of things where some are nimble and others are ponderous, and they interact with each other. For example, technology is very nimble. Ten years after it was realized there was a lot of potential energy there to be released in the nucleus of the atom, it was released in a big way.

On the contrary, if you take something like reaching consensus about what to do about something, say course corrections for our present situation, you’re forced to look for analogies like the European Union and the development of the Eurocurrency, which took basically 50 years – two generations of politicians – to pull that considerable feat off.

When you’ve got two things that are interacting and one is nimble and the other is ponderous, you have a problem that’s very different from just looking at the speed of one thing. When you hear, “How fast?” you’ve always got to ask, “Faster than what?” This is the basis of that memorable joke about the two guys being chased by a bear, where there are three speeds involved. The punch line is, “You don’t have to run faster than the bear, only faster than the other guy.” That’s the kind of situation in these complex systems, such as those David Wasdell described in the last talk, which you have to be very aware of.

... you really have to design society for an ability to be resilient, to bounce back, assuming something gets past our defenses.

I think that given all the sources we could get hit by that could cause famine, civil disorder, and a spiral of disease, you really have to design society for an ability to be resilient, to bounce back, assuming something gets past our defenses. Some things, when they get hit, fall over. But there are things that are designed so that they bounce back. You have to have strong righting reflexes; just as if somebody comes and slugs you in the shoulder, you go tilting over this way. If they get past your supports, you could take a fast fall. Your response has to be quick.

New Orleans comes to mind as a very good example of why you have to have preemptive responses, such as stationing all of your communications and emergency supplies in the area that’s going to be hit. This was done when Jeb Bush was running for re-election and the US federal government really went out of its way to make him look good. That didn’t happen in New Orleans. Particularly if we’re living close to the edge, it becomes very important to do this right.

The Internet reroutes around failure regions, by design. We certainly need to redesign our electrical grids, which are standing invitations to terrorists, to be that good at reconfiguring themselves. If you don’t include the economics of the reordering, all the rest of the precautions are going to fail. I keep asking every economist I meet, “Is any economist working on this problem of the emergency economy?” It’s the sort of thing we had in 1942 in this country when John Kenneth Galbraith, as I remember, sort of ran the economy. Market forces really can’t handle things like this by themselves. They’re very good at handling slow reordering of priorities – a great use of market forces. But they can’t do all the overcapacity, the stationing of supplies, and all these other things. They probably can’t do it in time, either, unless things go slowly.

That’s where I’m going to stop. Thank you.

SESH VELAMOOR (FACILITATOR): Thank you, Bill. Are there any questions?

GIBBS: You speak of the risk of drought leading to famine in North America and market forces not being able to manage overcapacity. Is there not actually a huge overcapacity currently of caloric supply?

CALVIN: We certainly ship a lot of grain abroad now. But reserving that for ourselves is going to get other people in trouble.

... isn't there already built in, by global and local markets, a tremendous caloric buffer against famine?

GIBBS: Also, the markets are set up to provide a fantastic array of choices in our foodstuffs, which also leads to another form of caloric overcapacity. So isn’t there already built in, by global and local markets, a tremendous caloric buffer against famine?
... certainly in the short term, before the market rearranges itself, I think you can get into substantial trouble with civil disorder perhaps more than famine.

CALVIN: Not, I think, for the reasons you mentioned. I'll mention one that does fit that model, and that is shifting your grain production to bread rather than feeding cattle with the stuff and only gaining back about 20% of your calories. That is to say, the production of bread drops to 50% – or something like that – of grain, when you just shift to eating it directly rather than feeding it to chickens, which gives you back about 25%. Pork gives you back about 15%, beef cattle about 20%. Those are all things that, in effect, market forces can affect.

My real question about some of these things that are going to last a long time – not just the Oklahoma Dust Bowl or the current drought – concerns the fact that it's going to be very disruptive. How much of the country gets into a famine situation on a long term, I don't know. But certainly in the short term, before the market rearranges itself, I think you can get into substantial trouble with civil disorder perhaps more than famine.

How much food is there in excess, essentially in store? There's less than a one-year supply on the planet at any one time.

MONTGOMERY: As I understand it, the resilience in this sense would be due to the buffering capacity. How much food is there in excess, essentially in store? There's less than a one-year supply on the planet at any one time. If you have an extended drought – 10 years, 100 years – and you don't have a buffering capacity to deal with it, then it will catch up. The other one is just the distribution question. We don't consume it where we produce it; that may be the big problem. Even with the perceived overcapacity at present, there's just not much of a buffer in the system.

CALVIN: Certainly we're not doing anything like the people in biblical Egypt. Joseph stored enough wheat for seven years; they had droughts pretty often. Not only did the people of Egypt have something to eat, they had enough extra so they made a fortune selling it to their neighbors.

MUSSEK: I'll accept your basic point that market forces can't handle these kinds of crises and abrupt changes. But I just want to point out that we have a lot of market distortions in the present economy. We don't really know what market forces are able to do. If water's so heavily subsidized, then you've got marginal areas that go into production.

CALVIN: It's heavily subsidized by fossil carbon. Look at all that oil it takes to run the tractors instead of having people doing the work, and all that oil that goes for fertilizer. There are just a number of inputs into the system that we treat as almost free because we don't consider that we're depleting them and ought to be figuring that into the equation.

POLAK: On the topic of famines, we have some pretty good examples of famines, most notable being in China with about 20 million people, and in the Soviet Union about the same number. Those were man-made.

CALVIN: Yes, they are good examples of political ineptness, or perhaps malevolence, that gets you into this kind of trouble. Let's take the Irish potato famine in 1848. This killed probably about a million people. It wasn't that they weren't growing enough potatoes to feed the people in Ireland; it was all contracted out. The British army enforced the contracts, and the people in Ireland got left with not much. Similar things happened in the Ukrainian famine of 1923, thereabouts, and in the Volga famine of 1933 or so. Those killed 2–5 million, if I remember correctly. The overwhelming example is, indeed, the Cultural Revolution period of 1959 to 1961, where the estimates range from 25 million to 50 million deaths. All these, or several of them – the last two, at any rate – are examples of major changes in economic policy. The institution of the first Five-Year Plan in Russia; the Volga famine; and the Cultural Revolution in the case of China's problem were situations undoubtedly exacerbated by droughts coming along; however, the major cause of famine was, in fact, the government being inept at managing transition.

POLAK: Perhaps the Irish potato famine is closer to what you're talking about. It wasn't stage-managed. The Ukrainian famine, I believe, is much higher than what you're saying. That was caused, really, by political forces. The Irish potato famine was technol-
ogy-derived because the farmers in Ireland had larger farms, and when the potatoes were introduced they could produce so many more kilos. The population expanded; the farm size got smaller; and then when the blight hit, it was disastrous. That was then complicated by bungled political management. That's sort of a prototype for what you're talking about, the kind of thing that can happen.

**CALVIN:** Famines are almost a separate problem from drought, I admit. Certainly, we know that droughts have been a big thing in the past, and undoubtedly are also capable of getting us into the same kind of trouble, in part, of course, because just as with New Orleans, government may just bungle the response. They may take sensible precautions and then they don't work because somebody is inept.

**ISHWARAN:** I have a different question. I guess you can't do much about what happens with the conditions that led to past famines and disasters. But recently we had a tsunami in my part of the world. I happened to be in Madras on the day tsunami waters came into the coast. The post-disaster relief efforts were phenomenal; it was very impressive. Of course, there was government bungling. In fact, there were also very funny things sent to our country. In Sri Lanka we received skiing boots, and those types of things happen. I would think that in the future, as long as we are hit by some global catastrophe, and all of us have one goal, disaster management relief work now has a track record for us to move things to places. Any thoughts on that?

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ties to be much more likely to panic in situations than they would if they knew that there was something in place with a good record of handling it. Preventing panic is a big issue.

WASDELL: In looking at resource sharing, the situation of scarcity in one area and plenty in another is one thing. But we have, at the moment in the Iberian Peninsula in southern France, not a drought, but a water shortage. It’s very interesting to see France not wanting to share water with Spain, thank you very much, because, “We haven’t quite got enough for ourselves. Spain can go fish for some.” You can see just that sort of shading of conflict around a resource at a very benign level. Then escalate that some, and that is what you’re talking about here.

The issue of very slow response in value system and human behavior is something about which we can also just think outside the box a little bit. The Berlin Wall came down as a tipping point. The wind blew, and it took a lot of buildup to that, but it happened quite quickly. I think the ending of British rule in India is another one in which pressure built up, built up, built up, and then reached the tipping point. Or the people-powered end of the Marcos regime in the Philippines was an interesting one, as well, where quite rapid change happened. It has reversed and come back to shame. The ending of slavery and the ending of apartheid, I think, also tipping points, to some extent. There are buildups and then quick changes in social systems. Perhaps we can look at how we can catalyze quite rapid value systems change.

CALVIN: South Africa is an interesting example. There was a futuristic planning conference in 1989 that brought together many of the people outside the country representing both what is now the government of South Africa and the previous government of South Africa to discuss the various scenarios for the future and what they looked like. I am told by somebody who was there that the white government of South Africa at that point realized there was really no viable option for continuing things the way they were; it would have just led to a lot of downhill. They really had to make some changes. That’s an example of how a rational planning process that’s consciousness raising enough for the participants can really change the way things proceed. We need a lot of this.

FACILITATOR: With respect to the example you cited, insofar as the need to react quickly is concerned, in the eventuality of some of these things happening, every one of those tipping point changes actually contributed to the slowing down of the reaction process. It would seem that liberal democracies don’t react as fast as a dictator might, or a totalitarian system.

MUSSER: I’m not sure I understand.

FACILITATOR: He cited the example of the British tipping point with the result of a liberal democracy in India, or the case of Marcos falling down and creating a democracy in the Philippines, or the Berlin Wall falling and what happened with the Soviet empire. In all these cases, the result is basically a liberal democracy. I’m pointing out that a democracy is not necessarily the fastest response system for global chaos situations like this.

MUSSER: It’s probably the worst response system except for all the other response systems.

FACILITATOR: That’s true.

MUSSER: All the examples you gave of famine …

FACILITATOR: … were also caused by the totalitarian systems …

MUSSER: … as Nobel laureate Amartya Sen says.

GIBBS: It’s a very interesting point, because when pressed to solve rapid problems, liberal democracies can be converted to autocracies very quickly. They can sacrifice the freedoms that they’ve enjoyed for security.
CALVIN: Some of these are simply changes in the system. For example, the US Congress periodically delegates some of its powers to commissions. The Military Base Closure Commission is an example where they did this to avoid having to take the heat themselves. A good example is the Securities and Exchange Commission where very substantial powers that are rather expensive to implement in many cases are delegated. The best example is the Federal Reserve Board, which is delegated the ability to raise credit card rates, raise mortgage rates, and change the currency supply—all sorts of things that, if Congress had to handle directly, they couldn't do, in part because they're not expert enough.

If we're ever going to have a carbon tax where the rate can be changed to try to achieve the unemployment goals, and so forth, that the Federal Reserve Board tries to do, we're really going to have to have a commission that's delegated the responsibility and given the expertise to do it. There are a lot of areas here where we don't lack for policy wonks who know enough to start grappling with the problems, but having to get the issues through that sieve of the Congress for each little step is what's going to take a long time.

FACILITATOR: Thank you, Bill. We will now conclude this session.
“Biosphere Futures”
Presentation by Natarajan Ishwaran

Dr. Natarajan Ishwaran is Director of the Division of Ecological and Earth Sciences, UNESCO, Paris, France. He oversees UNESCO intergovernmental scientific programs directly related to sustainable development, ecological sciences, and biodiversity conservation. Dr. Ishwaran is author of more than 25 publications in refereed journals and co-author of 2 edited volumes on ecology, biodiversity, and protected area management themes. Working often in political and diplomatic arenas, he endeavors to bring benefits to land use, conservation, and changes in land use that benefit human and other life. For more information on UNESCO’s Division of Ecological and Earth Sciences and the Man and the Biosphere (MAB) Programme, visit www.unesco.org/mab.

My area of interest is the relationship between land and people, and how that changes.

ISHWARAN: Good afternoon, everybody. I like to speak about futures rather than a future. Some of you in the options trading business will identify with that distinction.

My presentation will come from a person who is involved in the international arena to find some ways and means of influencing change on the ground using all kinds of possible means available. I work for the UN at UNESCO [United Nations Education Scientific and Cultural Organization]. We have to try to see whether we can, in response to global environmental changes, show some ways of coping, some ways of trying out things, however imperfect that may be. That’s the business I come from. My area of interest is the relationship between land and people, and how that changes.

When Bob Citron and I met about one-and-a-half years back and he asked me to come to this Humanity 3000 seminar, I thought, “How do I start thinking about 3000?” I like to think of the thousand-year frame in terms of a constellation of ideas and practices. I can talk about the thousand years of land use change and environmental history in Sri Lanka, my country. I can talk about how the land that was used for irrigation agriculture in one part of the country suddenly got left behind and everybody moved to another part of the country. There are reasons as to why that happened. Everybody is still speculating, but those things have happened over the last thousand years. I think it will be interesting to talk about those things for the next thousand years where it’s more projectional.

I still want wild elephants around when I die.

I like Einstein on that. I have his poster in my room with the quote, “Imagination is more important than knowledge.” The area I’m trying to get a handle on – not only because of my work – is wildlife conservation. I studied elephants in Sri Lanka. In the long ride to Adelaide to catch a plane to Perth with two Australians in the back seat and one other Australian driving, the person in the back seat asked me, “What is it that you want to see in the world?” or, “What is it you want before you die?” I said, “A) I want to have a good time; and B) I still want wild elephants around when I die.” So I have simple objectives.
What that pushes you into is to think of how we organize space in terms of what we share within human communities and with other life. I think one of the major crises we are going through, other than climate change, is also a massive loss of biodiversity.

We had the Conference of the Parties to the Convention of Biological Diversity meeting two weeks ago in Curitiba, Brazil. We were all there in big numbers. There have been various discussions going on, but that problem still remains. We are unable to reduce the rates of loss in any significant way. People are grappling with all kinds of possibilities, and the climate change only makes it even scarier as to how it's going to go forward.

I'm going to talk here about the spatial aspects of land use and land organization. Coming from AD 1000, if you're going to jump to 3000, there are a few things we didn't have in AD 1000 that we now have. I look at science as a major activity. For me, science is also an activity. This science, of course, can be seen in various ways, but now generates the best kind of verifiable knowledge that can be used for public decision-making. Whether things get done or not is a different thing; you can talk about that.

Science gives us knowledge that is tested and verified for use in public decision-making. However much you might be disappointed about developing country politics, there is an increasing number of decision-makers who are coming into high-level positions in countries like India, China, even my own Sri Lanka—a small place—who are beginning to realize that you cannot just ignore what you can know from existing information through data and its interpretation. I think that's a good trend. I don't know whether that situation existed in AD 1000. I think, based on what we now know, it seems to have not been there.

There's a whole process—I don't like the word “globalization,” but I don't know what else to call it—and there are also mechanization, industrialization, and technology. All these have science in them but not only science. Why is it that Americans produce the biggest cars? That's not only science. Why is miniaturization a favorite trend in Japanese industry? That's not only science. There are some other trends and tendencies that drive people to ask specific types of questions and search out those certain types of answers. I think those things are important.

We are clearly humanity-dominant now, compared to a thousand years ago. We are everywhere. Whether we like it or not, we have a major say in things. Elephants don't vote. There are people who support elephants who might vote and do things in favor of them. It's a major difference.

We have come to systems and ways of doing things that we have to take responsibility for; we cannot expect everything to just happen randomly.

We have come to systems and ways of doing things that we have to take responsibility for; we cannot expect everything to just happen randomly. Then there is this thing called capital. As I said, I'm not an economist, but it intrigues me. I'm a Sri Lankan of Indian origin, so I'm an immigrant in my own country, first generation, and I moved out already. My brother also moved out; he lives in England. We are a drifting family. My grandfather lived in Indonesia, actually. As individuals we had a bad feeling about fixed assets, houses, properties, and things like that. We all went for financial kinds of capital: financial assets, mutual funds, or things like that. That is important, I think, because different types of capital can be converted to different things at different rates of speed.

I think it was Dr. Calvin who said that more than 90% of Americans are living in cities. Cities have a lot of floating capital. How you use that capital is a very interesting—what can I say—option for the future. Whether you can use the capital in a way to connect back to land and some of these things we are talking about, such as fixing it back into land to minimize some of these negative trends, is an interesting question for us.

I'll share some statistics with you, although I'm not 100% sure that all these numbers are true. Dr. Calvin said more than 90% of Americans live in cities. But even worldwide, the trend is almost 40 to 60% of the population that live in cities. Cities make up only about 6 to 7% of the Earth's surface, at least from what I have read. It's a small area with a large concentration of people. Although I'm not 100% sure of the percentage of land use, agriculture, which includes forestry,
is still the largest cover in terms of what happens to land.

\[\text{... 11.5% of the total global area is supposed to be national parks, wildlife reserves, and similar kinds of areas.}\]

I don’t know what percentage of the global population stays dependent on that kind of land use. I’ve been involved in parks and wildlife reserves for a long time. A percentage given in the World Parks Congress, which happened in 2003 in South Africa, was that 11.5% of the total global area is supposed to be national parks, wildlife reserves, and similar kinds of areas. Whether they’re managed well is a different question, but the areas are there. That would give another 20–25% of land use that is not very fixed; it’s floating. There are degraded lands, or what I call “wild lands.” Sesh, is there literature about the word jangala, which is a Sanskrit word from which the word jungle comes? You may know Rudyard Kipling’s The Jungle Book. Jangala in Sanskrit does not mean a forest, not a wooded area; it’s more like open, uncivilized land.

SESH VELAMOOR (FACILITATOR): In north Indian languages, jangli means somebody who comes from the wild lands, uneducated and unsophisticated. The translation for the word jungle also means wild lands in north Indian language.

ISHWARAN: There’s a lot of land out there like that; not all of it is very intelligently or very wisely used. There are a lot of possibilities to play around with land in terms of trying new ways of not only conserving other species but maybe even going towards some of the more innovative uses coming up, like doing things for carbon sequestration. There are interesting possibilities for environmentally friendly purposes for which we would like to see whether we can reclaim land.

Bob Citron talked about long time frames and then came to a 30-year time frame. The Man and the Biosphere (MAB) Programme, which looks at land use management options, has been in UNESCO for more than 30 years, since 1971. It started as a program of interdisciplinary international cooperation for research, capacity building, pilots, and demonstrations and then a projected interface between humans and the environment. It started with seven ecosystem-centered projects; some of them have dropped out. We still have quite a lot of activities in the tropics, mountains, dry lands, coastal areas and urban ecosystems.

Project 8 was a project called Biosphere Reserves, from which my title, “Biosphere Futures,” comes, too. I’ll come to that. Then we also had other projects, which include looking at large dams, energy issues, pollution issues, environmental perception issues, etc. Most of them have dropped out for some reason or other; they didn’t continue on beyond 1992.

There are, throughout the world, about 482 sites that are designated as biosphere reserves under UNESCO.

As for this biosphere reserve project, the idea is to see whether we can harmonize conservation development and use research, monitoring, etc., in a global network of cooperating for countries and sites to achieve a balanced way forward with regard to social and environmental change. That was a simple idea that has been around now for more than 30 years. This biosphere reserve project tried to experiment with that in specific areas. There are, throughout the world, about 482 sites that are designated as biosphere reserves under UNESCO. One example is the Lanzarote Biosphere Reserve in Spain.

To explain what we mean in terms of land use management – the biosphere reserve scheme – I’ll give you a current-day status quo description, even though it’s changing already. Biosphere reserve land is declared as core, buffer, and transition areas. Core areas are mostly legally protected zones, which are surrounded by buffer zones and transition areas. What we are trying to do is to have other areas, other surrounding landscapes, that are connected to what goes on in the core zones. This idea has been around for a while. Now it has become a generally accepted view in the global protected area movement.

Another way to express the concept of biosphere reserves is to picture a bottle with all kinds of things in it. Then see the bottle broken and everything inside the bottle moving out. At the time when it was set up as a program, the biosphere reserve was basically challenging the idea of national parks and reserves at that time, which were being seen as contained in an enclosed space. One of the things the program did, I think, successfully, and now globally people accept, was place the emphasis on parks and protected areas,
working with local environments, communities, and surrounding areas, as one thrust that has largely come out of the biosphere reserve project and the Man and the Biosphere Programme. We tried to make that happen in particular places.

There are, at the moment, 482 places in 102 countries where we have such areas. This match between a scheme and what is there on the ground is not the norm; it’s more of an exception. It’s not easy. What happens more and more often is that this kind of co-buffer transition and neat separation of land parcels is less and less possible, because people are beginning to look at land use management in all kinds of ways.

This scheme came up in 1984. Already by 1995 there was another meeting where they came up with an idea, and they dropped the whole concept of relating it to parks and protected areas, and then started talking about landscapes in general. They said this should be applied to any area, whether there is a park and protected area in the middle or not. We haven’t adjusted the scheme to that kind of thinking. This is a big problem in international business. Things get fixed. You have an idea and you have an operation; people get jobs in it; things start to happen; and then it’s very difficult to change. Sometimes your clients are ready to change, but there might be secondary people who don’t want to change. That’s a management-government issue …

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I’ll give another example. Amboseli National Park and Biosphere Reserve is located in Kenya. It was a 27,000 square kilometer southern game reserve in 1906; it became a 3,280 square kilometer Maasai Amboseli Game Reserve in 1948; and now the national park is only 390 square kilometers. If you really want to talk about biodiversity conservation, you have to reconnect those 390 square kilometers with the surrounding landscape, because the Amboseli system depends on Mt. Kilimanjaro, which is in Tanzania, for some of its water needs, including a seeping water supply. There are transborder political issues to solve if you want to look at an ecosystem approach to managing this area. What the biosphere reserve idea has done is give that possibility. I’m not saying that it is happening there, but it at least made the connections in the ideas and in the minds of people who are beginning to realize it.

Two years ago I took this job as Director of the Division where this whole thing resides. I’m trying to push my staff and our partners by asking, “What is the evidence that this kind of thing is happening on the ground?” It’s all nice to say that conservation development, balance, and equation should be there, but what kind of evidence do we have that it is happening? Every context is different. How can we get that information? How can we see whether that kind of relationship is being built up? If it is not built up, what can we do? How can we help or support or do things with them in a way to make this happen?

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Yet, in the long run that might be the outcome. In the future the area might have to be managed under some incorporated system of the Maasai. It may not continue to be managed by Nairobi, which is far away. When it comes to actual practice, people were resisting it. They want to still have an established system rather than trying out a new system. We are trying to see what we can do, and how we can work with the combination of the Kenyan Wildlife Service, which is still responsible for the park, but the surrounding landscapes are under all kinds of authorities.

If you wanted to build connections between the park and the surrounding landscapes, what are the things you do with these administrative-managerial people?

If you wanted to build connections between the park and the surrounding landscapes, what are the things you do with these administrative-managerial people? We are trying to take people out of a certain mental box and make them do things differently. From my side, from the division side, this word reserve itself might be a problem. We are trying to move towards terminology that doesn't use the word reserve. There are some countries that are independently beginning to use the word biosphere, which has some history in the United States with regard to these artificial sorts of ecosystems that were built in some parts of the western United States as experiments to try out, where the ecosystems and their working relationship could be maintained in particular locations in artificially maintained environments.

What we are trying to do is test that model of thinking in different parts of the world as they do in space. We are trying to move towards a situation where we go away from the reserve mentality to more open landscapes where what we're trying to develop is context-specific, conservation-development equations. Our hope is that if we can demonstrate X number of such equations, then from there you can generalize what we can do at broader regional or global levels.

I like this quote from Rowena Young of the Skoll Foundation in a recent write-up on philanthropy and giving in The Economist: “In the world of social value-creation, context is king.” There are a lot of movements now that are going into this area of social entrepreneurship and social value creation. This can be done only in context-specific scenarios. We cannot fix the world in one goal; you have to work out examples of successful practice in a large number of cases or a number of contexts and learn from that. Evolution is likely to be more like the evolution of companies, just as private sector companies evolved in different contexts. Now you can talk about multinational corporations. There was a time you had only individual companies, and then they grew into this larger structure. We have to think about something like that; that's what we are trying to do.

To tell you the kinds of areas we now address, it's not any longer single national parks. For example, the Mata Atlántica Biosphere Reserve in Brazil encompasses the whole of the Mata Atlántica Ecosystem, which is the part that still remains from the original Atlantic forest ecosystem. The Atlantic forest covered almost the whole of eastern Brazil. Now only about 7 or 8% of that forest is left. The biosphere includes that 7 or 8% plus additional lands in nearby areas so that we can try to do things with them. If it is only protected parts, you can't do much. You need to have additional land parcels in order to experiment with things.

Interestingly, in this Mata Atlántica system is the Sao Paulo City greenbelt. It's a city surrounded by green space, a natural area. In this type of area you might want to experiment with carbon sequestration and climate mitigation financing options that contribute to maintaining the greenbelt and its ecosystem services. It's a place where you can experiment with that, and there are such things happening.

There are some other things that we would like to test. I went to Michigan State University, a US land grant college, for my Ph.D. It's a very interesting idea from 1862 that said that these land grant colleges must develop practical knowledge that would be useful as extension and outreach to farmers and others who are really doing work on the ground.

I think there are opportunities for those kinds of learning institutions to come up in these areas – biosphere reserves and similar areas – to test out practical things. Most of the time in developing countries, universities are located in cities. The areas we want to maintain, manage, and preserve are all located far
out. You need a research project to go there; otherwise, nobody travels to those areas. You might have to shift the face of the landscape and locate some of these learning institutions closer to these reserves and similar areas when you plan new development projects. That way, you start shifting around how land use and land cover look in different places.

Probably within the next thousand years you won’t have cities in the same places where they are now; they will be elsewhere. Similarly, universities and educational institutions will sit close to opportunities where you can learn in remaining parcels of nature. I think we should encourage that movement.

There is an article on “20 Ideas for 2006” in the *Harvard Business Review* – I think it’s the February issue. One idea called “Science in the Wild” talks about making scientific research move out of the laboratories and go to real-life contexts and experiments, not only as a pure science exercise but as an exercise where knowledge is being linked to applications. You don’t first work out something in the laboratory and then go to the application and then expand it; you try to make the connection at a much earlier stage. That type of work would be very interesting in these kinds of areas that we have promoted under this program.

Even some of the threats are being seen as opportunities. One of the ideas seen in that same issue is China as a green lab. Of course, it’s a scary situation if China develops along pathways that have been practiced elsewhere. It also gives opportunities to look at China as a place where you can develop technology and solutions that might go over the traditional development pathway and do things differently. How do you make that happen?

In UNESCO we have some opportunities that push such programs and launch such campaigns. In UN business there are events and activities around which you can build momentum. Last year the UN declared 2005 as the beginning of the Decade of Education for Sustainable Development. That is a decade where UNESCO provides leadership as the UN agency for education. We try to push these learning sites as part of that decade – not that it’s going to give solutions. If, by the end of the decade, we can have ten sites as good illustrations, in my view that would be a good step in the right direction.

Recently the UN declared 2008 as the UN Year of Planet Earth. I thought I should make this “Crossroads for Planet Earth” team aware of the UN Year of Planet Earth in 2008. That might not change the fate of Planet Earth for the next thousand years, but that gives you an opportunity to launch campaigns and events and activities that attract attention and build momentum to do things differently. For example, 2007 is the year of the poles [International Polar Year], polar ecosystems. These are campaigning sorts of opportunities by which, hopefully, you can build a different thousand years.

I’d also like to recognize Wayt Gibbs’s paper. I read the whole *Scientific American* issue from cover-to-cover – every page, no joke. I can show it to you; it’s in my hotel. I like the paper because of the diagram Wayt included: the “Farm of the Future.” I think, based on that, we tried to start designing a “Biosphere of the Future,” not in the whole biosphere sense but something like the Farm of the Future. We haven’t filled it in. We are imagining educational institutions being closer to the undeveloped areas. We are hoping that cities will be closer to these areas, also, because sometimes some of these natural areas are commensurable with cities; they are not commensurable with sugar cane plantations because elephants would eat all of the sugar cane. You might have to think differently about what is placed next to what inland if you’re going to manage and change things for the future.

In our imaginary diagram of the “Biosphere of the Future” there is a blank area. Actually, I asked a colleague of mine to illustrate the future layout. I gave her some ideas; she started doing it. She said, “I don’t know what to put here.” I said, “You should put in some ecotourism kind of things or recreational activities in the blank spot.”

**FACILITATOR:** You should put in the Foundation For the Future.

**ISHWARAN:** There’s an open space in the diagram of the future biosphere reserve if you want to suggest things.
I’m trying to change the schema I presented earlier. That’s a bit abstract for my taste; I think it has to be a bit more imaginative, since I believe imagination is an important thing. We are playing around with these kinds of ideas to influence our clientele and our partners to think differently about these things.

To Humanity 3000, I would say, “What’s next?” Thank you.

FACILITATOR: Thank you, Ish. Are there any questions?

KESAVAN: I would like to ask you about the Seville convention of 1995.

ISHWARAN: Do you mean the Seville Strategy for Biosphere Reserves?

KESAVAN: Yes. Don’t you think that’s the best way to reconcile the value and security of the people dependent on the forest areas, and also, conservation of whatever is still left?

ISHWARAN: I don’t say that it is the best but I think it’s a good document. It provided some directions forward for us to attempt things. I think some parts of the world where there are no designated UNESCO biosphere reserves have done better than some of the existing UNESCO designated biosphere reserves. I think it’s a work program that is adaptable to a lot of situations, as has happened. Now we would like to see: What’s the next step? The Seville Strategy is still dependent on legally protected cores with surrounding landscapes. We feel, increasingly, you can go into areas where there are mining areas and agricultural lands and build specific equations around some of these ideas.

The climate debate is intense here. Beginning in 2005 there is a European Climate Exchange based in the Netherlands. You’ll be surprised to know that it is a subsidiary of the Chicago Climate Exchange. We have been talking to some of the people in the Chicago Climate Exchange, because they have recently set up a scheme in Costa Rica where they have supported the purchase of carbon credits for land parcels that involved deforestation contiguous with natural forest land. They are even trying to acknowledge credit for what they call avoided deforestation, which are natural forests. That is still not possible under the Kyoto Protocol. Kyoto, at the moment, is largely based on credit traded in the industrial and power sectors. You can’t do avoided deforestation type of credit trading under Kyoto.

There is a small pilot project possibility under a biocarbon fund in the World Bank to experiment and do pilot projects. But Kyoto still doesn’t allow trading for land use-related carbon credits; it allows for industrial and power sector-related carbon credits only. Carbon credit trading is already going into billions of dollars in the European Climate Exchange, and it’s going to pick up. There are countries like Brazil where the private sector is moving into it in a very big way, also. That’s a financing opportunity that must be connected back to the land. You can’t go back to doing the normal thing that puts out more carbon. It has to be linked to other kinds of changes in land that could improve future prospects for climate mitigation, or climate change mitigation.

MUSSER: Bear with me; I’m not really familiar with some of the terminology. Can you describe what it looks like on the ground to be a transition buffer core zone? What is the practical, on-the-ground story? What’s happening there?

ISHWARAN: It depends which part of the world you are in. If you go to Europe, in the buffer zone you can have houses, cities, towns, agricultural areas, and all kinds of things. A lot of European parks and reserves are not really natural; they are wildlife areas at best. But they are also recovered landscapes, etc. For countries in Asia, buffer zones could be a mixture of rural and marginal areas with population living in one form or another, dependent on some of the resources in the legally protected core but also trying to practice other things.

In fact, I’ll give you an example, which is a bit exceptional – not normal – in a place called Chiangbaishan, China, on the border with North Korea. The central area is a park, but surrounding that are rural communities cultivating ginseng. They have deer farms, and they also hunt martens for skins, for the pelt. These are done in a very systematic manner; it’s organized business. That happens from the border of the park right up to about 100 kilometers outside where they trade the products and use them. Increasingly, the park is also building up a tourism industry, now that lots of people are going to China. There are a lot of variations. Normally, you don’t get a biosphere...
status designation from UNESCO if the site has no people and you don’t really have a human population-conservation interaction.

MUSSER: What’s happening in the buffer area that’s different from what’s happening either in the core area or just out in some unregulated area?

ISHWARAN: For the core area, most of the time the priority is nature conservation, wildlife conservation, some scenic area protection, and so on. In the buffer zone there will be activities that could happen anywhere else. Of course, it could be agriculture, forestry, and so on. In general, it’s not at the same level of economic intensity. If you have forestry, it’s not clear-cut forestry or vast acres of silviculture. It’s most of the time selective felling or local communities collecting medicinal plants or cutting one or two species for their own use, etc. The use element is not linked to very well-established markets or strong commercial forces. We’re not saying that it’s bad, but that’s normally the state.

POLAK: Could you say a bit about how you deal with potential conflicts or collaborations between preserves and agriculture?

ISHWARAN: Firstly, I don’t deal with it; it gets dealt with at the site level. There are places we come into and try to facilitate that, so it happens. Most of the time if there are conflicts, the groups sort them out by themselves in a lot of cases. If it comes to our attention, we would ask our national contact point under the Man and the Biosphere Programme for information: “What is happening?” “Why is there a conflict?”

Most of the time it comes to us as information from somebody who is outside the government system or somebody who is not happy with the way it is happening. It will come to us as a piece of information, and then we will find out what happened.

Then if the government folks, site folks, and rural population give us an indication that either UNESCO or some outside convening authority should come in there and play a neutral role, bring people together, and make them talk about it to arrive at some mutually acceptable result or outcome, then we facilitate that. We will organize an event where we bring these different groups together. If they want to do it themselves and they say, “Give us a moderator or facilitator,” we will do that. It’s a case-by-case situation. There are times when we can’t do anything about it because of the country situation, or the site situation is such that we can’t do anything. The strength of a group like UNESCO is its convening power. It’s seen as a neutral sort of arbitrator.

FACILITATOR: Thank you very much, Ish. We’ll now conclude this session and take a brief break.
Paul Polak, M.D., a psychiatrist and an entrepreneur, is the founder and President of International Development Enterprises (IDE), an organization that applies proven techniques to enable millions of poor individuals all over the world to work their way out of poverty. Based in Lakewood, CO, Dr. Polak and IDE’s work have been featured in National Geographic, Harpers, Forbes, and Scientific American, and recognized by the Ernst and Young Entrepreneur of the Year Award (2004) and the Tech Museum Award for the design of IDE’s low-cost drip irrigation system (2004). For more information on IDE, see www.ide-international.org.

POLAK: Yesterday when I realized that in this meeting we would be talking and thinking about a thousand years into the future, my first reaction was to throw up my hands and say, “That’s impossible.” In the exercises I did with George Musser in yesterday’s session, trying to think about 50 years into the future was very, very difficult.

But then in the cab ride back to the hotel, George reassured me a bit. He laid out the fact that some things are fairly predictable over a thousand-year pattern. One of the things that’s been reassuring to me in the discussions so far is the balance between changes in the physical context and the realization that Homo sapiens is probably the biggest wild element in the works.

I was thinking a little bit about what we know about people and how people work. I thought of several things. One of the things talked about yesterday was when Bill [Calvin] was asked, “Who was the scientist who had the biggest influence?” In response, he talked about evolution and Darwin.

One thing that has been an important part in the evolution of human beings is the capacity to hunt, kill, and eat, which, I think, has left a very important element in the makeup of humans that can contribute to tremendous achievement but can also spark violence. Because of my background – I was a refugee and was lucky to survive when I was five years old from the Holocaust in Europe in 1939 – I launched on a comparative study of holocausts. I started with three of them: the Nazi holocaust, the Turkish holocaust with the Armenians, and Cambodia.

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Then I realized patterns were very clearly similar in those three, but there were others. I decided to start looking at all of the holocausts in which at least a million people were killed. Very quickly I realized that would take forever because the list is unending. To some extent, I think the capacity for violence by man, or by humans against other humans, is in some ways a prototype to learn more about how violence against the environment – violence of all kinds – can take place.

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My work has been very much about – this is the other reassuring thing to me – learning a great deal about specific contexts at the grassroots. I’d like to present some of that material, with the hopes that there will be a crossover.
I’ll start with this. If you look back at the last thousand years, what can we learn from patterns of violence? Jumping ahead to the next 50 years, the focus of the article that I wrote for that issue of *Scientific American* was on water and agriculture over the next 50 years. In that arena there are two big challenges: How can we feed 3 billion more people without much expansion in water and land? How can we end poverty, since water and agriculture are central to both of those? One example of the kind of agriculture we’re talking about is on small farm enterprises.

In summary – I’m going to fly over vast areas here – feeding 3 billion more people can probably be done. I think it is quite realistic if we double productivity on large farms with good soils, using the same kinds of things that have worked in the Green Revolution. In terms of water, since there’s growing competition between industrial, urban, and evaporative uses of water, it’s necessary to double irrigation productivity. That also is feasible, but tough. For instance, we can store more water. There have been movements in Gujarat, India, for instance, where rainwater is harvested during the rainy season – the monsoon season – and directed through existing open wells into replenishing underground aquifers, where evaporation is very minimal. That kind of local action multiplied many, many times in a very large global effort could store much more water in a way that’s less destructive than big dams. I think, also, we have to continue to build a few carefully selected big dams.

Ending poverty is a little more complicated. And now back to the original theme. I’ll just touch on this, but this is a notion that I have: Violence and poverty are blood brothers. First of all, I think everybody sees that this is sort of self-evident [referring to a diagram of the interplay between poverty, wealth, powerlessness, and power.] One of the things that I think there’s a lot of evidence for is that violence, particularly, tends to occur at the extremes of these relationships. When you go from powerlessness to power, you have things like the 40 million people who really were murdered, in my view, in the revolution in China.

When you have wealth, with very ruthless pushing to maintain that wealth, you have the institution of slavery, which over 400 years murdered probably 40 million people, as well. I think there’s a lot to be learned from the extremes of violence about processes that apply to other issues in the world.

Now I’ll jump back to poverty. I want to start by saying that my context for this is based on over 25 years with this organization that I started, IDE, which has now about 600 full-time staff. They’re people pretty much all in developing countries. They’re in eight countries in sub-Saharan Africa and Asia – poor countries like Myanmar, Cambodia, Nepal, Zimbabwe, Zambia, Ethiopia, and Malawi.

Let’s start with what I would regard as common poverty eradication myths, and then I’ll focus my comments about poverty. First myth: We can end poverty through national economic growth. As many people have pointed out, a few hundred years ago most of the people in the world were poor. Now only 1.1 billion are in extreme poverty. The thing that has brought them out of it is the Industrial Revolution. The assumption is false that continued economic growth will end poverty.

This is a little bit like, as a psychiatrist, when tranquilizers came in and we started to find that people in mental institutions could go into the community. The first group went out quite easily. The second group went, and the third group. But in the end, the last group of people who had been institutionalized for 30 years – that was tough.

What the development economists expect by continuing growth is just as tough as getting the last group of people out of mental hospitals, and I’ll tell you why. The 1.1 billion people who earn less than a dollar a day now are systematically selected to live on marginal soils, on very poor farms, fragmented, and without water control for their crops. The idea that the economic activity on the coast of China will take the people out of poverty in the Yellow River Basin, while it may have some effect, is simply a false assumption.
The second myth is that we can end poverty by expanding the Green Revolution. In fact, some of the people at the center of the Green Revolution, which, by the way, has had a dramatic impact on increasing the world's food supply, now say the way to end poverty is to help small farmers improve grain productivity and sell the excess. That means a one-acre farmer in India is expected to compete with a mechanized, heavily subsidized, 3,000-acre prairie wheat farmer in Canada, which is absolute nonsense. The evidence is very clear. India has 200 million people who are hungry, but India has been a net food exporter for some time.

A third myth is that we can end poverty by donating money to the poor. This is my quarrel with the UN movement now. The theory is that people are too poor to work their way out of poverty, so we have to give them all kinds of resources and that will establish the basis for a marketplace, which will end poverty. That won't work, either; I've tried it. With “business as usual,” the Millennium Development Goals on hunger and poverty will never be reached.

Here's the evidence. If you look at the percent of population living in extreme poverty, the numbers are more pessimistic. Over about a ten-year period (1990 to 1999) there was very little change in South Asia and an inconsequential change in sub-Saharan Africa. The population growth over the next 20 years in sub-Saharan Africa is forecast to be so great that in absolute numbers, unless we change our approach, I think poverty will actually increase. Here are the facts: 800 million of the world's 1.1 billion people who earn a dollar a day or less earn their living from very tiny farms. I'm talking about farms that are typically one acre in four or five scattered plots.

Thirty years ago, the maximum average farm size in developing countries, such as China, Pakistan, Nepal, and the Democratic Republic of the Congo, was between 1.5 and 13 acres. In the period from 1990 to 2000 the average size of these farms had decreased to somewhere between just 1 and 8 acres. The trends for decreasing farm size are basically caused by population growth. The population growth that we were talking about earlier this morning is very clearly disproportionately centered in developing countries, poor countries, and poor populations. That gives you an idea of both the average farm size and the trends.

In a practical sense, small farmer prosperity is the key to ending real poverty. It means, in effect, increasing poor people's income from farming as a first step.

In a practical sense, small farmer prosperity is the key to ending real poverty. It means, in effect, increasing poor people's income from farming as a first step. What they do after that is up to them. The mission of our organization is to increase the income of 30 million families by US$500 a year (net), forever. In order to accomplish this, nothing less than four revolutions are needed, in my opinion. All of them are centered on one-acre farms: (1) a revolution in water, providing affordable small-plot irrigation; (2) a revolution in agriculture, with very different situations on quarter-acre plots versus crop rotation on thousand-acre plots; (3) a revolution in design, where a whole host of effective, income-generating tools are designed for poor people we treat as customers – not recipients of charity – who we expect to pay for every technology that we provide at a fair-market-value price; and (4) a revolution in markets, about which I think there's a great deal we don't understand, especially rural markets that economists would call riddled with market failure. I’ll go into this a little bit.

Regarding the revolution in water, water is the key entry point for increasing smallholder income. What we've done is design a whole host of affordable, small-plot irrigation devices that include treadle pumps, small drip systems, and a system I call the NAWSA MAD, which is Aswan Dam spelled backwards. It performs all the functions of a large dam and distribution system on a one-acre farm. The key principles of design for these systems designed for small farms are affordability, divisibility, expandability, and profitability.
Affordability is obvious. Divisibility means getting things down to the size that both fits one-acre plots and is small enough to be affordable. Expandability means making each of these things expandable, like a LEGO® set, so a poor person or poor family can find an affordable entry point. By the way, all of these technologies show a 300% net return on investment. If the entry point is $30, the family earns $100 after expenses in the first growing season, and then they can expand. You can eventually go to whatever size you want. Profitability means having a profitability threshold that offers at least 100% return on the poor person's investment; virtually all of the things we have done offer 300% return.

The second thing is design, which I define as practical problem solving. At the present time, 90% of the designers in the world work only for the richest 10% of the world's customers. A revolution in design is needed to reverse this silly ratio. The kinds of things that are underway and practical include $2 eyeglasses for masses of people; a $3 drip irrigation system, which we are selling; and a $7 household water filter, which we are selling in Cambodia. We are ready to launch a company to mass market a $10 to $15 solar lantern, and a $50 computer is feasible. One of the problems of housing in the world is that a lot of these poor people have land, yet their houses have no sales or loan value. I think it's possible to design a $100 basic house that can be expanded with real market and loan value.

The revolution in agriculture would address the same basic kinds of processes as in modern agriculture, totally centered on the problems of one-acre farms and quarter-acre plots. The kinds of things I'm talking about are developing new varieties of cash crops optimized for smallholdings, and improving farming practices on small farms for labor-intensive production of high-value crops.

I mentioned markets. We really need some basic new understanding of why markets in rural areas in developing countries are so inefficient. The practical strategies that we've implemented to end poverty for a lot of people are based on creating new markets and actually building the structures brick-by-brick in developing countries.

Now I'll give one example: the treadle pump that was also described in the article. A treadle pump is sort of a StairMaster® device. It costs $8 in Bangladesh. Put it on a tube well and it costs $25. We've sold some two million of them in Bangladesh by activating a system of 75 manufacturers and 3,000 village dealers. We train 3,000–4,000 village technicians by giving a three-day course with a little diploma.

We spent 75% of our time on rural mass marketing in an area with no media. We hired a group of troubadours who composed a song about treadle pumps. We had a treadle pump model, and a guy handed out brochures saying, "Go to Honest Sam's to get your treadle pump." These people performed at village markets.

In Bangladesh we produced a 90-minute entertainment movie each year. We had the top male lead in the country, the top female lead, and the top director, which cost about $25,000. This was a 90-minute movie with the treadle pump as a star in the plot. It was all done in local cultural values. A Bangladeshi movie has a wedding, a near suicide, a funeral, and lots of singing and dancing. We had some of our marketing staff in Bangladesh create a plot in which boy meets girl and they're going to get married, but her father is poor and can't afford a dowry. She falls into the clutches of a dowry bandit. There's depression and near suicide; all of this occurs in 90 minutes.

At the high point of the movie, the movie stops, and the dealers who have organized customers there put people on model treadle pumps, using that as an opportunity to make a sale. Then the movie commences again. A friend tells the father about the treadle pump; he buys a treadle pump and makes money. The couple gets married and lives happily ever afterward.

This is run with a generator in an open-air setting, with an average audience of 3,000–4,000. We play to a million people a year. Here's something about impacts: 2.1 million treadle pumps were sold. Poor families in Asia and Africa invested $50 million of their own money and increased their net income by $210 million a year, forever. It would have cost about $2 billion to put the same one million acres under dam and canal irrigation.
We look at our small farm customers as entrepreneurs.

I’ll just say a little bit about this. We look at our small farm customers as entrepreneurs. I can tell you for sure, from my interviews, that the Number 1 most important thing they’re interested in is increasing their income, because with that they can do whatever they want. Looking at a small farm enterprise, the first thing we do for each agro climatic zone is recommend four or five high-value, labor-intensive, non-mechanized cash crops that are likely to have sustainable market demand. In Maharashtra, India, for instance, we’re recommending pomegranate and sweet limes. Some farmers are growing eggplant – eggplant is very popular – some farmers are growing roses, and so on. With fruit trees we interplant vegetables. We use low-cost drip irrigation systems. Those drip systems are one-fifth the cost of the Israeli standard drip systems. We’re learning all over the world that farmers can add about $500 to their net annual income on a quarter-acre of selected crops, but you have to select the crops for each area, and you have to do market analysis.

Farmers, themselves, have invested $100 million of their own money, and their increased net annual income is $300 million a year.

Let’s take a look at the results of IDE’s work over the first 25 years: We have spent $100 million. All of these figures, by the way, are very conservative. The results are actually better. Farmers, themselves, have invested $100 million of their own money, and their increased net annual income is $300 million a year. We hope to do much better than that over the next 25 years.

Here is a little indication of how farmers spend their money, their additional income. This is from a survey in Nepal. Food is big. If the farmers grow vegetables, they obviously eat some, but they also invest in improving their farming. Education is very high on the agenda. Unfortunately, in many countries income is disproportionately spent on sons because of the dowry situation. Festivals are another area of common expenditure. Home improvements are down, but that doesn’t match what I’ve seen in the interviews I’ve done. I think improving the home – going from a thatched roof to a corrugated tin roof – is a very common kind of investment.

… the key to practical solutions to dollar-a-day poverty is increasing the income of dollar-a-day farmers. The private sector marketplace is the way to make it happen.

To summarize, the key to practical solutions to dollar-a-day poverty is increasing the income of dollar-a-day farmers. The private sector marketplace is the way to make it happen. Dollar-a-day farms are very small. Smallholders can create wealth for themselves by exploiting their comparative advantage in the marketplace, which is that they have the lowest rates in the world: five to ten cents an hour. A key first step is gaining access, opening access to affordable small-plot irrigation. Radical refocusing on agriculture markets and design is essential to optimizing smallholder income. And, finally, without a revolution in development theory and practice, the Millennium Development Goals on poverty and hunger will never be reached.

Thank you very much.

FACILITATOR: Thank you, Paul. Are there any questions?

KESAVAN: That was some good coverage. But as you know, in our foundation we need to bring several different technologies, not just one, namely water conservation, which is only one small aspect. We have gone a long way in terms of bringing two things. One is how to make use of natural resources. In fact, Dr. Polak mentioned that in India, though we are in a position to export food, there are 200 million people who are starving. That is very true. But you also know the reason there. From a famine of food, we now have a famine of employment. If you don’t have money in your pocket, you can’t buy food. That is the cause of hunger that has been inflicted upon 200 million people.

Therefore, in our strategy for the humanity that is at a crossroads in all of the developing countries, including India, you have to come up with the strategies that are able to empower the local people to be able to stand on their own feet. There must be a
continuous chain, a sequence of steps in which you produce crops from very small farms, as he rightly said, but then it has to also have the integration of certain technologies to make sustainable use of the natural resources available there. Knowledge empowerment is, again, important. I’m going to make a reference to that. And then market trends – that is where globalization is not in a very comfortable position for some of these countries.

In other words, I am happy that so much has been done, but I think a lot more needs to be done to be able to sustain what gains are being made.

**POLAK:** Just very briefly, I’m not sure I understand if there is any area in which we disagree. After all, about 800 million of the really poorest people make their living from farming, so that’s where I would start. That doesn’t cover everything. There are 300 million in urban areas. I totally agree that the problem is not hunger; it’s money to buy food with. If we can increase the productivity of small farms and the income generation, it will have a profound effect, an impact, on all of these other things. I happen to think, from watching small farmers operate, they preserve the environment much more than big farms do.

**KESAVAN:** Yes, that’s true.

**POLAK:** Things like growth in cities, all of those projections are based on current trends. If it’s profitable to stay in the country, in the agriculture, in the rural areas, then there are many other jobs that are created around small farm prosperity. I don’t see any disagreement in what you said.

**KESAVAN:** I said that yours was a very good paper, but I differ with this conclusion: “Access to affordability is the first step.” I’m afraid that you have to have concomitantly several steps. There is nothing called the first step, the second step. You have to have an integrated approach to ending poverty, whether it is ten different steps or more; all have to be simultaneously initiated.

**POLAK:** That may be your impression, sir. But I’m talking about what 3,000 farmers have told me. I’m a biased observer, so I could be wrong. But what I’ve learned from those interviews is that, by far, the most common first step – not always – is access to affordable water control for the crops.

**KESAVAN:** Thank you.

**ISHWARAN:** You said that there is still room for possibilities for building a selective number of large dams.

**POLAK:** Yes.

**ISHWARAN:** What would be the first dam you would build if you had all the money?

**FACILITATOR:** On the Amazon.

**POLAK:** The Amazon is great, but there are no people there. That’s the only problem. There’s a lot of water, though.

**FACILITATOR:** Water going to waste.

**POLAK:** What I’m talking about, really, is a process rather than prejudging the conclusions. But I think the World Commission on Dams came to some pretty reasonable conclusions. The building of big dams in the past has been really mindless. But I think there are procedures now for determining the proper balance between dislocation in the environment and the need for storing more water.

**ISHWARAN:** Maybe I should rephrase the question: Which country do you think has the best possibility of going into a large dam construction process?

**POLAK:** I’ll still pass on the question. I don’t think I’m enough of an expert to say that. I do know there are a lot of small water storage things that, if multiplied, would take away that need. I’m not enough of an expert to give you an answer to that question.

**MUSSER:** Can you tell us more about the market inefficiencies you mentioned? How are the markets inefficient? Maybe give an example of one.
Markets have inefficiencies; the inefficiencies keep changing. Entrepreneurs step in and create wealth by exploiting the gaps.

POLAK: First, here’s a question. I used a treadle pump as an example. If markets operated efficiently, why did it take an outside organization to come up with a treadle pump? And why did we have to invest a lot of energy into recruiting each of the components of the market system, such as a dealer network? Why did we invest in the marketing?

I can give you some of the answers, which are self-evident: corruption, lack of protection of intellectual property; lack of capital. There are all kinds of reasons. But the reality is that the treadle pump is only one tiny example. Markets operate through a symbiotic relationship between entrepreneurs and the market. Markets have inefficiencies; the inefficiencies keep changing. Entrepreneurs step in and create wealth by exploiting the gaps. That process happens very rarely or perhaps not at all. Part of it is that some of the best minds in the world – I hate to keep using India as an example – and the people who graduate from the best engineering schools in India are really interested in coming to Silicon Valley.

Market opportunities, in the end, are huge. I think there’s maybe a $50 million market potential for $15 solar lanterns. Why isn’t somebody working on that? Not only are they not working on it, they don’t see it as an interesting problem. I went to Israel and talked to the leaders of the biggest drip irrigation in the world, trying to con them into serving that market. No dice. Jain Irrigation, which is the biggest drip irrigation company in India, no dice. They don’t see it now as a viable market. I happen to believe that there is a huge market. Eventually, these problems will be addressed because there is profit potential in them.

FACILITATOR: Perhaps there’s also an orientation issue. I think most of these issues in these countries are looked on as a top-down issue as opposed to being a solution that is based on a bottom-up approach, which is essentially what you’re talking about in looking at the individual farm rather than devising some agriculture policy at the central level that percolates all the way down to farms.

Part of the issue is that people are not connected to the problems. When given that opportunity, a lot of them are intrigued and can make a huge contribution.

POLAK: In fact, what I found is some of the people from the West are fascinated by these problems. When I take them to the village, they come up with tremendously useful contributions. That’s why I was talking to you about getting your kids interested, because these are not rocket science problems. They’re fairly obvious, practical problems when you look at them. We’ve been getting Western students connected to these problems, and getting top Western designers in all fields involved, not just engineering. A guy named Jack Keller, who was a top person in irrigation when he retired, has been having a profound impact on the design of affordable irrigation equipment. Part of the issue is that people are not connected to the problems. When given that opportunity, a lot of them are intrigued and can make a huge contribution.

FACILITATOR: If I may, I’ll give you another example. I visit a rural area around Bangalore, India. There is a school in another rural area that I visit every year, in which 2,500-plus kids are being educated all the way from the lowest grades to high school. Every November or December when I go there I ask the kids, “How many of you would like to go to the USA?” Almost every hand goes up. On the other hand, if I ask, “Is there anybody here within the neighborhood available to fix an electrical failure in an appliance?” There is no one available. “Is there anyone here who can fix a two-stroke engine?” All over the place, whether in rural or urban India, there is nothing available.

Talking about market approaches, one of the things I suggested to the principal of the school there was: “Look, you may be graduating 200 high school students every year. Ten of them are going to find a job. Maybe five of them will go to college. The remaining 90% are going to be walking the streets, contributing to the hidden unemployment that exists. Why don’t you start a vocational training aspect to the educational system?”

Oddly enough, two years ago she took me up on it. I contribute somewhat to the teaching and the training of these students. Now they’re graduating between 60 and 100 students every year – actually, every three months. Employers come to their doorstep to hire
them, because pipe fitters, welders, two-stroke engine repairmen, appliance repairmen, and pump repairmen are simply not available.

*Addressing poverty doesn’t necessarily eradicate the violence. There are other causes of violence that cause ripple-on effects into poverty.*

**TREDER:** Paul, you started with two blood brothers, violence and poverty. You drew a diagram, which is a rich one, of the interplay between violence and power and powerlessness. Your interventions here have been in the poverty area and the catalysis of emergent self-sustainability. How does that affect the violence-poverty brotherhood when some of the violence eradicates the capacity to sustain small sustainable farming? It doesn’t seem to me that the relationship between the brothers is all one way. Addressing poverty doesn’t necessarily eradicate the violence. There are other causes of violence that cause ripple-on effects into poverty. How do you balance the approach to both blood brothers?

**POLAK:** I hope you didn’t get the impression that I was suggesting that what I’ve been doing is a solution to all of it.

**TREDER:** I was hopeful.

*Some of the biggest examples of violence in the world in terms of the lives of poor farmers are the obscene agriculture subsidies in Europe and North America.*

**POLAK:** Some of the biggest examples of violence in the world in terms of the lives of poor farmers are the obscene agriculture subsidies in Europe and North America. I’m not sure I know how to do anything about that. It is possible to help poor people move out of poverty. You have to find ways to operate politically, of course – we’re working in Zimbabwe – in order to make that happen. I’ve just chosen to do the things for which I can see a practical solution. That’s not to say that other things aren’t very important as well.

**FACILITATOR:** Thank you, Paul. With that, we’ll go on to the next part of the session.
“How Should We Set Priorities?”
Presentation by W. Wayt Gibbs

W. Wayt Gibbs is a Senior Writer for Scientific American, where he specializes in science and technology areas that raise social issues, are under intense debate, or are subject to some sort of controversy. Known for considering “far out” or even unpopular ideas, Gibbs's work has been honored by the AAAS Evert Clark/Seth Payne Award for Young Science Journalists (1995 and 1998); the Wistar Science Journalism Award (2004); and the AAAW Science Journalism Award (2005). Gibbs was awarded a Knight Science Journalism Fellowship in 1999–2000 at Massachusetts Institute of Technology, where he also completed a mini-fellowship in brain science in 2004. For more information about Scientific American, please visit www.sciam.com.

... there are so many things that pull societies in different directions. There are so many actors who try to tilt the playing field in one direction or another.

GIBBS: I'd like to thank Paul [Polak] for priming the pump, as it were, by providing a great case study in his presentation of one way in which market forces can be harnessed to solve some of these global issues, at least in local and regional areas.

My role in this special issue of Scientific American that we published [September 2005] was to look at this question of priorities. It's an inevitable one, of course, because there are so many things that pull societies in different directions. There are so many actors who try to tilt the playing field in one direction or another. We have companies that are always interested in jobs and profits; politicians, likewise, interested in the creation of wealth in populations; voters who have their own ideas; and lots of pressure groups.

Then we have the academic community, of which we have many representatives here, who provide great insight into the science and outline the limitations on what the possible futures are. Then there are the media representatives, who do a good job of just sort of fumbling around and mixing all this up and getting people's opinions wrong. But certainly an emerging trend that gets a lot of attention is how the world might make better use of market mechanisms to address some of these issues in ways that governments have tried and failed – or simply failed to try – to address.

... markets can operate much more efficiently than governments in directing resources to where they will have the most – and the most rapid – impact …

Of course, we're probably all pretty familiar with the theoretical benefits of things like cap-and-trade systems, with the idea being that markets can operate much more efficiently than governments in directing resources to where they will have the most – and the most rapid – impact; and that markets can be, in some ways, more sustainable if you set up something like an exchange, analogous to a stock exchange, which can last for generations or centuries. The rules of the game change slowly, in contrast to political systems that have administrations changing over on subdecadal scales and one administration undoing a lot of the policies and decisions made by the administration before it. Look no further than the recent history of the United States for examples of that.

Markets are seen as sometimes being very good for handling certain kinds of risks and uncertainty, and finding ways to rationally, or more or less rationally, price things or find mathematical representations of uncertainty and risks that, again, affect the flow of resources in ways that have desirable outcomes.
Because there are real money and real livelihoods at stake, markets are very good at readily assimilating new, high-quality information and hence paying for good information, too. These are things that are sometimes problematic in political systems.

Maybe the most important feature of market mechanisms, of course, is that they are analogous to science itself; that is, they can provide a consensus-building mechanism in the sense that they allow translation of values. They allow communities who have different value systems to trade. Perhaps I don't care much about my backyard, which happens to have a lot of endangered species in it. But I care very much about those butterflies that live back there. We can come to some arrangement, probably, where I'll keep the butterflies for you, and I promise not to kill them all, and you can give me something that I would like, like a new car or something. Monetization of values is powerful, but very difficult.

In the United States advocates almost unfailingly point to one example to show that this can work. It's the US sulfur dioxide trading program, which was passed by Congress about 15 years ago, allowing power plants and large emitters to trade their emission allowances – essentially, their permits to pollute – and thus to elect not to use those but instead to give them to someone else. Or they could simply improve their equipment, and then they would have leftover permits they could sell as a source of income.

Just because we don't talk about acid rain anymore ... doesn't mean the problem has actually been solved ...

It looks as if it worked pretty well. Over time the pool of emission allowances available for the whole community of industry polluters dropped. It was reduced steadily by the Environmental Protection Agency, and then emissions dropped, too. This is widely credited with solving the acid rain problem. Just because we don't talk about acid rain anymore, however, doesn't mean the problem has actually been solved; we'll come back to that point later.

The notion of "green" market mechanisms, though, especially in the past five years and certainly over the last decade or so, has been extended to lots of other areas. We're familiar, all of us, with the Kyoto Protocol and the market it established for carbon dioxide and other greenhouse gases. This is now trading in the European Union Emissions Trading System, which is swapping credits on the order of 250 million tons of CO₂ equivalent a year.

To put that in perspective, analysts, who now do very good analysis of emissions in Europe, project that the gap between the actual permits available under the Kyoto Protocol treaty to countries and the amount of emissions that they are on track to emit is somewhere between 3 billion and 5 billion tons per year of CO₂ equivalent. The trade, which is mostly, at this point, swapping among power plants from one country to another, is a very small fraction of the marginal decrease that they're looking for.

The idea is that rich countries will fund projects in poorer countries ... to either prevent emissions ... or actually collect and stop them.

The mechanism that has been set up, of course, to compensate for this problem in Europe and to generate reductions in emissions is called the Clean Development Mechanism (CDM). The idea is that rich countries will fund projects in poorer countries around the world to either prevent emissions that would otherwise be incurred or actually collect and stop them. An example is a landfill-to-methane energy project in Brazil, a very large one, which collects the methane being emitted and uses it to generate energy. The number of those projects approved so far amounts to something like 30 million tons of CO₂, a very, very small amount. Later we'll get into some of the problems that have resulted in this.

Another area that's been experimented with is watershed services from forests and wetlands. An example of this includes, here in the United States, the National Wildlife Service, which has met with very poor results just simply trying to regulate the destruction of wetlands. They required that developers mitigate that destruction by restoring wetlands elsewhere, and decided to allow these "banks" to be
created. You'd have entrepreneurs that would go out proactively, find a wetlands, restore it, and get these credits. They'd become fungible; they could sell these credits to developers who now don't have to deal with that hassle. It's seen as an improvement because you now have professional wetland restoration groups who have pretty good ecologists working for them. They gain experience doing it, so they get better and more efficient at it. It's certainly a boon for the developers who can go out and buy what they need to satisfy their permit requirements.

However, in the United States, this has generated something on the order of 23,000 acres of restored wetlands; it's tiny. In Mexico there's a larger example, where the government has set up a program to pay landowners, especially in mountain area lands in watersheds, not to log their lands, not to graze their cattle on them. They will pay them something like $15 an acre per year. So far, they've managed in this way to gain control of these waivers over something like 600,000 acres, I believe. That's the total they've got, which is roughly equivalent to the amount of acreage deforested annually every year in Mexico. So again, a small drop in the bucket. There are reasons to believe that it will probably be hard to expand that program. I'll talk about that in a minute.

… in Costa Rica … the government and others have bought, essentially, the development rights to valuable habitat to protect it.

A third example is habitat conservation. Here's where it starts to get much trickier. The best example is probably in Costa Rica, in a program where the government and others have bought, essentially, the development rights to valuable habitat to protect it.

Then in fisheries there are some interesting examples. In the United States, in Alaska, the halibut fishery collapsed, and the fishing season was at one point down to 48 hours for the whole year because the policing had gotten so bad. By switching to a fungible permit system, the halibut fishery was able to recover, and it's now up to something like a 265-day season.

In New Zealand they've taken this much further, covering now some 93 species through a tradable quota system. They've demonstrated that not only does this allow them to better monitor how many fish are taken by creating a census for accurate reporting of fishery hauls, but it also allows them to more easily ease fishermen out of the business by offering them a way to retire gracefully; they simply sell their quotas. The fishers can build up a quota and then just sell the whole thing rather than fishing that year, and, boom, they've got a big nest egg for their retirement. They can actually reduce the population of fishers and, in that way, ease the burden on the fisheries across a wide number of species. This expansive, tradable quota system is pretty highly developed in New Zealand.

I mentioned the CDM projects and the CO2 trading arena. If you look at a map of the Emissions Trading System from the ETS website [www.emissionstrading.com], you can see where they are so far. India is a very popular place for this trading system to happen. It's also throughout Latin America and China, which has the biggest projects. A lot of these right now are really low-hanging fruit. Factories that would otherwise be emitting very high CO2-equivalent-valued greenhouse gases (that are not CO2) are usually emitting HFCs. You can refrain from producing a small amount of those and get a big impact.

… in the future, a farmland might generate only a minority of its income from the crops grown there.

Looking out towards the long-term future, people enthusiastic about this idea have proposed combining these various market mechanisms so that in the future, a farmland might generate only a minority of its income from the crops grown there. Instead, they might have a very diverse portfolio of products they can offer to what could be international or global markets. They might be selling biodiversity credits to a conservation trust, essentially a nonprofit; CO2 offset credits to industries that have to have them; renewable electricity credits, actually the megawatts they generate from wind or solar. Maybe through sustainable timber programs being set up that actually give the imprimatur of some auditing organization certifying timber as being sustainably grown, they can sell into specialty markets that command a premium price. Through watershed protection they can, perhaps, be compensated by urban water markets for not filling in the wetlands that border the farm. They, of course, would also have their standard agricultural commodities to sell.
These scenarios are widely discussed among the optimists, and it really is a surge of optimism that one sees. George [Musser] mentioned the State of the Planet conference held in New York at Columbia University last week. There was a whole panel there on exploiting market mechanisms. Abby Joseph Cohen is an investment analyst who noted that the CERES [Coalition for Environmentally Responsible Economies] group – basically a consortium of large investors and corporations that works with the UN trying to work out ways for environmentally responsible sustainable investment – has, in recent years, grown from representing something like $300 million to now representing on the order of $3 trillion worth of investment. That’s a lot of money that is increasingly looking for opportunities to play in these new games – meaning markets – that they sense are going to be set up.

What are we actually buying here?
A species? A species year? A reduction in the probability of extinction of a species?

There are some pretty steep obstacles to making these markets work, however. There are economists who have analyzed this who note there are a whole set of prerequisites that you need for markets to work effectively. Some of these prerequisites, undoubtedly, are not met in developing countries. That’s one of the reasons that they have persistent poverty. It’s not easy to see how they’re going to get set up to enable these markets that are novel even from a Western, rich-country perspective. One big problem is having well-defined products. You’re not selling widgets here; you’re selling abstract products that are highly variable. My backyard is not the same as my next door neighbor’s backyard. What are we actually buying here? A species? A species year? A reduction in the probability of extinction of a species?

In biodiversity, it’s very difficult. In carbon, it’s relatively easy, because carbon is globally fungible. It goes into the atmosphere and it affects us all. We also have good chemistry to equate all different kinds of gases via their greenhouse potentials, but that’s the exception rather than the rule.

You need, of course, reliable suppliers. That means you need to be able to audit your suppliers. You need to be able to know that they’re not lying to you, that they’re not saying that they’re refraining, for example, from logging the land, but actually are logging the land and just cheating. Those require cultural institutions that are often not present or not reliable in many parts of the world where you’d want to exploit these markets.

Players simply will not participate if they fear that their investments will get stuck and they won’t be able to get out.

Robust demand seems as if it might be one of the easier criteria to satisfy. As I mentioned, there’s a lot of money that seems to be aiming in this direction, but you’ll need a trusted and transparent exchange, someone to stand in the middle. This is a long-term institution, equivalent to a stock exchange that can be trusted by all parties to be fair. It’s no trivial matter to set up something like this. That almost has to be done on an international level. Players simply will not participate if they fear that their investments will get stuck and they won’t be able to get out. You have to have enough volume that you can ensure there’s going to be liquidity and competition. This presents, of course, a classic chicken-and-egg problem.

… it’s a very interesting … question as to whether this can happen quickly enough … before this window we’ve been talking about closes.

It’s a bit of a pickle, in my opinion. Clearly, harnessing human self-interest and the human instinct for competition and acquisition are extremely powerful forces and one way to go. But, it’s not at all straightforward. How do we get from here to there? I’m with Ish in saying that what we need is a lot of experimentation at all different levels. The expectation should be tempered. It’s probably not something that can happen very quickly to accommodate an abrupt change. I think it’s a very interesting and open question as to whether this can happen quickly enough to make the difference that we need before this window we’ve been talking about closes.

In the case of sulfur dioxide, just to get back to that scenario, in the United States two-thirds of the waters that were acidic because of sulfur pollution are still acidic today. Whole large sections of the Appa-
lachians and other mountain ranges, forests, and lakes have still not recovered ecologically. It's only just this year, actually, that the EPA has finally done something in recognition of the increasing health hazards that sulfur oxides pose to humans; the EPA has significantly tightened the emissions by reducing the permits available for the market. That won’t kick in for another several years. It’s an example of how, once you have this set up, if, as you almost must, you rely on a politically influenced government structure to set the limits, you’ve still got to deal with inertia in that system.

It does raise the interesting question of whether it’s possible to set up something that is more analogous … to the Federal Reserve …

It does raise the interesting question of whether it’s possible to set up something that is more analogous, as Bill Calvin said, to the Federal Reserve, where you have a quasi-governmental system that is more separate from the political process and is much more staffed by technical experts who can take into account new information and act much more quickly as regulators to pull the levers, twist the knobs, and set the rules by which everybody then plays the game.

Thanks for your attention.

SESH VELAMOOR (FACILITATOR): Thank you very much, Wayt. Are there questions?

POLAK: I guess the obvious key thing is that you must think, and other people must have the idea, that relying on free markets as motivators will mushroom and make a huge impact. Is there some evidence to support that notion? This is a little bit like saying, “When will the irreversible process take place?” Say a little bit about why you believe that.

… the free market system – the harnessing of entrepreneurial power and investment – is spreading worldwide; it continues. There seems to be no stop to it.

GIBBS: Actually, I don’t. I’m on the fence. I’m trying to be an objective journalist who reports on both sides. I think there are good arguments to be made on both sides, honestly. I do find persuasive some of the arguments that are made by skeptics of market mechanisms, many environmental economists among them, who point out that for these things to mushroom and to work on a big scale, many of the prerequisites are not present in large parts of the world, specifically in the parts where you’d want these markets to be most effective.

Having said that, the free market system – the harnessing of entrepreneurial power and investment – is spreading worldwide; it continues. There seems to be no stop to it.

POLAK: Is it growing exponentially?

GIBBS: Well, possibly. I don’t know how one would measure that, actually. Certainly globalization has occurred and is continuing to occur. Certainly we are moving in that direction for setting the conditions necessary for new ideas about how you can account for resources, new accounting ideas, and new ideas for how you can monetize these more abstract resources to quickly be put into practice if they work.

The issue of alternatives is crucial here. As bad as these market mechanisms may be, what’s the other option? Do you see any clear control experiments that would show a comparison between, say, a market mechanism and a more standard command and control?

MUSSER: The issue of alternatives is crucial here. As bad as these market mechanisms may be, what’s the other option? Do you see any clear control experiments that would show a comparison between, say, a market mechanism and a more standard command and control?

GIBBS: The clearest parallels that are drawn, typically, are the cases from the US sulfur dioxide program, which pretty much did fail. It failed politically, that is. The environmental community and agencies within the government failed to persuade Congress to do the regulation necessary to reduce sulfur emissions until this market-based solution was proposed.

In wetlands restoration, the US regulations were simply not enforced and not really seen as enforceable. They were widely flawed in the United States. Once the market-based mechanisms went into place, they got a lot better cooperation from the regulated community.

Those are two very small and not necessarily representative examples. The clear alternative is the classic command-and-control approach to environmental
regulation, where at the international level and at the national level, leaders make decisions and decide to impose those on their people. They just have to fight the various powerful forces arrayed against those regulatory decisions and changes, and then they have to come up with structures that enforce them. The reason to be pessimistic about those is that they tend to require cultural shifts, which are very slow in coming.

FACILITATOR: Okay. Thank you, Wayt, for a very informative session.
“Dirt: The Erosion of Civilizations”

Presentation by David R. Montgomery

David R. Montgomery, a geologist by training, is a Professor in the Department of Earth and Space Sciences at the University of Washington, where he is also the Director of the Quaternary Research Center. Montgomery is internationally recognized as a leader in the study of geomorphology, the evolution of landscapes. Recently, he has been studying the relation between the success or failure of human societies and how they affect the landscape and soils in particular. Current research includes field projects in eastern Tibet and the Pacific Northwest of North America. He has published over 150 publications in scientific literature. For more information on the Quaternary Research Center, please visit http://gis.ess.washington.edu/grg.

… I’m going to talk about processes that occur over time scales that are far longer than those we’ve been talking about so far today.

MONTGOMERY: Thanks to Wayt Gibbs for an excellent lead-in about setting priorities. I’m a geologist, and I’m going to talk about processes that occur over time scales that are far longer than those we’ve been talking about so far today. I’ll argue that these time scales are far longer than periods over which market mechanisms can function, because they’re time scales beyond which markets actually have existed in the historical record as discrete entities.

It’s the privilege of a geologist to speak to that. It tracks right in with the idea of a thousand-year time scale. I’d like to ask you all for the next few minutes to indulge me on two of my passions: one, geology; and, two, essentially the connection of geology to human history – human societies – and the feedbacks between the two.

I’ve just about finished writing a book, Dirt: The Erosion of Civilizations. I’ll give you the executive summary of that book. I’ve been working on it for the last five years, and it ties in with the themes of today. If you look at the historical record, many, not all, but most major civilizations on the planet have lasted somewhere between 800 to 2,000 years. There are some really good exceptions, particularly on fertile river valleys for reasons that are obvious to me. I’ll be glad to talk about them, but I won’t waste a few of my 20 minutes going into them.

There is a pattern to many of the major civilizations on the planet that have followed sort of a gradual, slow spread of farms into occupying entire landscapes …

There is a pattern to many of the major civilizations on the planet that have followed sort of a gradual, slow spread of farms into occupying entire landscapes, moving out of alluvial river valleys where the soil is naturally replenished, up into hillslope environments where the soil is replenished over much slower time scales, and geologically, the soil thickness tends to be a steady amount, as I’ll get into in a moment.

Once the hillslope environments are farmed intensively for a long enough period of time, the soil goes away in society after society. The time scale is commensurate with the 800 to 2,000 year time scale for the survival of civilizations.

Where we’re sitting today has been free of ice for about 15,000 years, but a technologically sophisticated society capable of stripping soil off the landscape has been here for only about 100 years. We’re a juvenile society. Where we’re sitting is not even into the experiment I’m talking about. But globally, many regions of the world have gone through that experiment and provide perspective on where we may be going over
the next several hundred years, certainly the next thousand years.

I’d like to invite you to think about a hillslope the way I think about it as a geologist. If you think about soil, the next time you go out and dig a hole in the ground or just look at dirt, think about it as a system. It’s being converted from rocks via weathering processes into soil. As long as there’s any slope to the ground surface, the soil is moving downstream like a mobile carpet moving downhill. Soil migrates; it just migrates over time scales that are far longer than we tend to live. We don’t tend to notice it. Soil tends to move downslope by a millimeter to a couple millimeters per year.

The invention of the plow, such as early plows used in Samaria, fundamentally altered the balance between soil production and soil erosion in most areas of the world where it has been introduced. That imbalance imparts a long-term instability and vulnerability to all major civilizations that rely on the kind of agriculture that we still practice today in many parts of the world.

That said, there are examples of agriculture that build soil—not remove it—that are best practiced on small-scale farms. I think by the end of my talk we’ll arrive at outcomes very similar to those of some other presentations at this seminar in terms of the positive prognosis for the future. If we look at the past, in many areas the prognosis is not only positive, it’s demonstrably quite negative. The ideas I’m talking about today are not new; I’m not going to claim a whole lot of credit for them. John Playfair, one of the granddaddies of my field of specialty in geology, in 1802 wrote about soil with the following quote: “In the permanence … of a coat of vegetable mould or soil on the surface of the Earth, we have a demonstrative proof of the continual destruction of the rocks, and cannot but admire the skill with which the powers of the many chemical and mechanical agents employed in this complicated work are so adjusted as to make the supply and the waste of the soil exactly equal to one another.”

What Playfair was onto—and James Hutton before him, and, actually, if you go back further, Aristotle and Plato before them, as I’ll get into in a minute—was the idea that if you look at natural landscapes, the biota, the climate, and the topography all have, if you think in terms of geological time and the thickness of the soil that develops on them, an equilibrium thickness. It’s in balance with the processes that are shaping the surface of the Earth. That’s what I study.

Changing the surface boundary condition via plowing alters that balance. It fundamentally alters the relationship. Agriculture, as it turns out, has increased soil erosion by an order of magnitude in almost every place that I can reconstruct in the historical record and in the modern record where it is intensively practiced. Plowing has been the practical prerequisite to many aspects of agriculture, including the basic agricultural practices from Sumerian times, right down through the agricultural revolution in Europe that I talk about a lot in the book.

… agricultural disturbance of the ground surface has increased erosion rates … by about an order of magnitude and in some places by several orders of magnitude.

What we’ve done today is substitute mechanized agriculture for the same sort of procedure that accelerated soil loss in the past, as I’ll get into as well. As a practical matter, agricultural disturbance of the ground surface has increased erosion rates—the removal of soil over the net production of soil—by about an order of magnitude and in some places by several orders of magnitude. In other places there’s no net increase. On average, as far as I can reconstruct, it’s about an order of magnitude. Ancient Greece is probably one of the best examples studied by archeologists and geomorphologists like me, although I can claim no credit for the work.

Cycles of erosion and soil formation begin in the Bronze Age, with the introduction of the plow many thousands of years ago that basically increased erosion right after the introduction of agriculture. Originally, the reconstructions of the Greek landscape show that there was open oak woodland initially with soil up on hillslope environments, where there was clearing and cultivation. It wasn’t the forest clearing; it was the plowing and cultivation that followed that actually sustained soil erosion rates. If you clear and let a forest grow back naturally, you get only a decade or so
of accelerated erosion. It doesn’t add up to a major problem over time.

If you plow it, as the ancient Greeks did, and they had very intensive, major agricultural operations in the late Bronze Age, you essentially strip the soil from the hillslopes. It piles up in the valley bottoms, and it can bury productive agriculture soils because it can take a thousand years to form a productive soil on the valley bottom. If you bury it with the subsoil derived from upslope, it can turn agriculture off downslope, as well.

*Population reconstructions in southern Greece … show the pattern … rising through the Bronze Age and the introduction of agriculture; then there’s a crash.*

Over the last several decades, the record in Ancient Greece has become very clear that in different areas of Ancient Greece, soil was stripped from the hillsides at different times, out of phase from what you’d expect from a simple climate driver, but very much following the introduction of the plow. Population reconstructions in southern Greece developed a couple of decades ago by Tjeerd van Andel and Curtis Runnels show the pattern in the population of Ancient Greece rising through the Bronze Age and the introduction of agriculture; then there’s a crash. The time scale took a few thousand years of going from originally “swidden” – slash and burn – agriculture to, essentially, plowing the entire Greek landscape. There was a crash, a dark age of roughly a thousand years, as the soil rebuilt. Then a second peak in population occurred in the Classical Age, which is also when some of the first written records appeared. A second crash happened during late Roman times, followed by the modern rise. We’re still essentially in that period today.

*Plato wrote in one of the quotes that I draw from, “The rich soft soil has all run away, leaving the land nothing but skin and bone.”*

This periodicity of human populations and the time scales involved is something that I got very interested in a couple of years ago. It motivated me to start looking into comparing the time scales and talking about them today. Again, I didn’t dream this up. Plato was onto this a few thousand years ago. In one of the oldest written documents we have in Western culture, Plato wrote about the Bronze Age soil erosion in Ancient Greece. He recognized it; he saw the signature on the landscape. He and Aristotle got the time scales virtually right. They didn’t have radiocarbon dating; they just guessed, but they more or less got the time scales right. Plato wrote in one of the quotes that I draw from, “The rich, soft soil has all run away, leaving the land nothing but skin and bone.”

In those days, in the Bronze Age he was talking about, the damage had not yet taken place. “… the hills had high crests, the rocky plain of Phelleus was covered with rich soil, and the mountains were covered by thick woods, of which there are some traces today.” He saw thick pockets of soil in the uplands and the Greek landscape, and deposits in the valley bottoms. He connected the dots, finding agricultural implements on bare rocky slopes where no crops grew then. You can still find those today.

In the interest of time, we’ll leave Ancient Greece, and move to Rome. There is a very similar story in Ancient Rome, where erosion rates increased by an order of magnitude starting about the second century BC. There are a lot of interesting connections with economic evolution and social change after the second or third Punic war; I forget which one it is now. That’s why you write a book: You don’t have to remember it.

*… the introduction of agriculture in Roman times accelerated soil erosion by, again, about an order of magnitude.*

You can trace the erosions from the Roman heartland out into the provinces. You can argue – it may be a specious argument, but it may be correct – that the expansion of the Roman Empire was, in part, driven by the need to acquire food for the population of central Italy. There are contemporary Roman accounts; if you read Cato, Columella, and others that were writing in that time, you can trace the evolution of the degradation of the soils of central Italy. Judson, a Princeton geologist in the 1960s, demonstrated that the introduction of agriculture in Roman times accelerated soil erosion by, again, about an order of magnitude.

If we look to the south of Rome in North Africa,
soil erosion also played a major role in the demise of agriculture. We've all probably heard the story about the salting of the earth when Rome sacked Carthage and salted the earth to eliminate them as a rival. What we don't tend to hear about is that within a century after that, there were major olive plantations and agricultural developments all over North Africa that the Romans made use of. Mago's book, an agricultural manual that basically described how North Africa was put to work feeding Rome, was discovered in the sacked city.

Today North Africa has essentially no olive groves. They have virtually no soil left.

Today North Africa has essentially no olive groves. They have virtually no soil left. Tertullian, one of the first Christians to write in Latin, I believe, in the second or third century AD, was a native North African. He wrote at that time: “All places are now accessible, well known, open to commerce.” North Africa was completely farmed. “Delightful farms have now blotted out every trace of the dreadful wastes; cultivated fields have overcome woods…. We overcrowd the world. The elements can hardly support us. Our wants increase and our demands are keener, while Nature cannot bear us.” He was discussing how North Africa was becoming overcrowded with farmers. By the 1930s, the soil conservation scientist Walter Lowdermilk went on a tour of North Africa, the Middle East, and he was going to go around to Europe, too, but the Second World War interrupted his journey. He was trained as a soil scientist, looking at soil erosion in China and in the United States. When he visited North Africa, he was puzzled by the lack of soil on the hillslopes in the areas that were the granary of Rome. The quote from his soil conservation service publication described his trip to Timgad and other parts of North Africa with the words, “Over a large part of the ancient granary of Rome we found the soil washed off to bedrock and the hills seriously gullied as a result of overgrazing.” Again, the soil in this once agricultural, quite productive area was gone.

You can make the same argument for the Middle East. There's a great story in Israel, and a similar story in Jordan, with the Phoenicians, and in Europe. You can also discover a similar story in terms of the United States. The American drive west was, in great part, driven by erosion of the soils on the eastern seaboard, degradation of the soils. George Washington and many of his contemporaries recognized this. In a letter in 1796 written to Alexander Hamilton, Washington wrote, “It must be obvious to every man who considers the agriculture of this country how miserably defective we are in the management of our lands. A few years more of increased sterility will drive the inhabitants of the Atlantic states westward for support, whereas if they were taught how to improve the old instead of going in pursuit of new and productive soils, they would make these acres, which now scarcely yield them anything, turn out beneficial to themselves.”

Many of the wealthy farmers, including Washington as a plantation owner, weren’t hurting in Washington’s day. Many of them recognized the damage that was being done to the land by American agriculture. There’s a history of seeing that in Britain and Europe, and in France, particularly. It was well discussed; it’s not much of a mystery. It was widely talked about.

Charles Lyell, another grandfather of my field, upon a tour of the American South in the 1840s, wrote about seeing the destruction of the landscape and great gullies that he encountered on his trip and included in his books. He basically tried to connect the process: What was happening? Was this a singularity? Is agriculture the source of what changed land so much that the landscape was literally falling apart in the South? Lyell, upon viewing the great gullies that he viewed as a wonderful way to look down into the earth and see the nature of the rocks and how they weathered in the soil, wrote, “I infer, from the rapidity of the denudation caused here by running water after the clearing or removal of wood, that this country has been always covered with a dense forest, from the remote time when it first emerged from the sea.”

The clearing of the forest and plowing of land essentially greatly accelerated the erosion of the American South.

The clearing of the forest and plowing of land essentially greatly accelerated the erosion of the American South. This contributed in great part to the westward migration. The amount of topsoil lost historically since colonial days along much of the eastern sea-
board, particularly in the Piedmont area in a noodle of topography between Virginia, down into Georgia and over to Alabama, is on the order of 4 to 10 inches across the whole region. If you think about the average thickness of the actual topsoil horizon, it's usually about 6 to 10 inches thick. In other words, most of the topsoil was stripped off the South in colonial days.

... soil loss as a driver of human society is not just ancient history. It greatly structured the evolution of this country, and still does so today.

There's great contemporary documentation about how that essentially drove people west to fresh land. Tobacco was greatly implicated in this, as were other large-scale monocultures, the point being that soil loss as a driver of human society is not just ancient history. It greatly structured the evolution of this country, and still does so today.

A historian named Craven recognized that this problem was not because people did not realize that accelerated soil erosion was bad for the future of the country or bad agriculturally. He recognized that, “Men may, because of ignorance or habit, ruin their soils; more often, economic or social conditions entirely outside their control lead or force them to a treatment of their lands that can end only in ruin.”

The big problem, as far as I can see, is that dirt – soil – is the cheapest of all agricultural inputs. It is not valued; it is lost over a time scale for which individual farmers are not necessarily penalized economically for wasting. Over generations the costs are borne out, but not necessarily to the individual. Market longevity and market mechanisms, had you actually had a market mechanism in place for 400 years since the time of Columbus, would undoubtedly reflect unearned incremental value.

To reinforce the argument that plow-based agriculture on sloping land promotes soil moving downslope fairly quickly, you can run the experiment yourself if you have a horse and a plow. If you go out onto a steep hillside and plow it once, you’re going to move the soil down an average of about a foot. That is off-scale in terms of the rate soil can be produced geologically in all but fictional environments.

In the 1930s, Franklin Roosevelt, in the wake of the Dust Bowl, offered a quote that I think is exceptional: “A nation that destroys its soils, destroys itself.” The caveat that I would add to this is that most nations do it so slowly they don’t notice it. The process is still ongoing, despite Roosevelt’s efforts to essentially stem soil erosion in the wake of the Dust Bowl in this country. We’ve managed to cut our erosion by about half since then. It’s still well above the geological rate of replacing soils.

Just to demonstrate the problem of accelerated erosion, let’s take an example from Washington State. Go out about 200 miles east of Seattle into the Palouse area in eastern Washington. In the 1950s, small channels were carved into bare fields, a result of the basic problem of plow-based agriculture. When you remove vegetation for part of the year, it takes only one storm at the wrong time of year to accelerate soil erosion above the rate of soil production. If you’re talking over geologic time, all you have to do is change that ratio, and you’re just running out the clock to run out of soil.

In photographs of the Palouse in the 1950s, you’ll notice the rills – small channels – on the order of maybe one to two inches thick. They don’t cover the typical area. This is not a problem for farmers; they just come in and plow them back over. But by merging those levels, the net surface has dropped by essentially half the distance that those things are incised.

In a photograph of the same region in the 1970s showing the same kind of area and the same kind of process, you see the same kind of result. It’s fine agriculture soil, but it’s migrating. It’s leaving very fast geologically. Photographs of the Palouse document the rate at which soil is being lost, including pictures showing a fence line built about 1911 around a cistern. Essentially the only thing that happened on the field from 1911 to 1961 was that the field was plowed; that’s all that happened. The original fence around the original cistern is shown with a pole placed at the edge of the field measuring the difference in today’s soil surface compared to the soil surface at the time the fence was constructed. The pole shows one-foot increments.
in the drop. If you basically project the old soil surface at the level of the cistern, and then measure down, it's about a five- or six-foot drop in five or six decades, a foot per decade, or roughly an inch a year. I'm rounding one way or the other by about 20%, probably, but you get the idea. The soil is eroding at about an inch a year; that cannot be made up geologically. Plowing the field is basically mining the soil. There is no way around that geologically.

The thing that really got me into writing this book was the idea that if the fundamental prerequisite for sustaining a technologically advanced society is maintaining enough fertile soil to be able to feed the population, and if you think over a thousand-year time scale, how you sustain soil over those time scales is the key to sustaining society. Things like global climate change and carbon stuff are hugely important; they can wipe out a society. We've got to deal with them in the short term. But in the long run, if we can't bring agricultural erosion into phase with rates of soil production, we're just running out the clock.

Again, this is not my idea. Shaler, a Harvard professor a hundred years ago, wrote: “The true aim of a conservative agriculture is to bring about and keep the balance between the processes of rock decay and erosion. With rare exceptions, the fields of all countries have been made to bear their crops without the least reference to the interests of future generations.” He was basically saying that agricultural practices erode soil faster than Nature makes it, and that's a problem.

I'm going to spare you the details of the data that I've put together, but I'll show you the basic idea that we can quantify how fast this is happening; therefore, can we predict a time scale. If we look at erosion rates in natural environments, they range greatly. A thousand meters per million years is about a millimeter per year. That's about the rate at which your fingernails grow. What I've done is simply look at different environments to look at soil-mansted hillslopes on the planet. If you'll recall, natural erosion rates and soil production rates are equal to each other in natural systems; otherwise, the soil wouldn't be there in the first place. These erosion rates range from on the order of 1/100th of a millimeter a year up to about a millimeter a year. Tropical environments, for those of you who like flat areas where there's lots of rainfall, not much slope and the soil's just been leached out, are great to visit, but you can't really grow much in them. High mountain systems don't tend to be good either, because they're steep and erode fast. It's also hard to keep the soil on the slopes because they're so steep.

... if you think over a thousand-year time scale, how you sustain soil over those time scales is the key to sustaining society.

Let's look at a formalized equation of those erosion rates. If we take the simplest model that we can to predict the time required to lose a soil of thickness “S,” then we take time to lose soil thickness “S” as a function of the difference between the erosion rate and the soil production rate. It's simply a balance of the thickness of the soil that you have. If you're losing soil at some rate, that rate is the difference between the erosion rate and the soil production rate. How long does it take to run through the entire stock of soil?

The average thickness of a soil in a natural hillslope almost anywhere on the planet is about a foot-and-a-half to three meters thick. We're not talking about flood plains. But if we look at the time scale, the difference between the erosion rate and the soil production rate, and we recall that natural erosion rates are on the order of about a millimeter a year, there's about an order of magnitude increase. The difference between erosion rates and soil production rates is going to be on the order, at the most conservative end, of about half a millimeter a year to significantly above a millimeter a year.

It takes on the order of only 500 to 2,000 years
Presentation by David R. Montgomery | Section 3.2.8

to burn through the initial endowment of soil that a natural landscape would have. That time scale, driven by the one to two order-of-magnitude increases in soil erosion under conventional and historic agriculture, implies that you get rid of that typical half meter to meter of soil in roughly 500 to 2,000 years. That's approximately the lifespan of most major civilizations. I don't think that's a coincidence.

I'm also not the first person to think that. Walter Lowdermilk, the guy who drove around North Africa and the Middle East in the 1930s who also worked extensively in China in the 1920s on problems of famine and how to feed the population in China, basically saw this as the underlying hazard of civilization. He wrote, "Here in a nutshell, so to speak, we have the underlying hazard of civilization. By clearing and cultivating sloping lands – for most of our lands are more or less sloping – we expose soils to accelerated erosion by water or by wind. In doing this we enter upon a regime of self-destructive agriculture."

"...plow-based agriculture, particularly mechanized agriculture ... would, given enough time, undercut the ability to feed a large population.

He basically saw plow-based agriculture, particularly mechanized agriculture that was becoming very prevalent in his day, in the '30s, '40s, and '50s, as essentially suicidal in the long run, because it would, given enough time, undercut the ability to feed a large population. I'm not talking about today, but if you look at the relationship between soil fertility and soil production and soil quality and soil thickness, they're all bound up together.

Finally, Edward Faulkner, one of the godfathers of modern organic farming, which I think could actually provide a way out because it could help build soil while still producing large amounts of food, noted: "We have equipped our farmers with a greater tonnage of machinery per man than any other nation. Our agricultural population has proceeded to use that machinery to destroy the soil in less time than any other people have been known to do in recorded history."

Out in the Palouse, as I mentioned earlier, they're halfway through their soil. There have been farmers there for less than a century. At the current rate, it will take only two centuries for their soil to be completely gone. Parts of Tennessee have lost four or five feet of soil since colonial days. We're burning through our soil at a fairly major rate.

Certain places on the planet are building soil with labor-intensive agricultural practices ... They provide a model for where we might want to go ...
priority than soil erosion. If we can’t solve that, we may not have to worry about facing this problem. By the same token, it’s a problem that happens so slowly, it almost never rises to the point of being addressed. And soil is not fungible. There is no replacement. Yet it has no value. You connect the dots. I should probably stop there.

I’ll be glad to entertain questions. There’s a lot more in the book that I obviously don’t have time to talk about here today. I’m not an agriculture expert, but I do claim some expertise in geology.

MUSSER: Some people didn’t realize it. Some people did. Were they able to act effectively? Did George Washington implement measures on his plantation?

MONTGOMERY: He most certainly did, yes. He experimented with crop rotations; he took gullies and filled them with trash and then planted them with shrubs. He instructed his overseers to actually break some of his holdings up into smaller farms because they could be better managed and tailored to the land. There was a major movement in the antebellum South to basically improve farms and to actually try to reduce the effects of erosion.

In England, starting in the 17th century, there was a major move for agricultural improvement that resulted in increases in crop yields. It was the adoption of mineral and fossil fuel-based fertilizers, starting with guano, natural fertilizers in about the 1840s, that started to undo that, and then mechanization after that. But there was a major movement towards soil husbandry in the Western world.

Also, the Romans grew peas and legumes to replenish the soil with nitrogen. They didn’t know about nitrogen, but they knew that growing legumes improved the soil. They had a whole hierarchy for what kinds of manure were better or worse for maintaining soil fertility. Some of the Roman agricultural writers – I think it was Columella, one of four agricultural writers whose books survived – argued that slave labor on farms was basically going to ruin the empire. I’d argue that the Roman Empire didn’t so much collapse as it kind of petered out. People recognized the issue of soil erosion and people took steps.

The United States government in the ’30s created the Soil Conservation Service, an agency charged with protecting our soil. But the fact remains that we’re losing it faster than we’re building it.

The time scales involved are so long that it’s really hard to actually convince people to throw the resources at it that would be required to alleviate the problem. The analysis I’ve seen suggests something like $5 billion a year would be required to actually bring US soil erosion rates in line with soil production rates. The added value that one would get from not having to dredge rivers downstream or deal with the off-site problems could be huge. The challenges could be worthy of exploring. As for how you’d integrate that into a market-based solution, I’m not the right guy to solve. It could be a really interesting challenge to try to tackle.

MUSSER: What role do you see for no-till agriculture and perennial crops?

MONTGOMERY: Huge. I could paint two very different visions for the long term. One would be extremely pessimistic. A positive vision – if we could learn from it this time – would be to see a role for no-till agriculture, perennial polyculture, and a multi-story canopy. There’s a great example in the islands of the South Pacific that have practiced for millennia very intensive multi-canopy farming very sustainably. Of course, they coupled it with exporting their population every now and then.

Very early Roman agriculture, called agricultura promiscua, was based on a polyculture, keeping several levels of canopy between the rain and the dirt. What is really hard is when rain falls on bare dirt, the dirt leaves. Go to any construction site; it’s no mystery.

All you need is just a few plants in sort of a two-story canopy, with row crops and tree crops. The Romans used grains, olives, and something else, if I recall. But they would interplant.

No-till agriculture, polyculture, and – I’ll argue – labor-intensive agriculture that’s not mechanized on small farms: that’s the prescription for growing a lot of food for a lot of people for a long time and actually
solving the problem of not losing soil faster than we make it. You can have very intensive agriculture that builds the soil and builds soil fertility. It's pretty well known; it's just not widely practiced.

ISHWARAN: In terms of civilizations, they normally include an agricultural part of the population and others who are dependent on it. The rate at which the agriculture or sector part produces food might also depend on how big the non-farming sector is. In your historical research, are there any general conclusions in terms of what kind of a ratio of agriculture versus non-agriculture populations a civilization can support sensibly?

MONTGOMERY: That's a great question, and I wish I had a really clean answer it to. And I'm not sure. In order to have any kind of a civilization where everyone's not a farmer, every farmer's got to produce far more than it takes to feed his or her family. What that multiplier is that can be done on a level that doesn't degrade soils over thousand-year time scales, I don't know. But it is exactly the question that we'd want the answer to.

WASDELL: One of the richnesses of this kind of workshop is that the soil here is so varied. And it seems to me that we can never again have a study of soil without taking into account the effects of climate change on fertility and its erosion.

MONTGOMERY: I'm almost done. I'm not going to rewrite; maybe I'll do a sequel.

SESH VELAMOOR (FACILITATOR): But that's one of the objectives of a workshop like this.

BOB CITRON: That's why we do them.

Assuming that we could build greenhouses or hydroponic devices economically … is that part of a solution to being able to raise more food more sustainably…?

TREDER: Assuming that we could build greenhouses or hydroponic devices economically, very inexpensively, is that part of a solution to being able to raise more food more sustainably under controlled conditions where you can recycle soil and control chemicals, and so forth?

MONTGOMERY: Yes, as long as you have infinite sources of two things: basic nutrients such as nitrogen, phosphorous, and energy to drive the hydroponic system and the stuff that goes with it. At present, half the nitrogen that we eat – half the nitrogen in you and me – is coming from fertilizers that were generated by fossil fuels at a 10-to-1 ratio of calories burned to calories produced agriculturally. If we don't solve the problem of how to generate and sustain supplies of energy cheap enough to eat, then I would say no, that's not part of the solution. If that does get solved, then it could be a contributor.

In terms of building resilience, I'd argue that if we have an option that can work in terms of not necessarily a technological change but a social change of how we actually manage land to sustain and build the productivity rather than degrade it over time, then we're building resilience rather than degrading it.

CALVIN: The Sahara, at the moment, is not very productive, but in pluvial periods it certainly grows a lot of grass and supports raising a lot of elephants, lions, and other animals. The last such period started about 15,000 years ago, and it ended not abruptly, but rap-
idly about 5,500 years ago, back about the time of the ancient kingdoms of the Nile.

It's marked, basically, by soil erosion, by wind, because everything gets carried off and dropped near the Cape Verde Islands and places like that. Cores of the ocean floor tell the story. Think what would happen today if, in the more humid tropics that we're getting from global warming, the monsoons manage to penetrate further and further and turn the Sahara grassy again. You might think this would be a good thing; maybe we could use all that underground aquifer to irrigate it. But just think what you'd take out of circulation. You'd take out of circulation all the reflected sunlight, the high albedo of the Sahara that's bouncing a lot of heat back into space, and you would allow that energy to be absorbed, heating things up some more.

It's the same sort of thing that you get at the high latitudes. When you change the surface snow into slush, instead of reflecting 90% of the sunlight, you now reflect only 70%. You start absorbing three times as much heat, just by letting the temperature get above freezing for a day or two. There are all these interactions between what we do to exploit things and how they can turn around and bite us in the overall climate system.

Certainly, clearing the land and taking the forests partially out of the business of making CO₂, producing oxygen, and things that have changed the current climate scenario with Ruddiman's work I mentioned earlier are factors. I just wanted to point out the Sahara is a good model, at least a good teaching example, of how you can't have your cake and eat it, too.

Some students I worked with at Stanford designed a $20 hydroponic system that can use human energy to pump it…
There are lots of solutions.

POLAK: Just a quick response to Mike Treder's question. Some students I worked with at Stanford designed a $20 hydroponic system that can use human energy to pump it. The most obvious fertilizer is urinating into a bottle and applying it, and adding stuff to that. There are lots of solutions.

FACILITATOR: Okay. Thank you all for your contributions. We'll now take a break; then we'll reassemble for one more presentation to complete today's sessions.
“Nanotech Manufacturing: Driving Toward a Crossroads – and a Crisis”

Presentation by Michael A. Treder

Michael A. (Mike) Treder is Executive Director of the Center for Responsible Nanotechnology (CRN) and a consultant to the Millennium Project of the American Council for the United Nations University and to the Future Technologies Advisory Group. He is a Research Fellow with the Institute for Ethics and Emerging Technologies. In 2002 Treder co-founded CRN, a non-profit research and advocacy organization that promotes public awareness, education, and the creation of effective policy to maximize the benefits and reduce the risks associated with nanotechnology. Treder sees nanotechnology as the single emerging technology that will have the greatest impacts with potential for both positive advances and negative societal implications for humanity within the next few decades. For more information about CRN, please visit www.crnano.org.

… we are approaching a point, if we're not already there, where very, very important decisions will have to be made.

TREDER: The theme of this workshop/seminar is “Humanity at a Crossroads.” Today we have heard a number of wonderful talks that have illustrated the fact that we are approaching a point, if we’re not already there, where very, very important decisions will have to be made. Picture us on the road we’ve already been traveling, which forms our history. We’ve driving towards and approaching, literally, a crossroads.

Particularly in David [Wasdell]’s talk about global climate change, if we're going over the top of the hill and sliding down the other side, it seemed to me that it is as though there were basically two solutions. One was to turn to the left, and we just go down and down and down. Business-as-usual carries us into oblivion in what truly is an Anthropogenic Extinction Event.

Now, the other solution, or the other approach, as I understand it, was to go back to a village lifestyle, riding bicycles, and so on. I know I’m exaggerating, but I’ve got the microphone, so I can exaggerate.

WASDELL: What power.

A crossroads is, by definition, a cross … It’s not either “kill ourselves by staying with business-as-usual” or “survive by cutting way, way back.”

TREDER: In the context of the first scenario, you would see we still go down because we go through a heck of a lot of bad times before things balance out and we can achieve sustainability. What I’m going to suggest, of course, is that a crossroads is not a “T.” Right? A crossroads is, by definition, a cross. It’s not a binary proposition. It’s not either “kill ourselves by staying with business-as-usual” or “survive by cutting way, way back.”

I’m going to submit that, actually, the road continues; however, there’s a gate. We’re approaching a gate. This gate is closed, but it could be opened with technology and wisdom. Applied science could open this gate and allow us to move toward a healthy future, a sustainable future. The problem is that opening that gate will not be simple. If we do not succeed in opening it, either we go one way or the other, or we kill ourselves fighting over whether we're going to open the gate or not. That's a very real possibility. I’ll talk about that. My hope, of course, is that we can find a way to open the gate and move on to a positive future.

You might recognize these words: “Humanity has reached a crossroads where decisions of monumental consequence will be made, either proactively
or by default.” Do you know who I’m quoting here? This is from the materials we were sent to prepare for this meeting, quoting Sesh Velamoor. The word that scares me most there, or the phrase, I should say, is the last two words: We’ll be making decisions that have monumental consequences, and we may make them by default.

We have found our way, pretty much by default, to where we are as a species. There’s been no overall planning. We’ve gotten here without any specific intent to get where we are today.

I want to add one more word. If you take one word away from what I say here today, the word I want you to take is urgency. I think that I’m not the only one who’s expressed a sense of urgency, although I think the word has not been used yet. In my work I feel, very strongly, that we need to have a sense of urgency, because that crossroads that we’re reaching is not far away. It truly is a point of monumental consequence for all of humanity.

Back in 1959, the Nobel Prize-winning physicist Richard Feynman gave a famous talk in which he said that he could see no reason why we couldn’t eventually reach a stage where products could be built atom-by-atom. We could start a different way of manufacturing by making things exactly as we wanted them, building from the bottom up. He said there was no reason why not, except that we are “too big.” At the time, 45 years ago, we didn’t have the techniques and the tools to be able to work at that small a scale. It would take a lot of work to get to that point.

… atoms are so small that if you start putting them together one-at-a-time, it could take literally a million years to make even a gram of matter.

I’m going to add one more thing that he didn’t say, but which is also true, and that is that we’re “too slow.” In other words, even if we had small enough hands, so to speak, or small enough tools, atoms are so small that if you start putting them together one-at-a-time, it could take literally a million years to make even a gram of matter. We have to solve both of those problems to reach Richard Feynman’s vision.

The first thing we need is better tools, because we have been, in the past, too big. A lot of those tools are being created. Especially over the last five to ten years, amazing progress has been made. This is what I do in my work; I watch this stuff all the time. We get to cancel out the words, “We’re too big,” because we’ve made these improvements in microscopy. I urge you, if you’re interested in following up on this, to explore the University of Pittsburgh, NIST, Rice University, Zyvex, Bath University, MIT, and Nanorex, which are a few of the institutions and companies that are really doing astounding work in these areas. James Tour’s work at Rice University, in particular, and others doing phenomenal work are moving us rapidly forward in getting small enough that we can work at the nano scale.

How about being too slow? What we have learned, through modeling and through theoretical study, and now through practical application, is that we can use what’s called scaling laws, which say as things get smaller, they also move faster. It’s why a hummingbird’s wings move much faster than an eagle’s wings, and why a mosquito’s wings move much faster than a hummingbird’s wings, because they have a smaller distance to travel. You can magnify that by a million times as you go down to the nano scale. Things will happen much faster if they can be controlled. Today we don’t yet have the ability to control what happens at that scale. Once we achieve the ability to program, which we’re getting closer to, and to work in parallel assembly – not just building atom-by-atom in one spot, but having a whole range of machines working together to do this building – then we can accomplish something.

Back to our friend, Richard Feynman, who said, in 1959, “I want to build a billion tiny factories, models of each other, which are manufacturing simultaneously.” That’s what the famous physicist foresaw. It actually took 25 years, during the 1980s, until a man named Eric Drexler, a student at MIT who did his Ph.D. thesis on this, published a book that became a best seller, introducing the whole idea of what we now call nanotechnology. There was no such word in Feynman’s time, but what Feynman was describing is today called nanotechnology.
The future of this knowledge will allow us to do bottom-up, atomically precise, exponential, general purpose molecular manufacturing.

The future of this knowledge will allow us to do bottom-up, atomically precise, exponential, general purpose molecular manufacturing. Those last two phrases are important: “exponential” and “general purpose.” “Exponential” means that the manufacturing system will be able to make other manufacturing systems identical to itself. One product of what we call a nanofactory will be another nanofactory; you will have factories that can make factories. It is as if you took, say, the Boeing plant in Everett – for those of you who aren’t natives, there’s a huge Boeing plant not far from here – and if that factory could make a copy of itself, you’d make an identical factory in a day, or better yet, in a few hours. Boeing could make twice as many planes. Of course, it would cost them billions of dollars to make another factory like that. This technology will allow us to make a factory as powerful as that Boeing factory, in fact more so, within a few hours and for a few dollars. It’s astonishing, but it’s true.

“General purpose” means the products that are manufactured this way can be any product that can be made from simple atoms, carbon being the primary one. Virtually anything you see in this room, this whole building, other than the people and the food, could be manufactured very inexpensively and at super-high performance levels, much better than what we see today, because the machines doing the manufacturing will be programmable. You would enter a blueprint, a code, or a program into the machine to tell it what product you want it to make.

… you’ll see product development accelerate at an extremely rapid pace. Instead of product improvements happening in a period of years, it will be down to weeks.

One point that I hope I can get across here that is very important is what’s called cheap, rapid prototyping. This is one of the drivers of dynamic change of significant social impact through nanotechnology. In order to make new products today, to develop a new product line or introduce a new car, you have to go through a several-years-long process. For something like a new airliner, that’s 10 or 15 years. What if you could design and manufacture a prototype product in a few days – your design might take longer, maybe weeks or months – but what if you could manufacture that prototype in a few hours? Then you could test it, refine it, and make another one for a few dollars through cheap, rapid prototyping made from fuel that costs about $1 a pound, because it’s just basically readily available carbon. What will happen here is that you’ll see product development accelerate at an extremely rapid pace. Instead of product improvements happening in a period of years, it will be down to weeks. We’ll be able to make products that have never been seen before. The promise is magnificent. Unfortunately, there are some drawbacks that we’ll have to talk about.

What we call a nanofactory doesn’t exist yet, but the schematic design for it does exist on paper. An 80-page paper has been written to describe how it would work. Actually, since that paper was written a couple of years ago, new ideas have been applied that would make it even more efficient. When this thing becomes reality in another decade or two, it probably won’t look like this, but it will accomplish something similar. I have a movie; I’m not going to show it to you now because I don’t want to use up my precious 1200 seconds. If we do have time at some point, or if you want to look at it during break time, I’ll show you a movie of how this nanofactory would operate inside; it’s quite remarkable.

The movie shows the factory I was talking about that could make a copy of itself in a few hours by just putting some fuel in there and plugging it into the wall. The waste from it is a little bit of heat, hot air, and water; that’s what would be left over. It’s fascinating to see that movie.

Let’s talk about the impacts. I said that this would be a revolution in that it would really change things fast. We talk about this as the next Industrial Revolution. You’ve probably heard that phrase about nanotechnology. That’s not an exaggeration; that’s not hyperbole. If you look at the impacts of previous industrial revolutions, particularly the original steam revolution starting in England, and then later, the introduction of electricity or the automobile, or even the computer, there’s this familiar “S” curve on a chart. You’ve all read about and know about the “S” curve where, at the beginning, things are adopted a little more slowly, and then they become more and
more popular. At a certain point, we start seeing more societal impacts and the line starts to rise. The line reflects these patterns and is shaped as an "S." Over time, that line starts to level out. You can see this in virtually any application you talk about. If you study the impacts and compare them over time, you get this "S" curve; it's very well known.

When this nanotechnology revolution occurs, we'll have the same "S" curve, but instead of decades, change will be measured in years.

In previous technological revolutions, this change has always been measured in decades, with time scales showing 50, 60, 80 years of impact from the bottom of the "S" to the top of the "S." When this nanotechnology revolution occurs, we'll have the same "S" curve, but instead of decades, change will be measured in years. What you end up with, of course, as you look at this change on a graph, is an "S" that gets compressed. It's still shaped like an "S," but it's really an upright "S" that, in fact, looks like a wall, or a cliff, or we call it the step, just to make it a little less threatening. These impacts on society will take place over a very short amount of time. I'll talk about some of the implications of that.

I said that it's not all good news. I wish it were. You've probably heard the stories of how tiny robots swim through your bloodstream and clean out your arteries or repair cartilage, etc. These things are actually being designed, and very early versions of these things are already being used. That's going to happen; they're on their way.

However, the same technology that conceivably could manufacture lifesaving medical robots that will extend and improve so many lives can also be used to make untraceable weapons of mass destruction. The very same technology that could make networked computers, super-powerful computers, for everyone in the world – a million dollars would buy a computer for everyone in the world with this technology – could, unfortunately, also make networked cameras that could be placed throughout rooms and buildings, microscopic-size and networked together, so that the government could see everything you were doing all the time. We're talking about, obviously, trillions of dollars of potential abundance here. However, who wants to own that abundance? Will there be a vicious scramble between corporations or governments – a fight – to see who will have possession of this magnificent technology?

Regarding rapid invention of wondrous products, I mentioned rapid prototyping. However, that very same rapid prototyping also, unfortunately, leads to a situation where you could develop weapons so quickly and deploy them so quickly, that instead of the former stability of arms races, like we had during that long period of the Cold War, weapons development would occur so rapidly that we're afraid that a new arms race would not be stable and could rapidly devolve into an awful war.

[Image}

… we have to find a way, if there is such a way, to ensure that the negative applications don't take over the positives.

It's not an "either/or" situation. It's an "and" situation. The technology makes both. We can't choose; we can't say, "I want only the positive applications for my purposes. I don't want the potentially negative applications for some other nation's or individual's purposes," because the technology will be able to do both. To simplify things, we have to find a way, if there is such a way, to ensure that the negative applications don't take over the positives.

This is a very important point and an easy way to look at the situation. If we do want all those wonderful technologies – the things that can take us through this gateway to the future, the things that can help us to overcome soil erosion and rapid climate change, etc., and things that will be available within a matter of decades – then we'll never get the benefits and we'll never really get to enjoy all that the technology has to offer unless we find a way to prevent the dangers.

The challenge is that if you want all the good stuff, and we do, then we need to be aware that there are vicious cycles that take place when threats are perceived by the governments and restrictions are made that are not necessarily designed wisely. That creates a reaction in illicit trafficking of products and people trying to get around regulations to make a profit or to gain power, and black markets are created.

Then at a larger scale you have government oppression. In order to prevent war or violence or terrorism, governments may make the choice that they have to remove some rights from people in order to prevent
them from killing each other. Inevitably, humans will want to resist that. There will be battles and wars fought over that. The modern stage of war is not a pitched battle on a field. Modern warfare is basically guerrilla or protracted warfare. In the nanotech age, war might be fought that way, but the results will happen a lot more quickly. As weapons get developed, then more oppression comes. We get into these nasty cycles, which David [Wasdell], I think, called a second level positive feedback loop. We can't afford that. Because what happens then is that we reach a gateway into future potential, and we die fighting to see who's going to get to open the gate and who's going to control the gateway. Who should be concerned about this? Who will this affect?

Anyone who falls into any of the following categories and anyone who has any interest in any of these categories will be impacted significantly by nanotechnology: business and trade, medical ethics and research, intellectual property, arms control and geopolitics, ecological remediation, sustainable development, surveillance and privacy, information technology, social justice, and policing and criminology. Do any of these areas matter to you in your life? You can see where every single one of these fields must find ways to respond.

I'll submit that companies, individuals, and organizations in every field have to wake up, start taking nanotechnology seriously, and begin their own plans for dealing with these implications. It will not be an easy thing to do.

To begin that process, my organization, the Center for Responsible Nanotechnology, has organized a global policy and implications task force. We have about 60 people around the world now who are working with us on this on a volunteer basis, first identifying the problems, trying to see how the problems interact with each other. Then our intention is to design different potential policy recommendations and see how, in modeling, those might work together.

We can't do it all alone, obviously, even with 60 people on the task force. We want to start the process, show our results to others, and encourage a worldwide effort. One reason I feel urgency here is that about this time last year, the Battelle Laboratories and the Foresight Nanotech Institute started a process to develop a Technology Roadmap for Productive Nanosystems. A productive nanosystem is basically another term for machines that can make other machines at the nanoscale level.

The idea here is that about this time next year they expect to have the first draft of a technological road map to show how we get from where we are today with the tools we have to the point at which we'll be able to create machines that can make other machines at the nanoscale. Our best guess is it's something that could probably be achieved within, say, ten years if a big project like a Manhattan Project, or a "Nanhattan Project," were put together for this. If it emerges more naturally, it might be 20 years. The median range for getting there, we think, is roughly 15 years, around the year 2020.

However, we also think that we would not be responsible – we would not be living up to our name – if we didn't encourage people to prepare for the earliest potential development of the technology. We can't afford to have it come upon us without fair warning or without preparation. What we would like to see, ultimately, is a global commission composed of four different groups that have equal say in developing and implementing effective solutions. Those groups would consist of government; commercial, or business and industry; civil societies, or NGOs [nongovernmental organizations], charities, etc.; and the FSOS, which is shorthand for the Free Software Open Source movement, an untapped resource that we believe can be applied very usefully to develop emergent solutions. We're not in favor of a top-down approach; we're in favor of an emergent network approach, but that has to involve all of these different stakeholders and power arenas.

We know we're at a crossroads and we're ready to
make decisions. That's the question we'll have to end the day with. Thank you for this opportunity.

**SESH VELAMOOR (FACILITATOR):** Thank you, Mike. I have a question. I've been reading about this for the last ten years now. In fact, I think it was *Scientific American* that put out a review maybe seven or eight years ago, called, if I remember correctly, "Nanotechnology: Hype or Hope?"

**BOB CITRON:** We ran a workshop here seven years ago on nanotechnology.

**FACILITATOR:** Right. But subsequently I keep reading news reports every once in a while about some basic products that have actually now been made. Could you talk a little bit about that?

**TREDER:** It's easy to misunderstand what's happening, in part because the term nanotechnology has been co-opted by government and business as a marketing tool. The National Nanotechnology Initiative was formed in 1998 by the US government, and it was decided that they would put half a billion dollars a year into funding research on nanotechnology. Of course, then, all of the universities and companies said, "Oh, we want a piece of that."

A lot of what you see today – not everything, but a great percentage – that goes under the name of nanotechnology basically is material science, or chemistry under another name. It's stuff that was already being done anyway, but now they can call it nanotechnology. Not that it's not important work; it is, and it's valuable work, but it's not the same kind of revolutionary work.

It's incremental work being used to make better coatings, paints, and better lenses. We're already working at the nanoscale level to make semiconductors. You can even buy consumer products such as tennis balls and ski jackets and such that include nanofibers to make them last longer, repel moisture, etc.

What is called nanotechnology by the broad terminology being used today is not what's coming. We're now in a separate, primary, or preliminary stage before we reach the generation of nanotechnology development that will result in what I'm talking about here.

**FACILITATOR:** I recall going to a lab and looking at some electron force microscope, which would have to be the basic equipment required to even begin to think about assembling stuff. What do you foresee by way of the commercialization of nanotechnology? Will it take 20 years, 30 years, 50 years, or 100 years?

... looking at miniaturization of industry in general ... the techniques that will be needed will be readily available in 20 years, or sooner if people try hard.

**TREDER:** If we apply Moore's law, looking at miniaturization of industry in general, and if you look at a chart showing progress, it seems very obvious that the techniques that will be needed will be readily available in 20 years, or sooner if people try hard. We expect that the upside we'll see – the profit potential for one, the military potential for two, and, hopefully, the humanitarian potential for three – will result in applied programs to develop it quickly.

Our belief is that this technology should be developed as fast as it can be done safely and responsibly. The benefits are so great; we want them to occur as soon as possible. But we have to go about it wisely. A 15-year time frame as a guess is probably not going to be that far off.

**ISHWARAN:** Where do you think the nanotechnology research is happening most? United States? Japan? Where else?

**FACILITATOR:** India.

**TREDER:** Yes, the current President of India, President Kalam, is a nuclear physicist. He has asked India's government scientists to spend a lot of time and energy on this. In fact, one of the ominous things that President Kalam said when he spoke to, I think, the Naval Research Center in India a year or two ago, was that he foresaw nanotechnology as a technology that would revolutionize future warfare. Obviously, his country is between China and Pakistan and below Russia, in a vulnerable spot. He didn't want his military to be behind the curve, so to speak. I'm sure President Kalam also wants to see development of civilian applications, among others. But the fact is that there are countries around the world waking up to the potential nanotechnology offers.
Still today, the United States spends about a fourth of all the money that’s spent in nanotechnology development. Japan spends close to another fourth. All the European Union countries spend about a fourth. The rest of it is spent by the rest of the world. There's an active program in Brazil. China has begun, but because of the lack of transparency there, it’s hard to know how far they’re going and how much money they’re spending. We don’t have accurate figures from China. But it would be expected that they would put quite a bit of effort into this.

POLAK: How much money is being spent?

TREDER: Right now, about $4 billion a year. That’s government investment. That doesn’t count commercial investment, which is probably about the same amount.

KESAVAN: It was an excellent talk. I’d like to ask you, with the fusion technology that is going on, can we have some common parameters as well as some kind of a common pathway?

TREDER: You’re talking about nuclear fusion?

KESAVAN: Yes, I mean nuclear fusion, but energy production.

TREDER: Right. Nuclear fusion, of course, is done under extreme pressures, temperatures, in order to force hydrogen atoms together to make helium.

KESAVAN: Cold fusion.

TREDER: I’m not a physicist. I can’t tell you how far away cold fusion is or if it’s feasible. Sure, it does seem like it’s in the same ball park. However, with fusion you’re talking about not just covalent bonding of atoms; you’re talking about fusing two atoms to make another type of atom and releasing the energy.

What we’re talking about in this manufacturing is bonding atoms to make molecules; bonding molecules to make products; mostly using covalent bonding, electrons, or van der Waals’ forces – surface forces – in some cases. It’s not really the same thing. However, a lot of the tools that are being developed for other fields can be applied here. We say the nanotechnology tool box is rapidly being filled up with the things that are going to be necessary to reach this point.

CITRON: Could you talk a little bit about the competition, the awards that they give for nanotechnology machines?

TREDER: The Foresight Institute has an annual prize they call the Feynman Prize. I mentioned Richard Feynman earlier. They present an award to the researcher that’s accomplished the most within the last year. They’ve been doing this for 15 years or so. Last year I believe they awarded it to Nanorex, a company that is developing simulation software to model how these machines will work, taking into account all of the forces that exist at that scale. Rather than just sort of guessing, they’re actually modeling how gears would work when you have Brownian motion as electrons make atoms jiggle, etc. That company is doing remarkable work.

Several other researchers have been honored over the years. Each year someone gets awarded this prize. I should mention, though, that the ultimate Feynman Prize is for the person who can develop the first what used to be called “assembler,” and now we call it a “fabricator,” a nanoscale machine that can produce a copy of itself under programmed control. This prize is $100,000 or something like that. That prize has been out there for a while. But they award incremental prizes along the way. The Feynman Prize is meant to be a plum to try to get researchers to reach that point. I should say that I have mixed emotions and feelings about how fast I want to see this come. I really want to see the benefits arrive, but, just as David was saying earlier about having fear or sadness over the potential in his field with climate change, the potential for power being placed in very few hands – enormous power, more than we’ve ever seen before – is tremendous. It really is conceivable that through one of these vicious cycles, these feedback loops of war and economic turmoil, bad things could happen.

I didn’t even talk about what happens to jobs when you can start manufacturing products at home, and
all the regular factories go out of business. When you have turmoil, uncertainty, and fear, that’s when despots or dictators can come in and fill the vacuum. That’s what happened with Mao in China, Hitler in Germany, and so forth. We fear that the social disruption that may result from this technology could be put to bad ends by someone who just wants to grab power. These capabilities will enable so much control. I talked about sensors, ubiquitous surveillance, where you might not be able to go anywhere without being seen. It could enable one person or one small group to basically control the world. It sounds crazy, but it’s the sort of thing that is moving toward us very rapidly. Science fiction is becoming science fact. It’s time for people to start being aware that these things are on the way to becoming reality.

ISHWARAN: When is something nano? What’s the dimension?

TREDER: What’s considered nanotechnology is between one nanometer and 100 nanometers. A nanometer is a billionth of a meter. That’s so small that, of course, we can’t conceive it. One way to think of it is to take a human hair – yank a hair out of your head – put it down on a cutting board; take a really, really, really sharp knife; and slice it about 50,000 times, the long way, into 50,000 strands.

FACILITATOR: Longitudinally.

TREDER: Longitudinally. Thank you. Then you have one nanometer width of human hair. A human hair is roughly 50,000 nanometers wide. That’s the scale we’re talking about. A hydrogen atom is roughly a fifth of a nanometer. It’s the smallest atom. If you put five hydrogen atoms side-by-side, then that’s a nanometer. It’s a scale at which atoms combine and molecules combine. You could build effective machines, in theory, at around 100 nanometers. That’s the smallest size at which you could put enough atoms together to have them work.

ISHWARAN: What would be the size of that self-replicating factory?

TREDER: The desktop factory? That’s the size of a copier on your table. However, that nanofactory could be made basically any size that is convenient. It could be the size of a garage if you wanted it to make cars, or the size you could carry around in your pocket if you just wanted to make small items. It’s scalable. The scaling laws are such that you could make it essentially any size for the same amount of investment. That particular one, that idea I spoke of earlier, was something that would sit on a desk top.

The interesting thing is exponential proliferation. One of those nanofactories could make another one within a few hours – let’s just say a day. Then you start with one; a day later you have two; in ten days you’d have a thousand because of the way numbers work; in another ten days you’d have a million. Literally in a matter of weeks you could have enough for every person on Earth to have a personal nanofactory. That’s not going to happen, probably, in the real world. But the fact remains, that could happen. What will be done to make sure it doesn’t happen? Will some government or some company want to prevent that from happening and try to enforce some sort of regulation? What will happen when someone tries to circumvent that regulation? Will hackers try to get in and remove whatever technical restrictions are built into the nanofactories? The scary thing about this is that I can think of many, many questions, and I have very few answers. So I’m here to bring more questions to you than answers, I’m afraid.

WASDELL: You’ve raised some issues this evening that have been passing through the day in common waves. May I just take the opportunity of bringing this up within your own area, because of the responsible – or responsible – issue? I think the Freudian slip is also interesting within this culture today. People, have a look at Mike’s name tag here [Center for Responsible Nanotechnology]. The issue of human nature and its capacity for making responsible use of rapidly changing environments, technologies, inventions, innovations, etc., has been coming up in presentation after presentation and in questions. It’s fascinating. The flexibility, the pace of change, in area after area
after area of what we do is being noted, but not any sense of a pace of change in who we are and how we engage with this.

You're on this bridge, it seems to me, between an extraordinary, expanding, new technological revolution and its interface with the human, because I think that's what "responsible" is intending there.

How do you come back on the other side of that to match the emergence of human nature to live responsibly with what human capacity is generating? I think this is an immense issue that is being brought up in facet after facet during the day.

TREDER: Is this bottle half empty or half full? That's sort of where we are. Do you sense that humans are good enough, wise enough, responsible enough, far-seeing enough….

WASDELL: Flexible enough.

TREDER: Flexible enough. Yes. Can we even change our paths, our ways, fast enough? Or are we basically just hairless apes focused on survival and competition, showing who's the biggest, so to speak.

FACILITATOR: I might point out that the Foundation hosted, a couple of years ago, a wonderful workshop on future humans. The proceedings are available for all of you if you wish to have a copy. That answers some of these questions: Who are we? What are we likely to be? What manipulations can occur? What iterations of human beings will we see in the future? What are the technologies? What's happening, even now as we speak, with the state of research and development, etc.?

TREDER: If I could just say one more thing about David's point there. I was speaking with a group of high school students in Toronto, Canada, not long ago. I said to them, "Do not make the mistake of thinking that nanotechnology is about technology. Certainly it is about technology, but that's not all by a long shot. In order to survive the entry into this nanotech era, it will take a lot more than just engineers, physicists, and chemists. It's going to take really, really smart and committed sociologists, economists, and political scientists. You name the discipline; virtually every discipline will have a role to play in developing some way that we can survive this awesome technology. 'General purpose' applies not just to the products that it can make, but to the impact it's going to have and the need for response from every sector of society."

If you dream for a while, what would nanotechnology do to cut carbon emissions in half?

POLAK: It sounds almost too good to be true. You clearly are convinced that it is true. So let me join you; I'll be Mary Poppins. If you dream for a while, what would nanotechnology do to cut carbon emissions in half?

Nanotech-enhanced devices could help dollar-a-day villagers achieve the equivalent of an Industrial Revolution within their villages … to sustainable levels of high health, nutrition, productivity, etc.

TREDER: Several things. Probably the first thing is that, again, in theory, nanotech, when we can build things atom-by-atom from the bottom up, should be able to make solar cells that are 100 times more effective than they are today; maybe not 100 times, but nanotech will make solar power very affordable on wide scales. It will make storage of power much more efficient than it is today. Basically, it will get us weaned off a planet-wide need for oil. That's one huge way: energy production and storage, with solar energy as the primary means. There may be others as well, but solar is the obvious one.

Second, as I mentioned earlier, might be not only reducing our agricultural footprint through very inexpensive, very effective methods of irrigation, desalination, and water storage, but also greenhouses, hydroponics with virtually zero-cost materials and readily available energy, and highly efficient solar energy production capacity, where you can, theoretically, walk into one of those villages where people live and die on a dollar a day, and carry in a suitcase full of nanostartes. Nanotech-enhanced devices could help dollar-a-day villagers achieve the equivalent of an Industrial Revolution within their villages – leapingfrogging more than any frog has ever leapt since Mark Twain's time – to sustainable levels of high health, nutrition, productivity, etc. That's the upside. It's like a dream; it really is. Then again, if you went back in time one or two thousand years and you told them how we live today, nobody would believe you. They'd say, "You're crazy. Nobody could live like that."
CITRON: Even one hundred years ago.

TREDER: Yes, exactly. There's a great saying that I like: “If you're looking at the future and what you're seeing looks like science fiction, it may or may not be true. If it doesn't look like science fiction, it's definitely not true.” The future is so different from today.

FACILITATOR: Thank you, Mike. On that note, we will conclude the proceedings for the day.
Breakout Group Discussions

Before dividing into two groups for small-group discussions on specific topics, participants received guidelines and explanations of topics.

FACILITATOR: Sesh Velamoor
PARTICIPANTS: Plenary Session

… we’ll see if you can get your arms around the critical issues going forward. The idea is to identify three of these issues in each group.

SESH VELAMOOR (FACILITATOR): We will now go into the second phase of the seminar. Let me quickly describe what happens here. If you will look through the Group Assignments tab of your binder, you’ll see that there are two groups. There are five in one group and four in another. At this point we end the presentation phase and move into the conversation phase of the seminar. In this first step, what happens is that the groups, individually, will not so much get into the depths of what has been presented, but we’ll see if you can get your arms around the critical issues going forward. The idea is to identify three of these issues in each group.

These two separate groups meet simultaneously. Then you come back together and your Group Lead presents your findings, at which time we’ll try to generate a consensus on the six issues, if they happen to be three each mutually exclusive issues. It usually turns out that you end up with almost the same ones, but maybe not. Then we have a conversation about what might be a consensus out of the six issues. That becomes the focus of our fishbowls. I’ll tell you about that a little later.

The time frame for this group discussion is one hour. Group 1 will consist of George Musser (Lead), Bill Calvin, Natarajan Ishwaran, David Montgomery, and Paul Polak. Group 2 will be David Wasdell (Lead), Wayt Gibbs, P.C. Kesavan, and Mike Treder.

Are there any questions? If not, please proceed to your groups. Thank you very much.
We’ve been deputed to come up with three critical issues … How shall we interpret that phrase, “critical issue”?

We’ve been deputed to come up with three critical issues. I’m actually wondering: How shall we interpret that phrase, “critical issue”?

Are we supposed to come up with issues or priorities? The topic guideline says, “Discuss priorities for Planet Earth.”

… we have to identify some things that can be focused on; presumably they’re ones that we can make some progress on rather than stating vague generalities.

It seems to me that we have to identify some things that can be focused on; presumably they’re ones that we can make some progress on rather than stating vague generalities. That would be my suggestion. In terms of prioritizing them, we can get to that if we have time.

I’m better, perhaps, at reacting to things than defining them. If we could just throw out three really broad categories to start talking about, we could synthesize a lot of what we’ve already talked about. Global warming and its effects is one; sustainable agriculture as a second; and poverty as a third.

I’m sure there are more, but that will give us targets to shoot at.

What was your first?

Global warming and all its effects; I’m thinking it’s really broad.

Would it be broader to say climate?

Yes.

Yes. Delta climate.

Yes, climate change.

What was your third?

Poverty. Climate and climate change; and sustainable agriculture, which can cover food, soil, and the works.

We don’t have to stop at the first three.

No, no.

Okay. We’ve come up with three. Let’s go have a break now [laughing]. Yes, I think that does summarize the key points of the past day. My thinking – Paul [Polak] is probably with me on this – is to be somewhat impish and try to find some backdoor way of thinking about these questions that is provocative. What that means, I’m not sure.

I’m good at the provocative shtick. Let me start out by saying that I absolutely hate “sustainable,” anything sustainable. I don’t think it’s sustainable.

Please explain.
POLAK: Okay. Probably the meaning of “socialism” became forever meaningless when Hitler formed the National Socialist Workers Party. We’re sort of at the same place with “sustainable.” Everybody jumped; everything is now sustainable. I saw a conference in which Coca-Cola Company and a number of other corporations were part of a sustainable group. Coca-Cola’s contribution to the group had to do with the slogan “Remarkable experience drop by drop.” They were advertising Coca-Cola®. When you talk about “sustainable,” you can talk about economic sustainability or sustainability in terms of environmental impact; you can talk about a thousand different sustainabilities. I can’t disagree with the intent behind the word, but the word has become meaningless.

MUSSE: In our little mini-list “sustainable” really came up in the context of sustainable agriculture. Did you want to clarify what you meant by the word “sustainable” in that context, and maybe get away from the problematic word?

MONTGOMERY: I actually don’t mind the semantic confusion because the concept is just fine. If the semantics have been co-opted, that’s really not an issue that I’m terribly concerned with.

CALVIN: I think the term “sustainability” is fine; it’s just that you have to broaden it in places. You have to get through the glitches as well as study the trends.

MONTGOMERY: That’s a good point.

CALVIN: People want to know what they can do to help. Sustainability is the easiest thing to focus on for most people to at least get them on the train.
is between sustainably managed forests that include timber production and multiple-use versus those that are all some crop such as palm oil, which would become monoculture. I would have problems using the word “agriculture.” I would settle for “sustainable use of biodiversity” or “sustainable use of biological resources.”

MONTGOMERY: Could you cover both bases by calling it “sustainable land use”? Biodiversity is fundamentally tied to land use.

One way of sustaining a piece of land in its productive situation might be to vary the kind of use you are putting it into over time.

ISHWARAN: I’m with Paul [Polak] on the word “sustainable.” I’m in the UN and I have to use it a lot. The words “integrated land use management” are better for me; that’s much more comfortable to try to bring in the different aspects together: ecological, economic, ethical, employment, and social. Everything should be sustained. One way of sustaining a piece of land in its productive situation might be to vary the kind of use you are putting it into over time.

If everybody wants it, I’ll live with it. But I think it’s better to use clearer terminologies in terms of what we are thinking. I have the MDGs [Millennium Development Goals] in my pocket if you want to review them. You can repeat that language, but the thing is to find something that is a bit clearer.

If everything should be sustained, should the accumulation of nuclear weapons be sustained?

POLAK: If everything should be sustained, should the accumulation of nuclear weapons be sustained?

ISHWARAN: Yes, as far as I’m concerned.

POLAK: Oh.

ISHWARAN: It’s there. You don’t think….

POLAK: The question is whether it’s sustainable in some definition.

MONTGOMERY: Not if they’re used.

ISHWARAN: The nuclear energy….

POLAK: I said nuclear weapons.

ISHWARAN: For me, that’s a subset.

Is the first priority feeding 9 billion people in terms of the use of land? Or are we talking about all of the other aspects of use of land?

POLAK: I’m just being overambitious. Part of the thing, again, is definitional. The change in your replacement word for “sustainable agriculture” is good, but the question is: What is it that is the high priority?

I would assume that a big part of the high priority is feeding 9 billion people. You can take the view that 9 billion people are too many. But if you’re talking about feeding 9 billion people, then “sustainable use of land and biodiversity” could include recreational facilities. Getting right to your area, is wildlife part of this or not? What’s the priority? Is the first priority feeding 9 billion people in terms of the use of land? Or are we talking about all of the other aspects of use of land?

ISHWARAN: First of all, 9 billion people is a number to come.

POLAK: Yes.

ISHWARAN: Out of the 9 billion, not everybody is starving. Feeding 9 billion people is not the problem. The problem is feeding the part of that 9 billion who are not being fed; that is the problem.

POLAK: Oh, then we need to clarify that. I’m switching hats. Most of my presentation was about feeding the people who are hungry, or dealing with poverty. Zooming out from that, one of the problems of agriculture over the next 50 years will be to feed 9 billion people, and I mean the total 9 billion. How does agriculture globally feed 9 billion people? That includes the people who eat a lot of meat, who use a disproportionate amount of protein, and so on. One of the problems facing the globe is feeding the total global population, whatever it is. Even though it’s not 9 billion now, we have to do an agricultural policy to feed the 9 billion. I’m talking about all of the 9 billion. To me, the first priority in the use of land is how to feed the 9 billion.
ISHWARAN: Yes, but feeding the 9 billion can’t be only an agriculture policy. If you’re going to feed the 9 billion people and assume they’re all going to eat the same way they’re eating now, then we’re in trouble.

POLAK: I’m making no assumptions. The basic issue is that we are very likely going to have 9 billion people on the planet. They are all likely going to have to eat. The only options include getting rid of some of them. Then within that, figuring out how they will eat and get all their needs met is all up in the air, as far as I’m concerned. But a problem facing the globe is how you will feed 9 billion people.

MONTGOMERY: The related question of why I started with the horrid word “sustainability” or “sustainable” is that at present we’re feeding people in a manner that will not allow us to continue doing so for the same number of people, whether that’s 6, 9, or 12 billion, over the long run. It’s just a question of the matter of the time frame, whether it’s a few decades or a few centuries.

The basic issue is that we’ve got to be able to devise an agriculture that’s capable of continuing – whatever word you want to assign to that and at whatever level we want to have – a quality of life. We need to be able to maintain the ability to feed people with the system that’s in place, so that it has to be maintainable, if we don’t want to call it “sustainable,” or “sustained.” There may be a better word for it. I see the fundamental challenge at the moment, or one of them, as the fact that we’re basically mining the biological productivity of the planet in order to feed the people who are on it at present. We risk being in the position of just running out the clock geologically.

CALVIN: Mining was also the metaphor that was coming to mind for me. One of the things we might consider, either as a fourth category or to fit it in someplace, is: When is it ethical to mine the Earth’s irreplaceable resources? When is it ethical to eat through the soil and wash it out to the ocean, and so forth, as one example? When is it ethical to use up all the groundwater in a non-replaceable fashion? There are clearly periods, for example, if you’ve had a big disruption where you may have to do that. But certainly the current American strategy of – I’m not quite sure whether I can even say it diplomatically or not….

POLAK: Don’t be diplomatic.

CALVIN: Certainly a strategy of using a lot of oil and a lot of mining to live better for now shows no thought for the future.

POLAK: Perhaps a useful example about mining is when people retire, and they have certain assets to live on. They can predict they’ll live a certain length of time. At what point do they make a judgment about using their capital?

CALVIN: That’s very good.

POLAK: The point is: If you make an estimate and you’re right and you die fairly quickly, or whatever, the issue is not to use your capital before you die. The reason that analogy is actually practical is that it is totally reasonable to overuse groundwater in a major drought if the probability is that it will be replenished. Not only that, some of the people I’ve talked to in Gujarat are knowingly overusing the aquifers for producing milk because they say, “In a couple of generations, we’ll have made enough money and we’ll all be in the city with better jobs.”

CALVIN: Right.

POLAK: Now, is that a good judgment or is that a bad judgment? Is that sustainable thinking or not sustainable thinking? They’re doing it knowing what they’re doing.

CALVIN: The problem is converting everything to money.
MUSSER: In that case there's also a problem in whose interest is at stake here. For those individuals, that may be the most rational approach, even if collectively, it's not.

The challenge is: How do you view the natural resources of this planet as a collective endowment?

MONTGOMERY: That's where I think maybe the better analogy than the retirement analogy would be a foundation. When you set up a foundation you endow it with enough to perpetuate it; whereas, with retirement, there is a sunset clause, and you're planning towards that. The challenge is: How do you view the natural resources of this planet as a collective endowment?

POLAK: Why don't we ask Walter how he sees that for his foundation?

BOB CITRON: Do you want me to answer for you, Walter?

WALTER KISTLER: Yes.

CITRON: Normally, we don't get involved in these discussions; we just listen. When Walter established the Foundation and became a benefactor, he stipulated that the assets he provided to the Foundation would never be used to operate the Foundation. The Foundation operates only on its earnings. In fact, we operate on less than half of the earnings. The endowment is actually growing pretty substantially every year.

When you have people exploding in growth, what do you do? We have a finite planet, finite arable land, and that's a serious problem. Do you want to add to that, Walter?

KISTLER: Yes. That's my personal view. The way things are going now, the planet is deteriorating; we'll eventually have less water. More and more water will become saline and not very good for irrigation.

As we heard yesterday, the soil is disappearing very slowly but steadily. And we have global warming on top of all that. Humanity is still happily multiplying and making babies as if there were no tomorrow. It's pretty obvious, I think. The unavoidable catastrophe will be coming, and humanity will be hit pretty badly, I think. It's Darwinism, survival of the fittest. Sometimes Nature fights back and starts smashing down; then the survivalists will survive. It has been so through the whole history and evolution of life on Earth. When all the dinosaurs disappeared, that was no small event; it was a relative catastrophe. That's the way life progresses. Maybe it would be boring if there weren't some changes – sometimes unpleasant, wild changes – and I think that's life.

POLAK: Thank you, Walter.

CALVIN: I'm just thinking about catastrophes versus sunset clauses, at least in terms of how one sells things to the public in areas where they have lots of experience; at least they've certainly heard about the problem of saving for retirement, etc. Applied to society, I don't think we want this. That is to say, just consider all of the Armageddon-like religions and a class of people who will seize upon this.

James Watt was the Secretary of Agriculture in the early Reagan administration. He was distinctly someone who thought you didn't have to save any of this because we were all going to heaven in short order. It was a matter that you could make whoopee with what's there.

MONTGOMERY: Party as if it's 1999.

MUSSER: In my attempt to be impish I've come up with a few other lists of three topics here. Our original list was: global warming and its effects, sustainable agriculture, and poverty. But on another axis, in thinking about the problem, there are three modes of change that we've really discussed here. There are the kind of secular changes to the steady loss of soil or the steady accumulation of greenhouse gases; there are extreme events that we need to plan for and risk-manage our way around; and then there is non-change – a lack of change in the stasis – that applies to a lot of the poverty issues Paul [Polak] deals with.

Another dimension in what's becoming a multidimensional approach to this involves three approaches to dealing with the three sets of problems. One is “land use management,” which clearly has to be a part of this; “energy demand,” which is obviously crucial for dealing with climate change; and “knowledge dif-
fusion,” which, perhaps, involves boiling down a lot of what IDE has done that is crucial to working on poverty issues. I’m actually fascinated by the latest trend in our discussion: Do we always have to be “sustainable”? The assumption is that “sustainable” equals “good”; maybe it doesn’t always.

We have such a productive society that we can spend more on pet food than we spend on X, Y, Z. There are a lot of choices, and we’re probably not making those choices very wisely.

CALVIN: As opposed to the second home, the third car, and the fourth computer? We have an enormous range of choice. We have such a productive society that we can spend more on pet food than we spend on X, Y, Z. There are a lot of choices, and we’re probably not making those choices very wisely.

MUSSER: Let me ask you this question, which is actually for the whole group. We obviously need to plan for major catastrophes of that sort. But what’s the proper level of investment in that kind of disaster planning versus other necessary uses of those resources…?

Is it conceivable … to perhaps allow that something catastrophic is inevitably going to happen, so that you react or anticipate, to the extent that you can…?

VELAMOOR: If I may intervene, based on what Walter said, an expression you hear quite often in the business world is “creative destruction.” This puts forth the idea that a company such as IBM, which operates within a paradigm and then finds itself on the verge of failure, creates the requirement to remake itself completely so it is able to even survive. Is it conceivable, thinking in terms of how Walter said at the end, “This is life,” to perhaps allow that something catastrophic is inevitably going to happen, so that you react or anticipate, to the extent that you can, and then the lessons learned form the basis for getting organized in the right way?

KISTLER: That’s the reason for the Foundation For the Future: to allow humanity at least to look ahead, worry, and be concerned about the problem. People tend to see things in pink – mostly the nice things, positive things. The idea of the Foundation is to make people aware of the dangers, the negative things, and be prepared at least for what I consider unavoidable catastrophe, or let’s call it “big change,” that we will experience; it’s unavoidable, but at least it’s good to be prepared, to think and worry about it.

CALVIN: Just briefly, the other thing I’d add is that not all of these preparations really require reacting to things. The unstable hillsides are a good example of the fact that if you just remove the stuff and throw it into the ocean slowly, you avoid the problem entirely. It’s only civil engineering, after all.
You have a dream; you have a vision; you are committed to that vision, and you realize that 70% of what happens is totally beyond your control.

**POLAK:** Part of this is a broader thing. As I heard the two of you talking, I was feeling that it’s the way you live your life. This is the way I’ve lived my life. You have a dream; you have a vision; you are committed to that vision, and you realize that 70% of what happens is totally beyond your control.

**MUSSER:** 70%?

**POLAK:** Or 90%. You tend to respond to opportunities and threats creatively. Part of this is unplannable. Much of life is unplannable. This is what I get from what you were saying, and that is the reality of my involvement with IDE for 25 years. In everybody’s life, a big part of the variation is unpredictable and unplannable. You have to have a clear vision and be able to respond. Then you can take the threats and turn them into opportunities. It starts with a posture. Then you can do certain things to give you a better chance of this bonding between the threats and the opportunities.

**ISHWARAN:** There’s an old Tamil song – a question and answer song – and one question is, “What do you control?” The answer is “yourself.” I think total control is only possible for each of us individually. We are all in situations where we are working with other people at other institutions. Whenever we say, “We are this,” the question is, “Whom are we representing?” The word “we” gets used a lot in these forums. I use it, too. Who is “we”?

I think whenever it comes to a group, making choices and making decisions are not easy. They involve a certain level of talking through and agreeing on things. Now we are talking planetary scale. There is no system or mechanism to come to planetary-level choices and decisions; it’s not there. The UN is there to provide a forum for discussion of planetary-level issues and problems. But whether the UN is the organ where planetary-level choices can be made is a big question. Having a forum is not the same as having a mechanism for choosing and deciding. I think that’s a big problem that will be there for at least another hundred years as far as I can see.

There is no system or mechanism to come to planetary-level choices and decisions … that’s a big problem that will be there for at least another hundred years …

... adaptation should occur along important trajectories … to include fish, ocean resources, etc. I think more and more human enterprise will extend out into the sea.

That’s where, I think, when you say “Priorities for the planet,” for me, those have to start on the assumption – and I am with Walter on this point – that things are going to change. Some of the changes will be catastrophic. For me, what is important is the readiness to adapt. That’s important. But what do you adapt to? That’s the question. For me, adaptation should occur along important trajectories in terms of “biology” – rather than “land” – to include fish, ocean resources, etc. I think more and more human enterprise will extend out into the sea.

The second, for me, even though it didn’t come up, is human arrangement, manmade arrangement, to organize, design, and plan. We try to control; I think we can only tinker. Unless you’re totally in charge of a system of government where nobody else tries to object to anything, total control is not possible. Planning in itself is an exercise; it’s a nice, intellectual exercise. But to make the plan happen, to execute something, is not easy, particularly if the plan has to do with two different groups. There are differences. I think that is a real issue: how groups come together, make choices, and decide. Then how do you make it happen? For me, those would be the three most important things. I think climate change involves our use of resources. It’s happening; it’s beyond a point. I think we can mitigate it to some extent now, but we are beyond mitigation. Now it’s adaptation for which we should prepare.
... there is perhaps the largest class of choice, which is some kind of emergent collective choice, where there's no guiding hand ... it just happens.

MUSSER: The whole question of choices is another dimension in our problem; I can try to synthesize. There are the individual choices that some of us – unfortunately, not me – have made to buy our fourth home; to endow foundations; or to attend sessions such as this one. There are collective, explicit choices, such as the ones you described being made perhaps a hundred years from now where the human race collectively comes together and says: “We need to set certain priorities.” But there is perhaps the largest class of choice, which is some kind of emergent collective choice, where there's no guiding hand. It's an invisible hand; it just happens.

ISHWARAN: It’s natural selection or market.

CALVIN: Natural selection comes later. This is about the emergence of pattern, like the crystallization forming now in the bottom of your glass of iced tea.

ISHWARAN: I understand. The time scales are different. Still, it falls into this general category of invisible hand, whether that's natural selection or markets, or sometimes God, right? Some things are not totally explainable in terms of their components, but they provide a framework for understanding certain things and for us to formulate hypotheses and test other things. What is an invisible hand?

POLAK: I think that if we start with the assumption that this whole process is one in which many of the variables are uncontrollable, then the questions are, “What is the vision?” “What is the direction?” To me, it’s hard to get a clear vision because there are several things that I am very murky about. I’m not an expert on climate control.

CALVIN: No one is.

POLAK: No, but hearing David [Wasdell] and you talk about climate control or climate change, I come away without a clear feeling about how imminent an irreversible course is. I know David is very passionate that it's just around the corner, but I see him as very passionately believing in a point of view that sounds extreme without knowing all aspects. I would be very much reassured if I heard more discussion from several people who are very much immersed in this field about how imminent an irreversible downward spiral is in front of us.

The situation we have with climate now is saying, from a couple of directions, that somewhat irreversible changes are already in motion.

CALVIN: This is about like the situation where you’ve now got the technology, and you discover someone’s carotid artery is almost plugged up and they're very likely to suffer a stroke sometime soon. You don’t know exactly when. Some people will never have one; some will have a stroke the next day. It’s that kind of situation we’re in. We’ve got the technology in terms of scientific methodology to discover it’s happened a lot of times in the past; it’s not just a theoretical thing the way global warming was at the beginning where we weren’t quite sure, back in the ’60s. We had good, visible principles to say that this ought to happen, but we weren’t sure that something wouldn’t come along to counter it.

The situation we have with climate now is saying, from a couple of directions, that somewhat irreversible changes are already in motion. It’s just like that artery closing down to 10% of its original diameter. We now know that every little 1% change in that diameter is going to translate into a 4% change in the blood volume that can be pumped through, and we know the chances for forming clots on the far side, in the back of these arteries. That’s the kind of situation we’re in with the climate. You can’t give a time-to-failure down the road, but you can say that it’s sure to the point that unless you fix this, you’re not going to live very long.

Is there some way of coming up with a realistic carbon objective to significantly change the probability of the environment having a “stroke”?

POLAK: In each of the presentations, I’m very much oriented to practical solutions. When you gave your presentation, David [Montgomery], I wanted to know what you would do in that area close to here where the soils are eroding. There are some, happily, clear things that you could do in that situation. I don't get a clear picture of a practical course of action in terms of
climate change. Is there some way of coming up with a realistic carbon objective to significantly change the probability of the environment having a “stroke”?

**CALVIN:** The problem is that you’ve got multiple routes to failure. Even if I can give you a timeline for one of them, I can’t guarantee that one of the other routes won’t preempt it. The fastest train that gets there preempts all the others.

**POLAK:** If I may interrupt, let’s say that’s true of the artery that you mentioned. A physician is likely to prescribe cholesterol-lowering medication, exercise, and diet.

**CALVIN:** Right.

**POLAK:** There may be even the procedure to come in and mechanically widen the lumen of the artery.

**ISHWARAN:** Inserting a stent.

**CALVIN:** You also have a chance of stirring up more trouble.

**POLAK:** Exactly. What I think is very useful for us is asking: What are those various analogous procedures that you can use to change the odds with no certainty? That’s where we’re starting from. It’s uncontrollable and there are variables totally beyond prediction. There are certain things that we can do that change the probabilities, right? What are those things?

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*I’m not sure we can do much about the rainfall into the ocean except by getting at the source – global warming – in the first place.*

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**CALVIN:** For some things, like the hillsides falling into the oceans, there are clear things we can do of a civil engineering nature. Carotid arteries might collapse on you at the time, but nonetheless, it’s a familiar enough problem that you might think of tackling it.

For things like the failure of the Gulf Stream in the North Atlantic Current, there are at least four ways that you can get enough dilution of the Greenland Sea and the Labrador Sea to cause failure. One is just spontaneous. For example, in some decades the Greenland Sea flushing is way down by 90% but the Labrador Sea is strong. What if both of them go down at the same time? That’s a spontaneous route. We just don’t understand those weather systems enough to know if they are linked in such a way that might be safe, never failing both at the same time. We just don’t know that yet.

The second route is a steady dilution of the Greenland Sea and Labrador Sea by rainfall into the ocean. We know where the additional rainfall comes from: it’s global warming. It’s additional evaporation from the hotter equator that’s putting a lot more humidity, I suspect, into the entire atmosphere. Since humidity is also the biggest greenhouse gas of all – it accounts for about 60-some percent of the greenhouse effect – we’re probably also changing the heat-trapping capacities of the Earth, which is a positive-feedback system. You have that problem. I’m not sure we can do much about the rainfall into the ocean except by getting at the source – global warming – in the first place.

The third route is the melting of Greenland, the steady trickle of water right in on the surface, right where it does the most harm. Both Labrador Sea and Greenland Sea sites are very close to being fjord systems that empty that out. It’s freshwater coming into exactly the wrong places. We might be able to divert some of that to a safer place; I don’t know.

The fourth one is, really, the floods that can result from that Greenland melt. You can get big meltwater lakes that form. The ice dams, which have come in from the sides of the fjord and blocked the meltwater, can build up for years, holding the meltwater lakes until the dam gives way; then all this water comes sluicing out at once. You could kill the circulation of either the Greenland Sea or Labrador Sea in that way, perhaps at a time when the natural oscillation had the other one down. Now, that’s an easy problem to solve. You just have to send a helicopter with somebody that can lower some dynamite sticks down into the right place; just stand off and blow them. You do that when the ice dam has been there only a few weeks. A certain amount of water will come out, but the threat would be eliminated. There are all these ways that you can tackle some of the problems, but you can’t guarantee that other ones won’t be there. So you can’t do a time-to-failure.

**POLAK:** No, but if you forget about time-to-failure, what would be especially interesting to me is that if you run through all this again and cancel out the Chicken Little side and talk only about the Horatio Alger side, what are the opportunities to drop dynamite? What are the positive things that can be done at each of these points, if any?
**MUSSER:** This conversation might go on a little bit about climate change; we’ve got only a couple of minutes. Let’s try to synthesize what we can from our conversation so we can have something semi-polished to say to the other group. Are there any thoughts?

... people are trading carbon credits ... to redirect or reengineer financing and incentive schemes to better alter land use and biological resources patterns.

**ISHWARAN:** If I may go on what was exchanged a few minutes ago regarding whatever long-term geographical and social consequences of climate change occur in the next hundred years, there are certain immediate things that are happening now. For example, people are trading carbon credits. Whether that is ethically correct or not is not something I’m going to get into, but it is giving some interesting opportunities to redirect or reengineer financing and incentive schemes to better alter land use and biological resources patterns. I think we should look into those things, also. Whatever we say about the explanatory basis of climate change – why it is happening or how it will happen – society is already responding to opportunities created by that phenomenon. If those opportunities are not used in a way where they go towards a different climatic future the next time around, then we are failing to take advantage of an opportunity.

**POLAK:** From what I gather from what both you and David [Montgomery] said, that’s a very useful thing. But what I’m hearing is that we need to act globally, and the consensus is that the Kyoto Accords would not be anywhere close enough to changing the outcome.

**CALVIN:** No.

**POLAK:** I think what’s fairly clear from our best information is that we need an immediate action that goes far beyond the Kyoto Accords in terms of carbon emissions.

**MUSSER:** Let’s not get into specific climate change mitigation strategies by trying to summarize our thinking. Maybe what we’re trying to get at is that we have knowledge of the climate system. Now we really need to develop particular direct interventions.

**POLAK:** It seems to me that we can take that same approach to all three of the things that we came up with, which we didn’t have enough chance to discuss. There are very specific practical actions, which go far beyond current agendas on the world scene, that need to be taken.

**CALVIN:** The most obvious one, really, is to get off carbon by developing other portable power sources, whether it’s hydrogen, nuclear, or whatnot. We just have to have a major replacement of the problem-causing stuff, which is typically oil and deforestation.

**MUSSER:** David, do you have an analogous set of proposals for dealing with soil loss, for example?

**MONTGOMERY:** Yes. Essentially if you’re talking about society directing things, developing policies that actually promote a no-till, organic culture in smaller farms and promote agricultural practices that do not inherently mine the future, that would be a sea change in terms of policy. It sounds as if what we’ve just discussed in terms of climate change is that the time is essentially here for implementing policies that have the potential to actually move the ball downfield. It seems as if the consensus is that the policies that are in place might hold the line or be losing ground at a lower rate, but they’re not actually making progress on solving the problem. Yet there are suggestions that could be made for soil as well.
… there needs to be an immediate shift to income generation from small farms as a major approach to poverty, done in a sustainable way …

POLAK: On the poverty front, I don’t know how much you would agree with my position, but I would say that there needs to be an immediate shift to income generation from small farms as a major approach to poverty, done in a sustainable way (even though I hate the term “sustainable”).

… the main thing is to empower and enable people to bring themselves out of poverty, rather than trying to subsidize them out of poverty.

ISHWARAN: I agree. I think for poverty, the main thing is to empower and enable people to bring themselves out of poverty, rather than trying to subsidize them out of poverty. That’s what I think it could be for small farms. If it’s the urban poor, it might have to be other things, maybe some kind of entrepreneurial measure.

You talked about no-till agriculture. That has links to carbon sequestration and other possibilities, too. Some of these things are interlinked. That is where I think sometimes it is not very clever to isolate these issues from each other. What is important is to maximize the use of existing knowledge, whether that is in the climate front, the biodiversity front, or the farming front, to make decisions and judgments that will move towards the next round of our interaction with the global resource base so that those future interactions would be better than what we have done in the past. That’s what we can do, I think.

POLAK: By the way, the reason that the first priority should be rural is that most of the people who are poor are rural. A meaningful approach integrates crops, fish, livestock, and forest.

ISHWARAN: And wildlife.

POLAK: Again, wildlife is not necessary. It can be a source of income for the poor, as well, but absolutely, forest gathering, fish, and animals, in addition to crops, are the livelihoods, the ways of increasing the income for the poor.

Maybe the opportunity is to simultaneously address all three over the long run; maybe that is where a lot of action, policy, and support ought to be focused.

MONTGOMERY: In terms of all three of these things, it seems that there are strategies and policies that could be proposed and pursued to help on all three and address the interconnectedness. Maybe one of the priorities that we could discuss, advertise, or disagree on, is that they shouldn’t be viewed in isolation. Maybe the opportunity is to simultaneously address all three over the long run; maybe that is where a lot of action, policy, and support ought to be focused.

MUSSER: I think that’s a good place to end because I see the other group is adjourning.

There’s one thing to think about over the break, because it’s probably going to come up in the subsequent discussion. Although we’ve talked about the knowledge of what’s happening and a very sketchy, but reasonable, set of actions, we haven’t talked about the third link of it, and that’s how to convince people to actually do all this. Maybe just ponder that.

VELAMOOR: Thank you, all. We’ll now dismiss the breakout discussion group and reconvene with the larger group.
PARTICIPANTS: David Wasdell (Lead)
W. Wayt Gibbs
P.C. Kesavan
Michael A. Treder

WASDELL (LEAD): The job for this group is to discuss the priorities and come up with three by the end of this session. Then those will feed in.

KESAVAN: Three priorities?

WASDELL: Right.

TREDER: We've each already submitted our own priorities.

WASDELL: My sense is that in terms of the dynamics, the task of this group is to reduce complexity to simplicity, and to lose most of the richness on the way. Let's just be aware of that dynamic and try to stay in touch with the depth, richness, and focus. Let's keep all those in mind.

TREDER: I agree.

WASDELL: In terms of Lead, I shall do very little. I shall also be a participant, not just the Lead. That's important for my part. I came here as a participant in a dual role. I will show you as little Lead as possible.

TREDER: I believe it would be useful for us to have a board, or flip chart, or some way for us to write down something for the group to see.

VELAMOOR: Okay.

WASDELL: How do you want to begin?

TREDER: Perhaps each of us should take 30 seconds or a minute to describe our initial three ideas for what the most important priorities are.

GIBBS: Seems like a good start.

TREDER: I'll describe the three most critical priorities/characteristics facing the planet going forward into the future. This is a really great exercise to think about. I came up with three. One covers what I would see as the next couple of decades; another covers, roughly, the next half century; and a third covers until the end of the century. Actually, I've switched the order I listed them in.

First of all, the focus of my talk yesterday was surviving the entry into the nanotech era. I don't need to elucidate on that. My belief is that unless we get through that gate safely, there won't be any other problems for us to worry about. We have the potential, perhaps not to destroy all of humanity, but to go backwards far enough that all other issues will be reduced simply to a matter of survival. That's challenge Number 1 in my view. The technology that has the nearest and most severe potential for catastrophic damage is nanotechnology.

Second will be whatever is in my list here as Number 3. In the next half century or so I believe that humans will expand their capabilities through genetic engineering and through their connection with machine intelligence, or even through creation of completely artificial intelligence. We will come into
a time when we’ll have to deal with the existence of various non-equivalent classes as opposed to human descendants. That will be a difficult era. It’s the first time in a million years or so that we will have more species, if you will, of intelligent life on Earth than just Homo sapiens. It will be a time of post-Homo sapiens. (A philosopher friend of mine says Homo big-headed is the species we’ll have to be dealing with.) In an era of non-equivalent classes of post-humanity, the challenge of maintaining freedom, liberty, etc., will be something new that we haven’t faced. It will be a new class of challenge. I think that’s something that we’ve not yet had enough time to deal with.

Third will be the one I mentioned yesterday, which is expanding our habitats beyond Earth. I think, similar to the Apollo project in the 1960s, we should have a global habitat-expansion project by the end of the century to create a thriving, sustainable nest of humanity beyond Planet Earth.

Those are my three.

Unless all the multinational biotechnology companies … immediately start to conserve biodiversity, both the technology and the beneficiaries … will perish.

KESAVAN: The previous speaker, Mike Treder, has already covered some of the points I wanted to talk about. I would like to be specific with regard to a couple of important issues in terms of technology facing not only mankind, but also Nature.

Take, for example, biotechnology. It has come to be, today, a commercially driven field. This biotechnology, unfortunately, does not recognize that biodiversity is the feedstock of biotechnology so far as agricultural biotechnology is concerned. Unless all the multinational biotechnology companies, most of which are based in the United States, immediately start to conserve biodiversity, both the technology and the beneficiaries for whom it is working – namely, humans – will perish.

... similar to the Apollo project in the 1960s, we should have a global habitat-expansion project ... to create a thriving, sustainable nest of humanity ... beyond Planet Earth ...

The other important thing is the attitude of the humans. Today, I am very disturbed that with all the positive gains on one side, there is a very unfortunate pull on the other side: humans against humans. Despite enormous advances in technology, maybe because science and technology have not been created in all parts of the globe, there is, unfortunately, stagnation in human minds, and acceleration of religious fundamentalism. This, in fact, has emerged as the greatest enemy of humankind. Although I hear some people say that it will be all right over a period of time, I don’t think there is much time to lose on this. All of your gains will be wasted, just like a ship filled with precious jewels, gold, and diamonds sinking, drowning in the sea. That kind of situation should not be allowed to happen.

Humanity, I have great faith, will be able to rise above many of these situations, but the need is to address these issues now, no matter how. All the democratic nations of the world must get together to solve this problem, to overcome this.

TREDER: Could I ask you to state in just a few words each of those three, so we can write them on the board? What are your top three?

KESAVAN: The top three are “technology,” the technical pull; “biotechnology,” balanced with biodiversity conservation; and “the advances of humankind,” the progress in science and technology, being pulled by certain religious fundamentalism.

TREDER: It’s the challenge of religious fundamentalism.

KESAVAN: The progress in science and technology is being challenged by that.

WASDELL: The phrase you used was “humans against humans,” wasn’t it?

KESAVAN: Yes, this is exactly religious fundamentalism.

WASDELL: It’s wider than the religious aspect, as well.

KESAVAN: The words came from another source. You
have to polish it in a better way. What I mean by “humans against humans” is that groups and causes attacking each other are also humans. That’s what I meant.

To the extent that one can get the rich societies using different energy sources, one can free up energy at lower cost for use in alleviating poverty …

GIBBS: In a priority-setting exercise, it seems to me that one of the most important principles is to try to identify those issues that are not only important, but those about which we have the knowledge to act now.

There are a whole class of significant, disturbing global issues for which the means to act have not really been fully discovered yet. That sets a research agenda, but not necessarily a priority for taking policy steps. In deciding which ones are actual priorities now, I agree, to a certain extent, that you have to have this ethical pull. But ethical pull has this connotation of a change, a shift in values. It’s an education of the world to help people appreciate things in ways they don’t currently. It’s absolutely essential in the long term, unquestionably. It is, however, extremely difficult to accomplish. It’s not easy, nor is it entirely clear, how one goes about accomplishing it. From my perspective, when one identifies the most critical, high-priority issues, they’re the ones where we have enough knowledge about the time frame of the challenge, the magnitude of the threat, and what we can do about it to basically demand of our government structures that they take the appropriate steps.

I identified in my write-up three areas where I think that clearly applies. One is in engineering better ways to produce and use energy. I see that as a fundamental, enabling advance for a lot of the other improvements that we want to accomplish, including, for example, in agriculture and poverty alleviation. To the extent that one can get the rich societies using different energy sources, one can free up energy at lower cost for use in alleviating poverty and improving agriculture. It’s a fundamental input for those.

The current rates of land conversion are clearly unsustainable; there are ways to slow those that have been demonstrated.

Second is improving land use efficiency and restraining land conversion. The current rates of land conversion are clearly unsustainable; there are ways to slow those that have been demonstrated. The problem is appreciated, so it doesn’t require, I think, an ethical change; however, in the absence of quick action on that front, biodiversity is not going to be available for much longer.

The third gets to this question of ethical pull. There are activities that can be done now to start work on that. It’s urgent that we try to widen the scope, horizon, and politics so that they take into account these more abstract, or intangible, resources that have been taken for granted and subjected to “the tragedy of the commons.” This is where I think market-based mechanisms and advances in economic thinking can play a tremendous role in re-directing the use of financial resources and human self-interest, the goal of which is directed to more sustainable ends.

WASDELL: You spoke about the critical, high-priority challenges as the ones that can have something done about them in the current. Can I ask you to step back a little bit? Our task is to identify critical challenges facing the planet, which may not be in that short a time scale. How would that change the way you bring in, perhaps, things we may not, at the moment, know what to do with? You identified critical issues facing the planet. I find this a difficult agenda to address. Like you, I want to get to the immediate. It’s one I’d love you to struggle with.

If we were to live long enough to develop a society based on carbon-free energy, we would still be subject, eventually, to climate change.

GIBBS: This is something that, in the course of putting together our “Crossroads for Planet Earth” special issue, we did struggle with, quite a lot. The reason is that there are some forces to which humanity is going to be subject, and there is just no way that we know of around that. It could be that climate change includes
a component of that, to the extent that climate change happens in ways that are not anthropogenic, which, of course, it does.

If we were to live long enough to develop a society based on carbon-free energy, we would still be subject, eventually, to climate change. Maybe our technology will advance to the point that we'll have a firm enough understanding of climatic systems to understand at what points we could intervene to control them to suit us, but it may be that that is not possible. Because of the abrupt changes that do happen for so many reasons that are so hard to predict, we're simply susceptible to those forces. Should that be a critical issue? It's critical in the sense that – and I agree completely with Bill Calvin on this – one needs to try to design our society to be resilient against those changes. That's something we do know how to do, to a certain extent. In fact, we've done that, to a degree, by designing, especially in richer nations, for the alleviation of natural disasters. You've sketched out how that routinely happens now, as well, in medium-income countries. Can we adapt those systems for larger-scale, climate-wide changes? Maybe; maybe not.

**TREDER:** Wayt, you just mentioned resiliency, increasing or developing civilization resiliency. David, when you asked Wayt to try to expand beyond his immediate goals, would resiliency be one of those larger-scale, longer-term goals? Is that something we should talk about here?

**WASDELL:** Resiliency is a response to the problem, and one of the ways of developing response-ability. The issue is vulnerability to issues where we may not have, at the moment, ways of handling them. These are the big elephants sitting around in the room...

**GIBBS:** These are two sides of the same coin, aren't they? There are vulnerabilities to the planet and humanity for which we have no good proposals that alleviate. We're stuck with them, essentially. We're vulnerable because of our ignorance about what we could do to change those vulnerabilities. What I'm suggesting, I guess, at the root, is that it's maybe not necessarily a realistic goal to try to reduce all of our vulnerabilities to zero.

If one accepts that, then this is the mirror side which is: How do we create mechanisms so that we can adapt? When these bad things happen to us, how do we survive them and do better than surviving?

**WASDELL:** Thank you. I really appreciate how you got into that. This whole buildup of resilience is critical.

**TREDER:** I think what Wayt said is really critical, about the fact that we will never reduce our vulnerability to zero. Our goal needs to be reducing vulnerability as much as possible while, at the same time, increasing resiliency.

**WASDELL:** I struggled with the question for the three critical priorities or characteristics facing the planet going forward. I think every single participant, apart from me, came up with priorities facing humanity, going forward. I struggled, and I rewrote, and I reframed this to make it a terra-centered, a planet-centered perspective. I almost wrote from the place...
of, “If I were Gaia, what would I be talking to you about?”

Ecology, from a planetary perspective – how the viability, the sustainability, the complexity of the adaptive system that makes the planetary environment one that sustains life – how is that, itself, going to be sustained? Is the critical question facing the planet for the next millennium – it is a millennium-scale issue, not something we humans can do much about at the moment – about how the planetary system responds to this extraordinary biota that it has created, bred, resourced, and is now facing the consequences of?

We have that presentation about bringing in bio….

KESAVAN: Biodiversity?

If you were looking at the pest control of the human pest, on behalf of Gaia, what would you do next? It’s out of all control, and it’s threatening the whole life support system …

WASDELL: No, biological pest control. If you were looking at the pest control of the human pest, on behalf of Gaia, what would you do next? It’s out of all control, and it’s threatening the whole life support system that you have spent billions of years nurturing. That was my first one: the ecological perspective from the planetary view.

… the unconscious, the less conscious, the shadow side of humanity is its own worst enemy.

The second one was the issue of the psychology of the pest, which I think brings up the issue of fundamentalism, human response. Yes, I know our conversations here have to do with the conscious understanding of what’s going on. But the unconscious, the less conscious, the shadow side of humanity is its own worst enemy. It is the dysfunctional behavior of this pest, in response to threats from its environment, which can actually see the environment as responsible and go to war on the environment, rather than saying, “We are responsible,” going to work on our own response. The second issue facing the planet would be how Gaia – if you like that term – deals with this psychotic species that is threatening its very habitat. There’s a lot of work being done on that. This is my life’s field. The work on climate is simply a contextualizing for that particular area.

My third point is that Homo replicans, Homo unconscious, and Homo technans are three facets of the pest. The technology that we use is value-neutral. This is something you brought up yesterday, Mike. Technology itself can be immensely destructive to the environment, the way we destroy soils, yes, but also, the way we destroy each other. The split between Pakistan and India, for instance, is holding the clash of civilizations with bloody history behind it.

The technology we have now to destroy environments is more massive than anything we have ever had in the past. You combine nanotechnology with nuclear technology, and the capacity for environmental destruction (in order to give subgroups a so-called advantage) is vast. I’ll give an illustration.

About two years ago I was the process consultant for the World Health Organization authorities’ global meeting on leadership. While I was there, it became clear that the best minds working in the field of biological engineering and biotechnology were being brought together to work on how to make the Ebola virus capable of survival as an airborne or droplet-borne organism. Secondly, they were exploring how to enable the smallpox organism to become immune to all drug attack. Those two capacities, again from the US military intelligence, were going on at the same time as the World Health Organization was trying to wipe out things like malaria, etc., as well as the AIDS epidemic, which is a huge threat on which we’re still expending massive resources.

Here we get the same technologies being used to destroy as to create. Kali, I think, rules as Creator/Destroyer. This power is embedded in it. This is what I meant when I said that Gaia needs to keep her eye very sharply on emerging technologies of this extraordinary biota.

So I have my three: “ecology,” “psychology,” and “technology.” The greatest of those, in my understanding, is the psychology, because it governs how the other two are engaged.
GIBBS: I’m struck by the commonalities in our lists here and how we’ve arrived from different perspectives at similar concepts. Regarding the psychology that you speak of, it’s interesting to note that, historically, multiple numbers of technological developments have enabled one group of people to basically destroy a great fraction of others. You mentioned a few examples – nuclear weapons are, of course, the preeminent one – that have not been used for large-scale destruction, with the exception of the two atomic bombs used in the Second World War. Arguably, the reason for that is that there are counter-balancing psychological/ethical/political/economic forces on my list. It’s an interesting question: Did those arise naturally? Can one count on those arising in the future? And, will they, to a certain extent, prevent technologies from being used for massive self-destruction? There’s great pessimism, which is probably warranted, that it’s rather inevitable as we produce more and more technologies capable of destroying us that at some point, they’re going to be used. I wonder now whether that’s not necessarily true, whether there’s a way around that.

WASDELL: Wayt, I’m not saying psychology is always about the shadow. There’s an ambiguity and an ambivalence here that is fraught right through the system about using our human psyche for the ultimate achievements of humanity, and that it is also flawed. We have to live with that reality. I think that’s what I’m saying. In terms of the destruction of the nuclear program, the resources used in the nuclear armaments program have been colossal. The destruction of the resource base of the Earth, because of the nuclear engagement, has already happened, and is still going on. I think it’s not just about the exploration of nuclear energy; it’s about the energies that have gone into the program. Let’s not get too diverted. I love the idea you’re bringing in here, which is of convergence around this material.

TREDER: First, I want to follow up on David’s comment about technology. The power of technology is valueless; it’s becoming increasingly empowered. As I mentioned in my talk yesterday, I want to make sure we realize that it is not always a dichotomy. It’s not just that we use it for good or we use it for bad. Often, the intended uses for good result in damage to humans or to the planet. As the power of technology grows, the danger of unintended consequences becomes greater because their magnitude is greater. That’s one of the things we’re concerned about with nanotechnology and molecular manufacturing. It will enable, for the first time, what we call planet-scale engineering. Unless that is thought through very carefully, projects that could be undertaken inexpensively and rapidly might have really catastrophic, unintended effects on the planet.

KESAVAN: I’d like to, again, emphasize that all technologies require resources. Biotechnology, particularly, delves deeply into biodiversity. You cannot produce a gene unless you know what the characteristics are; therefore, you necessarily have to go into biodiversity. Only when I’ve been talking about this do people understand and say, “Yes, yes, yes.” Is there a gene for salinity tolerance? If this gene is not present in a certain species, where would you get it from? You can’t synthesize, no matter how hard you try.

TREDER: There’s artificial evolution, but it’s much more efficient to go with Nature’s way.
If you ask me: “What is the greatest threat facing this planet?” It’s ecology.

KESAVAN: No, artificial evolution has a long way to go. You don’t know the end point of it. You are entering a tunnel; you don’t know what is on the other side of the tunnel. Therefore, I would like to place emphasis on ecology, as was pointed out by David. Number 1 is ecology. If you ask me: “What is the greatest threat facing this planet?” It’s ecology.

WASDELL: Is there a commonality between the four of us?

TREDER: Absolutely.

WASDELL: Can we just pinpoint that? That’s what I heard.

KESAVAN: I think no ecology means no humanity, no matter what advances in technology occur. Next comes psychology. I have put it into different language; others with a better English vocabulary could put it in a better way. “Psychotic” is fine; that word I understand, and I totally agree with you. That is exactly what we are talking about. With all the advances on one side, you also have these opposites. As you rightly pointed out, the problem is not the definition of nuclear weapons; it is the resources taken up by the nuclear industry or any other. Come to think of it, I totally agree with your list of ecology, psychology, and a whole lot of other things that we have been talking about. I think that David has been putting it all together in order to get a commonality, a convergence of the whole thing. I think that’s quite good.

There’s one more thing. We talk about vulnerability and resilience. Once we are into your aspects of ecology and psychology, then vulnerability and resilience could also be taken care of automatically, I think.

TREDER: P.C., your statement, “Without ecology, we have no humanity,” is obviously true. I can’t argue with that. I will argue, however, with the statement that it is our single, most immediate, highest priority. I believe that unless we respond to David’s Number 3 (“technology”) and my Number 1 (“establishing the safe introduction of new, powerful technologies”) first, the immediate challenge of surviving the power unleashed by technology is a higher priority.

Ecological impacts we’re creating won’t matter if we succeed in wiping ourselves off the planet first. David talked about Gaia – I like his approach there – and I would comment that Gaia has no particular interest in us as humans. Gaia is concerned about the planet as a whole, as a holistic being, theoretically.

WASDELL: Gaia isn’t concerned about anything. “It’s all a system,” is what she said.

TREDER: Right. There’s not an anthropocentric viewpoint there. Whether or not humans survive, the planetary ecology will continue. It is resilient and will respond. It’s up to us, however, to make sure that we survive long enough to play a role in how that ecological response takes place.

There is a tendency when facing an overarching agenda as we have – key priorities for a thousand years – to reduce it to what we can immediately get to.

WASDELL: Can we break here? I think there’s a system-order issue here, in which, as David Baum says, every system has a context; therefore, the contextual system is the ecology. It’s the whole Gaia system. I’m not using the term Gaia in the anthropomorphic sense, at all; it is an adapted system that has emerged. That provides the context, within which all the subsystems are dependent and interdependent entities. I think the issue of order, the order of system, is critical. That’s why I put ecology on the front end. I think there is also an issue between overall issues and strategic response and tactical response. There is a tendency when facing an overarching agenda as we have – key priorities for a thousand years – to reduce it to what we can immediately get to. That is a simplification.

The tactics thing may be our next job. But keep it in the context of the overall issues and priorities of the macro system and its contained subsystems. I think this helps us to get some sense of ordering values into what we’re doing this morning.

TREDER: I agree.
We're faced with these new technologies that have the potential to be highly disruptive … What can we do to restrain … human behaviors to reduce that vulnerability?

GIBBS: I think that's an excellent point. Nanotechnology is one of a family of technologies, biotech being another one, where we don't fully appreciate their potential but we know they're profound. We cannot anticipate, honestly, how they're going to evolve. We can try, but the history of technological forecasting is not a pretty picture. It would certainly be useful to think about this in a broader perspective, as you're suggesting, so that maybe one can try to arrive at a strategy that is more generally applicable. We're faced with these new technologies that have the potential to be highly disruptive and highly damaging not only to human populations but to the environment that sustains them. What can we do to restrain or circumscribe human behaviors to reduce that vulnerability?

WASDELL: Can we capture that? That seems to be an emergent idea.

TREDER: Do you want to say that again?

GIBBS: When faced with new, highly destructive technologies that have the potential to damage humanity as well as the natural systems that sustain humanity, is there a general strategy that one can apply to reduce the vulnerability posed by those?

WASDELL: What is a general strategy to reduce vulnerability to unpredictable threat?

KESAVAN: “Unforeseen” threat.

GIBBS: Right.

It's complexity that we're dealing with. You cannot, from initial conditions as we know them, say, “This is going to happen.”

WASDELL: Technically, “unpredictable” might be the word. It's complexity that we're dealing with. You cannot, from initial conditions as we know them, say, “This is going to happen.”

GIBBS: A major reason for that is that humans are part of the system, and humans have free will.

WASDELL: Absolutely.

TREDER: The question could read “… new and highly destructive technologies with capacity to …”

WASDELL: “… disrupt both humanity and its holding environment.”

TREDER: “Ecology” or “environment”?

WASDELL: “Holding environment” rather than “ecology.” “Ecology” has received too much common use. “Holding environment” is my better term, if that's okay with everyone.

TREDER: That's too vague. “Biosphere”?

WASDELL: Yes, let's use “… and its biosphere” – as if we own it.

TREDER: Wayt, does it matter if we choose “unforeseeable” or “unpredictable”?

GIBBS: I think, basically, they are the same. They get at the same issue.

KESAVAN: I think “prediction” is more in the astrological realm. I think “unforeseeable” is a more scientific approach. Scientists don't predict.

GIBBS: That's more of a near-term thing than a long-term one.

KESAVAN: “Unforeseeable” means you can reduce it.

WASDELL: “Unforeseeability”? Let's see. I want to pick up there on linguistic civilizations. “Predictability” and “predicating” – very, very Latin, isn't it? The vision to “see” is somehow broader than the left brain. The holistic envisioning thing is so critical here, isn't it? Some things we don't “see” ahead, rather than the more narrow left brain “predicating” ahead. That's important.

A learning community has resilience in human culture, rather than traditionally rigid communities that respond defensively.

TREDER: Right.
How can we enable a high-quality, high-order learning community at the global scale to build resilience to deal with whatever comes?

**WASDELL:** It seems to me it should be one of the critical issues that emerged several times yesterday and again in our discussion this morning. How can we enable a high-quality, high-order learning community at the global scale to build resilience to deal with whatever comes?

**GIBBS:** That’s excellent. You pointed out one great way to do it, which is to use technology. It’s having a profound effect already, isn’t it?

**WASDELL:** On our learning styles.

**GIBBS:** And the ability to share and disseminate information globally.

**TREDER:** Is that something you want to write down?

**WASDELL:** It is something we might want to hold.

**GIBBS:** Constructing or supporting the learning community …

**WASDELL:** … enabling the emergence of a high-order learning community at the global level that generates resilience to deal with the unforeseeables of the future. It’s building in resilience to the knowledge civilization, just as building in resilience in reserve capacity has to be there also in the material civilization. Catastrophe preparation is practical. These are new thoughts to me.

**TREDER:** May I ask if we can synthesize the answers that we’re going to present from what sounds like two very important statements? I’m wondering if they’re saying essentially the same thing, though in different words.

**WASDELL:** It was intended to be.

**GIBBS:** I think, actually, David’s more recent statement is the answer to this question.

**WASDELL:** It was intended to be.

**GIBBS:** It’s one answer, anyway. Maybe the question, really, is: Can we find multiple general strategies? One of them clearly is about a global learning community.

**TREDER:** So this is the meta question, and this is one approach to the answer?

Priority Number 1: highest-order environmental sustainability ecosystem.

**WASDELL:** It’s a necessary but not sufficient response. I think we’ve got our three here, haven’t we? Shall I have a go?

Priority Number 1: highest-order environmental sustainability ecosystem. Number 2: I think we’ve said “psychology.” Really, the human-nature question is critical. Number 3: emergent technology and its impacts.

Those are key issues. And then come back in with the response, which is: reducing vulnerability and building resilience. And the action to enable that response is enabling emergence of a high-order learning community at the global scale, which generates resilience to deal with the unforeseeables of the future.

Can we improve on that? How do we want to facet it? We’re in the synthesis stage.

**TREDER:** Can I suggest the wording, “Gaian nature, human nature and techno-nature”? Would that be of any use?

… I am skeptical about the prospects for changing human nature …

**GIBBS:** I think that might confuse more than clarify. With regard to human nature, I am skeptical about the prospects for changing human nature, but the prospects for changing human social nature, or human social systems, or the nature of human cultures are much more promising. Human nature is, well, it depends on how you define it. A lot of it is hardwired, and short of changing human’s hardwiring….

**TREDER:** Does anyone object to changing “human nature” in Number 2: “psychology and the human nature question” to “human social systems”?

**WASDELL:** I do. What you speak of there is the fatal-ity, almost, of seeing how humans behave as almost hardwired and unchangeable, very difficult to do anything about. There were repeated comments com-
ing out yesterday on this. That does need challenging in light of the last 25 years of research into the origins of anxiety defenses and the origins of the roots of religion. We now know much, much more in the psychodynamics of human nature than we knew two decades ago. It hasn't got through to common understanding yet. There's a huge amount of work there that says what we saw as instinctive is actually learned. Therefore, the transformation of what we have seen as rigidities is a possibility. It's as important as the nanotechnology.

KESAVAN: I quite agree. It should be “human nature.” Much of it is also now conditioned by society as to how human nature develops over a period of time. I don't want to go into details, but you all know about “Mother’s sauce,” schooling, and other factors; they all mold human nature to a great extent. I think of human nature as science, plus genetics, plus environment.

TREDER: May I suggest that we include “post-human nature” – “human and post-human”?


WASDELL: That would be emergent technologies, I think, as we go on beyond human intelligence into AI (artificial intelligence), etc.

TREDER: Okay.

WASDELL: Thank you. We've completed exactly on time. Thanks to all of you for your contributions.
BREAKOUT GROUPS

Summaries and Consensus

FACILITATOR: Sesh Velamoor
PARTICIPANTS: Plenary Session
GROUP REPRESENTATIVES: Group 1 - George Musser
Group 2 - David Wasdell

I’d like to invite the leaders of the two groups to present their findings along with a bit of background.

SESH VELAMOOR (FACILITATOR): At this time I’d like to invite the leaders of the two groups to present their findings along with a bit of background. We’ll spend about an hour trying to boil the six critical issues identified by the two breakout groups down to three, if there are no commonalities among the issues.

Ideally, we’ll have you present your group’s issues with the background, and then allow a brief period of time for questions and answers. Then the second group will come on. George, from Group 1, would you want to go first?

MUSSER: Sure.

FACILITATOR: Listen carefully, because the results of this session will provide the basis for the next set of conversations. Two of the three issues identified in this session will be the ones we’ll discuss in depth later.

MUSSER: Trying to summarize our free-ranging discussion will be somewhat tricky and will make trickier subsequent efforts to compare our combined lists. We have several lists, not just a single one, which we’ll share with you. I think the lists will summarize what we discussed. After a couple minutes of my rambling on, maybe my fellow panel members can chime in and tell me if I was completely wrong.

The first list that we came up with right off the bat was, essentially, a summary of the topics that struck us as the most significant, which were the ones discussed in the papers presented here. The three big issues are 1) global warming and its many effects, 2) the question of sustainable agriculture, and 3) poverty. We basically analyzed each of those because “sustainable” is a term that everyone uses but no one really has a firm handle on. That’s one way of thinking about our group’s discussion, but there were several other ways of thinking about it that emerged, as well.

Another was that the various ways to tackle those three problems (global warming, sustainable agriculture, and poverty) can also be divided into a list of three – there are a lot of lists of three. One is land use management and revising how we handle that; another is energy demand, reducing that and also changing, presumably, its character; and a third is diffusing knowledge more effectively, which is especially crucial for poverty alleviation.

Then I suggested that the problems, and, actually, even the mitigation strategies, could be divided into yet another list of three, which is the type and mode of change that is occurring in the world. One mode of change is a secular one: a loss, for instance, of the topsoil, which seems to be occurring at a steady and super-geological rate. Another type of change is abrupt and extreme: the kinds of excursions that Bill Calvin talked about, for instance, with drought. Another is lack of change: persistent poverty, which occurs in certain areas of the world, where Paul Polak has exerted an effort to move from stasis to action.

Then there was a list of three modes of choices...
that we make as human beings or societies. One is
at the individual level: our making choices and buy-
ing things, with, for example, Walter Kistler setting
up the Foundation For the Future to deal with these
questions. Then there’s the governance level: democ-
racies, dictatorships, etc., make collective decisions,
which are then diffused down and enforced or not
enforced. Then there is a third, emergent decision-
making that occurs: an invisible hand, an Adam Smith
type of approach, which is also a bottom-up approach
of decision-making, as opposed to top-down govern-
ance.

Toward the end of our discussion we got into try-
ing to move from description of the problems into
what can be done. Again, there was a list of three that
emerged from that discussion. The first was informa-
tion, knowledge-gathering, and development strategy.
Then there was the development of practical actions
to take. We came up with practical actions to take for
each list of those three priorities I discussed at the
beginning.

Then there was actually something that we left at
the end, which we really haven’t talked about very
much at this meeting, or certainly within our breakout
group, which is how to convince people. It’s one thing
to know what to do or what’s going on or to have some
guess about it, but convincing the bulk of humanity to
go along with that is yet another question.

It’s one thing to know what to do or what’s going on … but convincing the bulk of humanity to go along with that is yet another question.

The final item that you mentioned there about
convincing people ties in, actually, with one of our
topics that David will present in a minute. It also ties
in with P.C. Kesavan’s presentation and a discussion I
had with him during the break about what Professor
Swaminathan said in 1968. He could see that unless
changes were made in the management of sustain-
able agriculture and similar areas, we would end up
with a disaster. What he foresaw has taken place; it is
a disaster.

I said to P.C., “Could you tell me what might
have been done differently in 1968 or 1970, so that
we wouldn’t have ended up where we are today?” In
other words, there were people back then who knew
what the problem was and who, I’m sure, could have
come up with valuable solutions. But for some reason,
they were not able to convince enough people, or the
right people, to make changes. Even though Group 1
has that in the realm of solutions, I think that actu-
ally, as we will say when our group presents, one of
the key problems facing humanity is how to transmit
knowledge into action.

George, if you were to articulate 3 out of that mix of
18, combined in any way, what would those be?

MUSSEr: My first reaction would be to resist, but I will
attempt to answer. My resistance is stemming from
the fact that there are just so many different ways to
look at what our enterprise is here. Personally, I think
that convincing people has to be on the list of things,
but maybe that’s just the enterprise that I happen to
be in here. I do think a lot of problems are recog-
nized and solutions have been developed, but getting
them out is another issue altogether.

I think the question of how choices are made has to
be in there, too. A lot of choices are made by default.
Maybe that’s good, maybe that’s bad. I’ll put that on
my final list of three.

I guess I’m struck by a lot of the comments Bill has
made about dealing with risk and extreme excursions
of events. I would put that on a final list of three. We
really need to be better at either preparing for emer-
gencies or preparing to not prepare for emergencies,
accepting the tradeoff that comes from not having reserve capacities to deal with certain emergencies. It's just one of the inevitable tradeoffs of life that one has to navigate.

**FACILITATOR:** As Bill normally says: What is the fallback? What is a safe fallback position?

**MUSSER:** Right. But I qualify that a bit in terms of tradeoffs, because we could stop fires by building a fire station on every corner, but we obviously can't do that. We have to know that preparing for an emergency means we're taking away resources from some other needy priority as well.

**FACILITATOR:** Thank you, George, and members of Group 1. Now I'd like to invite David Wasdell to present the findings from Group 2.

**WASDELL:** We had a collective, distributed view of leadership for the second group with my own role as more of a catalyst within it. Mike Treder did a lot of the work, and he's going to help me by displaying the lists we created.

We found that we struggled, as did the first group, I think, with the difference between complexity and simplification, and saw the possibility of this morning's exercise as reducing the richness of massive information and huge complexity to a very narrow stream, a thin, broadband simplification, as a way of dealing with our anxiety of being overwhelmed. As a policy we said, "Let's try to maintain richness and complexity in the way we work."

The second issue was the tension between a planetary perspective – what are the issues facing the planet – and an anthropocentric perspective – what are the issues facing humanity? The question that had been put before us was: What are the issues facing the planet?

There was some tension between issues and action. What can we do, as distinct from what are the questions we're addressing? We felt we needed to identify the critical issues, and that the agenda of action followed from that clarification. There was also something about the order of systems. In other words, macro systems contain subsystems, which contain smaller systems, which contain smaller systems, etc., like the fleas. Those system levels also governed some of our ordering of material. Note that, as the group leader and reporter, I can bring in my own contributions and ignore everybody else's in the group.

**FACILITATOR:** The greater the lack of consensus, the greater the influence of the leader and his or her views.

**WASDELL:** Except that my task was to develop consensus catalytically, so everything I say is totally "group mind." We shared three critical issues each, and then began to look at how they interrelated. Out of it came our three key points, which were as follows:

1) Ecology or environmental sustainability. The macro system sets the parameters within which everything else happens.

2) The issue of human nature: religious fundamentalism, psychotic behavior, dysfunctional responses, resistance to change, instinctiveness. Is human nature hardwired, or is transformation at that level possible?

3) Emergent technological innovation and its impact. That goes right across the board from nanotechnology, to technologies for bioengineering, to a capacity for destruction and its application in war. Those were the three planetary issues as Gaia seeks to maintain her own engagement and integrity in the face of the onslaught of *Homo sapiens replicans*.

The first point is that, because of complexity and unpredictability, which then becomes "unforeseeability," it's about visioning the future, not just predicing it. We don't know what we're going to be facing. There are things in the future that we are profoundly vulnerable to, some of our own making, some over which we have had no anthropogenic sourcing. That will put us, and the planet itself, under stress. Building in resilience and "response-ability" are critical steps to take, whatever we face.

Mike, contribute your language, please, as well as comments from the others.

**TREDER:** We talked about the relationship between reducing vulnerability and building resilience, and that a responsible approach is to deal with the problem on both fronts. We'll never reduce vulnerability to zero; therefore, we must increase resilience as high as possible. In addition, we can't even foresee all of our vulnerability; therefore, flexible resilience on a global level is necessary. The third point – actually, I will let David describe that.
WASDELL: Thank you very much, Mike. That led us together to articulate something that, I think, is quite significant, and that is that the greatest issue we face in human terms is enabling the emergence of a high-order learning community at a global level that generates resilience to deal with the “unforeseeables.” That, in a sense, is building in resilience for the knowledge civilization, just as building in reserves in practical problem-solving is also required at the practical material level of civilization.

Others in the group, please, help me to facet that out. Have I done enough?

KESAVAN: Excellent.

WASDELL: Thank you all, group. It was a super effort, being quite different from the other group, obviously. We did our own work of integration instead of just providing 18 things, not that we entered any sense of competitiveness.

MUSSER: No, not at all.

FACILITATOR: Any questions?

MUSSER: If I could make one comment. I’m actually amazed at the two converged evolutions of the two groups. We both developed eyeballs through completely different pathways. Our list is very similar to this one, though phrased completely differently.

WASDELL: I think the parallel processing has something to do with emergent synchronicity within the process of this seminar. Beautiful.

FACILITATOR: That’s right. Actually, George, if you were to put into a sentence the final three points you made, it would pretty much be identical to what David just said.

MUSSER: Yes.

FACILITATOR: Again, thank you all for an excellent session, and for the topics you’ve identified. The work you have done has helped us get to the next part of the seminar a lot sooner than I anticipated, which is good. We’ll now move into the next segment, the two fishbowl groups.
Fishbowls

**FACILITATOR:** Sesh Velamoor

**PARTICIPANTS:** Plenary Session

*In each fishbowl, half of the participants are required to listen to what is being said instead of talking.*

**SESH VELAMOOR (FACILITATOR):** We’re now ready to jump into the next aspect of the seminar. We will pick two of the issues identified in Group 1 and Group 2 breakout sessions as most critical for humanity going forward.

We’re going to divide the seminar participants into two groups of four each – with only four in each group since David Montgomery had to leave – to form what we call Fishbowl 1 and Fishbowl 2. We refer to this fishbowl process by that name because those of you conducting the discussion are the “fish” in the bowl in the middle of the room talking about one of these two issues we’re going to identify. Everybody else in the room looks from the outside to see and hear what’s occurring in the bowl. Then the observers get to comment and participate at the end.

This fishbowl format is one we’ve tried over time, and it works very well in promoting listening more than talking. For most of the seminar, we’ve stressed having you present. In each fishbowl, half of the participants are required to listen to what is being said instead of talking.

Fishbowl 1 will consist of George Musser, Paul Polak, Mike Treder, and David Wasdell. They will discuss one of the things that we now will attempt to identify, while others in the room listen and participate at the end.

Then Fishbowl 2 group members will take their turn in the middle discussing the second issue, while the group that’s outside listens and gets to participate at the end. The Fishbowl 2 group is Bill Calvin, Wayt Gibbs, Ishwaran, and P.C. Kesavan.

With that in mind, what do you suppose we should focus on for the two fishbowls this afternoon? Should they be two issues, two separate aspects of the same thing, or two completely different things in themselves? This is an open discussion for the group now.

**WASDELL:** I wonder if one person from each of those small groups could work with one person from the other group, just for three minutes.

**FACILITATOR:** Oh, that’s fine. Go ahead.

**WASDELL:** That would give us a pooling of ideas, and we could use that brainstorming to come to that consensus.

**FACILITATOR:** Please, feel free. We have the time to do this.

**ISHWARAN:** I have a question. What’s the status of these one, two, three issues we just identified? Do we just note it and move on?

**FACILITATOR:** We have noted them. At this point, what I’m trying to do is boil that down even further to two things, because there are two groups and we have so much to cover. Mind you, the issues and the conversations and the lists of things are now permanently recorded. It’s not a case of saying we did not discuss something. We may very well create another group or a workshop to flesh this out.

**CITRON:** All of this seminar content will be published.

**FACILITATOR:** Again, the idea is very much along the lines of what has come up here: How do we go about educating the public? Here is one mechanism of doing it. Here is a two-day process that resulted in all these findings. Whoever wants to be made aware of it is welcome to do so. We make an attempt to cir-
You've got to get down to two priorities. You could adopt what in physics would be statics and dynamics ... secular change and extraordinary events.

CALVIN: You've got to get down to two priorities. You could adopt what in physics would be statics and dynamics, which we might call, as George did, secular change and extraordinary events. There are some good analogies you can use for this; for example, heart attacks may be the dynamic part, but it's the steady narrowing of the arteries, etc., that's the secular change.

A lot of things would fit into that, particularly if you include “no change” as one of the types of change. For example, the poverty question does fit into the no-or slow-change category. Then the extraordinary events are things you can perceive that you're drifting towards. The question might be how to either prevent them or build in the resilience so that you can recover from them.

FACILITATOR: What about the process that David proposed, where you pair up for three to five minutes. What would the pairing up do, David?

WASDELL: Each person would be identifying those two issues, and then we come up with a pair, sort of a cross-fertilizer effect.

FACILITATOR: Oh, I see.

TREDER: Pair up in four groups of two, but one from each of the separate groups?

FACILITATOR: Yes, I think that will work fine. I think he's simply suggesting a process.

POLAK: Here's a simpler thing. Why not have the two group leaders meet as a fishbowl? The two leaders of the two groups get together and talk, and we're outside the fishbowl for two minutes.

FACILITATOR: That's fine. You can do that. I'm totally open to whatever. Maybe David and George can have a conversation. Right now, we're trying to determine which two issues from the morning to discuss, so you two could interact.

TREDER: Do we have to be quiet?

FACILITATOR: At the beginning, you have to be quiet while the two leaders of the two groups interact, but after that, you can participate.

WASDELL: Just a process comment: It's interesting that when we move to a high participative suggestion, we move to low participation.

MUSSER: Actually, the three issues seem to, themselves, break down into two groups.

WASDELL: Can I work to catalyze your thinking?

MUSSER: Go ahead.

WASDELL: Looking at the overall pattern of your group there, what is the issue facing the planet that, overall, if you had to tackle nothing else, your group would support you in putting up as Number 1? After you have answered, please ask me the same question.

... everything is connected; all the problems are integrated. You can't push on one side of the balloon without the other side popping out a bit more.

MUSSER: I'm not sure, and I'm not saying that simply because I'm being rhetorical. I think one thing we felt and one reason the conversation progressed the way it did and took the pattern it did was that everything is connected; all the problems are integrated. You can't push on one side of the balloon without the other side popping out a bit more.

WASDELL: There's a sort of matter issue, then, and that is the interconnectivity of the whole complex situation.
MUSSER: Yes.

WASDELL: That is an issue that needs to be addressed and taken on board.

MUSSER: But I'm not sure what we would do with that to talk about it. I like Bill's characterization – my background is in physics, so I would like it – of breaking into second-tier groups as statics and dynamics, one dealing with the secular processes and one dealing with questions of resilience.

WASDELL: Let's just look back on what we did in our quartet.

... we have a high-order system, which is the ecological, environmental, Gaian perspective, the container within which everything else is a wholly owned subsidiary ...

WASDELL: It seems to me we have a high-order system, which is the ecological, environmental, Gaian perspective, the container within which everything else is a wholly owned subsidiary or subsystem upon which it depends. There's an issue of system order and dependency on that order. To miss the overarching planetary issue would be, from my sense of our group, irresponsible. The engagement with a sustainable, ecological outcome seems to be the fundamental high-order issue to be addressed. That, I think, would be the statics, the given issue.

MUSSER: An overall, planetary, overreaching issue.

... the issue of building resilience, becoming a learning culture – not just learning, but learning to learn – is a high-order, reflexive learning system ...

WASDELL: The overall, planetary sustainability of the biosphere. If we don't get that right, "there ain't no bio in the sphere." Then to take up the other one, which is the dynamics, the response, if you like, it seems to me that the issue of building resilience, becoming a learning culture – not just learning, but learning to learn – is a high-order, reflexive learning system that builds in the dynamic response, whether it's technical, behavioral, political, about leadership, or whatever, but learning to respond to the crisis, whatever it is.

MUSSER: Are you then saying to divide the issues by goal and method, the goal being the sustainable equilibrium planet?

FACILITATOR: I think so.

WASDELL: It gets to that point. I think the method, then, is building in “response-ability” without being precise about the specific issues and facets being faced.

MUSSER: I'm just worried, then, about the goal of the fishbowl group. What will it discuss? What will be its role? To come to some consensus about the science? In other words, if we remove from the goal group – the statics group – the possibility of action, we're neutering them.

WASDELL: I have a suggestion. George, this afternoon you and I are going to be in the same group. If we choose which one we want to tackle, the other group has the problem.

MUSSER: Then we should take the more challenging one because that's more fun for us. Leave them the easy one.

The focus of the first fishbowl could be connectivity ... articulating the elements that make up the notion of a Gaian complex.

FACILITATOR: If I could repeat what David said, one of them could be to flesh out the context of what it means to look at things in a planetary sense, using the word “Gaian,” as he was pointing out. Maybe that would involve describing the context itself. The focus of the first fishbowl could be connectivity, the relationship between soil erosion and loss of biosphere. In other words, articulating the elements that make up the notion of a Gaian complex.

The second one could be what you described as the method, which would incorporate elements of not only building a response system to the extent that vulnerabilities are identified, but also creating the educational basis for a learning system that enables people to be on top of things on an ongoing basis.

What was the third element of that method? To build resilience; I think that's what he was getting at.

MUSSER: I'm coming around to this, because the first group is the one that's fleshing out the challenges, the question of global sustainability. They can be dele-
gated the task of explaining “sustainable,” because the term floats around and we don’t really pin it down.

**FACILITATOR:** Right. Any other comments from the core group on inputs?

**POLAK:** Just one point. George felt that his thing about communication was very important, but I don’t see how it’s going to fit in.

**FACILITATOR:** It comes into the learning and the education.

**MUSSER:** It’s a subsection of education.

**TREDER:** In the second group, as well, I think the challenge is to identify not only how you enable this emergence of a higher-order learning so that we look at not just how do we make this structure, but also how do we deal with the expected resistance of human nature? It’s not just an idealistic problem; it’s a realistic problem.

**In the second group, as well, I think the challenge is to identify … how do we deal with the expected resistance of human nature?**

These seminars are to identify the most critical issues facing humanity during the next thousand years … based on real scientific evidence …

**CITRON:** We have to keep in mind the purpose of our seminars and the differentiation between the seminars and the workshops. These seminars are to identify the most critical issues facing humanity during the next thousand years. They’re not to solve problems; they’re not to point the way to what we should do; they’re to identify problems based on real scientific evidence of what’s going on in the world.

The workshops, on the other hand, such as next year’s “Energy Challenges” workshop, gather groups of experts who focus on a specific issue. The outcome of this seminar – what we’d like to see – is the identification of what you, collectively, feel are the most serious challenges to humanity during coming centuries. The seminars are not designed to solve any problems. You can mention what is doable or may become doable to mitigate disasters, but we really want the outcome to identify two or three of the issues that you feel are the most significant.

**MUSSER:** I think this breakdown of groups will do that, although perhaps not quite in the way you had originally intended. The first group, which we’ve called the goal group, gets at it from the truly global perspective where physics is integrated with geology, etc. The second group really focuses on the human subsystem of that and what it does. There are problems associated at both levels.

**FACILITATOR:** I think you’re absolutely right. When we talk about interconnectedness or Gaia or the program that P.C. Kesavan laid out for the villages, implicit in that is the notion of Gaia in every sense. That is something everyone at this table completely understands, or is able to understand. If you go mention the word “Gaia” to someone on the street, he will say, “Have you gone ga-ga? What does it mean?” I think even fleshing out the notion of interconnectedness or defining the elements of all of these things would be a great educational feat if you’re going to communicate to the general public. Then you could go to the next issue of asking: “What are the methods by which you can enable this process of comprehension?” I think that would be absolutely perfect.

**CALVIN:** That’s more or less the task Bob was suggesting the workshops are for, as I understood it.

**FACILITATOR:** No, it’s the other way around. A workshop, for instance, is specific to a topic such as global warming. It doesn’t include soil erosion; it does not include the biosphere; it does not include anything else. Strictly what do we know, what do we understand by way of saying there is global warming taking place? That is the subject of a workshop.

Whereas, what we are talking about here in “Crossroads for Planet Earth” is a large, all-encompassing subject that involves not only global warming, but also education, the biosphere, soil erosion, and experimental tactics or methods in the villages of India. That is a seminar, if I’m not mistaken.

**CITRON:** You’re right.
CALVIN: May I suggest that another way of dividing this is simply between things that happen slowly or not at all and those that happen quickly? Just as in my heart attack analogy, the things that cause the slow buildups in the arteries and the things that produce potentially damaging clots are the distinct events, the probabilities of which are changed by the other stuff. That would divide many of our issues here, as we talk about the slow, creeping events together. We could discuss the dynamic stuff, like extreme events, etc., separately.

WASDELL: Can I build with that, Bill? We have sort of the container, which is the big environment stuff, and the contained, the human biota and its interconnectedness. Then we have slow change and rapid change.

CALVIN: Yes.

WASDELL: In a sense we have a four-quadrant approach there. Is that possible? Because there are some slow processes of the environment and there are some rapid flip-flops of the environment. There are some slow processes in the social culture and the response, and there can be some quite fast ones. That seems, to me, to enrich very deeply what we're getting to.

FACILITATOR: I think part of the conversation would be: “What does learning mean?” “Who is ‘we’, and to whom are these topics and outcomes directed?” Those are the kinds of issues and challenges that can be raised.

ISHWARAN: What came out of the dialogue here, the context and the method, is a good way to go, I think. If we are going to be a learning community, for the lack of any other words, what are we going to learn about? When you talk at the planetary level, where are we going to focus the learning exercise? If you went into business management, there’s a lot of jargon on learning, usable knowledge, and such things. At the planetary level, what does “learning” mean? It may be useful to put a highlight on this notion of planetary sustainability and on learning as an emergent thing. I don't think many people are thinking about these things.

FACILITATOR: Yes. One thing I might relate, though, at least in my experience of going before fifth-graders or speaking in any other environment with people who have absolutely no concept of any aspect of the complexities we are discussing, regarding the resonance I see when even talking about the notion of a planetary consciousness, there is hardly any resistance or any comprehension as to what that means. It always amazes me how quickly people grasp these concepts once they're explained. It seems to me that where the resistance is built in is between conversations like this and all the institutions and the structures and all the formal organizational setups that have become the roadblocks. There are too many vested interests that block this perception, rather than saying, “These people are totally dumb; they don't know anything. Let's
go teach them.” It’s almost, I would say, an exercise that might be a case of “unlearning” more than one of “learning.”

As P.C. can perhaps point out, when he goes to the villages to explain, he doesn’t need to go into the high theory about Gaia and things like that. When he starts explaining to them, I think they respond favorably, positively, and very quickly. Right, P.C.? As long as the conversation does not go into some controversial areas such as what god they believe in and how these ideas are contrary to and not contrary to those beliefs.

KESAVAN: You are absolutely right, Sesh. The point is we have realized over a period of time now, about 14 years, that when you go to the villages, their ability to grasp and accept is based on the needs of the system. They understand whether it’s going to be good for them or bad for them. Also, they’re very clear that globalization has brought one very good thing, which is knowledge dissemination. They see a whole lot of things. They think that if they are irresponsible, they will lose all their resources; they’re very careful about that.

As Sesh also pointed out, there are issues that politicians often speak about because they are based on communal concerns, which sometimes come into conflict. There again, their common interests, the instinct for survival and for developing some livelihood for themselves and for their children, unite them again. This is a very complex scenario.

One point about which I totally agree is that today there is a very orderly situation in which the villagers take to these ideas like a fish to water. These people are open to anything that is good, and they are very easily convinced about what is good for them.

POLAK: I’m getting a little uncomfortable with the tone of this discussion about the village. When you go to the villages, the first thing is to learn from them; it’s not to see if they are able to absorb your information, but to learn from them. I think it’s very important to start at that point.

FACILITATOR: It’s not very different. I think you’re just expressing the other side of the same coin.

POLAK: It’s the tone of the discussion that was beginning to bother me.

KESAVAN: I must clarify. The first and foremost step in meeting with villages is what they call “social mobilization.” The social mobilization is participatory and bottom-up. I thought it was taken for granted, but I must make it very explicit that you not only learn, but you also think along with them. That is even more important. Learning is one-sided; this is a two-way process. You think along with them; you become them, and then go along. That is how you can identify the natural resources on which you can build conservation and development of land use.

FACILITATOR: Okay.

TREDER: One more question. It occurs to me that we may be making the old Cartesian error of separating man from nature. Our first two items on the list and in the agreement we’ve discussed here say that we might divide the issues and talk about the container, the planet, and the contained, the human. Are we committing some sort of a fundamental error by removing humanity from the biosphere or from the environment in that separation into two areas of discussion?

FACILITATOR: I don’t know that we are, but go ahead.

WASDELL: Could I speak on that? It’s difficult to separate the mother from the child within her; it is a symbiotic relationship. I think we have at a macro level that sense of the interdependency of both container and contained. For the sake of our work this afternoon, we may focus on one side of that or the other, yet the two groups are part of the synchronicity of this seminar. I take it that insemination has something to do with what we’re attempting: to get seminal ideas, give them good currency, and then find a resting place from which creativity emerges. I take your point: It’s a risk. Let’s keep it in mind and remember the symbiosis. Is that okay?

FACILITATOR: Yes.
ISHWARAN: The point you raised is a rhetorically relevant point. As for the Man and the Biosphere Programme of UNESCO, some people still think it should have been Man in the Biosphere, not Man and the Biosphere.

In terms of the way it was expressed here, when you look at something as planetary, that doesn’t mean that it excludes humans; we’re part of it. When you come to the learning side – and this I tell my folks who work with me – I think man, humans, have a special responsibility and have to take that responsibility. Of course, elephants learn, too. But then elephants don’t have our resources, skills, and responsibility to change things, at least in the way I understand things. There’s a special role for humans; I think that has to be kept in mind. It’s nice to consider that we’re equal to everything else, but if, like everything else, we do whatever we want, that could be not a good way to go.

FACILITATOR: I think with that, we’re upon lunch. I had announced the groups, but maybe I should offer an option. Now that we have identified the two issues, whatever group you’re part of now can discuss one of the issues. Do you wish to change? Or can you remain in the group you’re in?

MUSSER: I’d like to mix things up.

FACILITATOR: Yes, that was the idea. Currently, these groups are mixed in that sense.

WASDELL: There are two subjects. Maybe we could just say which group is to address which topic.

FACILITATOR: Fishbowl 1 is interconnectedness or sustainability.

WASDELL: In which case can I go to Fishbowl 2?

TREDER: Yes, I’d like to be in Fishbowl 2.

MUSSER: Why doesn’t Group 1 take the second topic?

WASDELL: Are you happy to stay with that? I am.

TREDER: Can we flip the order?

CALVIN: What’s the second subject?

FACILITATOR: Learning, education, and building resilience and ability to respond.

FACILITATOR: Let’s call it “goal” and “method”; those are the two discussions. Let me identify the two groups and you can say who is taking what. The first group is Musser, Polak, Treder, and Wasdell. It’s mixed up. I know you’ll have preferences, but which of the two issues does this group want to take? You want to take Number 2, method? The second group is Calvin, Gibbs, Ishwaran, and Kesavan, so you will take Topic 1, which is goal. So, in effect the two fishbowl groups have switched order. Fishbowl 1 will now be Fishbowl 2, and vice versa.

ISHWARAN: I want one clarification: Is the current level of understanding here that the context or the goal is planetary sustainability?

FACILITATOR: Yes.

ISHWARAN: And the method is learning, but “learning what” has to be elaborated?

FACILITATOR: Exactly.

Thank you all for your contributions. Now we’ll end this session and break for lunch. When we return, we’ll begin with the first fishbowl discussion.
This group's goal is to flesh out the notion of interconnectedness and what it means for all the world's elements, components, and relationships to be interconnected.

**FACILITATOR:** Sesh Velamoor

**PARTICIPANTS:**
- William H. Calvin
- W. Wayt Gibbs
- Natarajan Ishwaran
- P.C. Kesavan

_Sesh Velamoor (facilitator):_ If I can please have the first fishbowl group members in the middle: William Calvin, Wayt Gibbs, Natarajan Ishwaran, and P.C. Kesavan.

This group's goal is to flesh out the notion of interconnectedness and what it means for all the world's elements, components, and relationships to be interconnected.

Who would like to take a crack at getting us started? In fact, I might invite P.C. to get us started. What he presented this morning seemed to represent the concept of the connectedness of things in the experiment his group is doing in 40 different villages.

P.C., would you start us off by talking about the word mentioned here, “Gaia,” or the interrelatedness of the different elements and the connectedness of things, to put some flesh on the notion of the context that we agreed would be the first subject?

Would you also remind us of the elements you were trying to integrate in the village project you presented earlier? Then we can take it from there and see if it needs to be expanded with other elements for our purposes.

_Kesavan:_ Taking a cue from what Sesh has said, I think we have to look at the scenario as it existed for many years in India and in many developing countries. You have villages far away, cut off from the realities of the modern world and not aware of technology that has percolated into the cities. Here you have a population that has no wealth, no literacy, no skills, and no clue as to what the future holds for them. It is these people who require our attention in terms of enabling them technologically and also in terms of knowledge and power.

What we did, as Sesh has pointed out, was to go and interact with them. No program of this kind should be from top down; it has to be a bottom-up approach. We can’t impose anything, particularly in a democratic country. We started out by identifying with them, gathering information along with them. We did not come in and tell them about resources; instead, we asked them about their lives and learned from them what kinds of resources they have.

Then we tried to interact with them, telling them these resources can be converted into wealth. We said: “You have two things: a lot of leisure time and also some resources. What you can do is to make use of the leisure time that you have – your free time – and convert these resources into wealth. What we can do is to provide you with the kinds of technologies with which you can do those things.” That is how we started.

With the introduction of the Village Knowledge Centres – computer-based Internet and video conferencing – the villagers have become capable of interacting with each other. As also has been pointed out here, some of the people we’ve trained have become trainers of others, building continuity and community, with trainers becoming trainers’ trainers.

_Facilitator:_ P.C., if I can interrupt you, please. What I would request you to do here is to go more into the notion of what caused the transformation from the Green to the Ever-green Revolution. That change
implies the notion of the context that we are trying to flesh out here. The Green Revolution is one approach; the Ever-green Revolution is a little different.

The chemical interventions of the Green Revolution … resulted in soil erosion; water salinization, reduced aquifers; pesticide toxicity residue, etc.

KESAVAN: Thank you for that change. I was thinking of the village project.

The Ever-green Revolution, as you know, was begun in India by one of the architects of the Green Revolution itself. The chemical interventions of the Green Revolution for the proliferation of agriculture resulted in soil erosion, water salinization, reduced aquifers, pesticide toxicity residue, etc. We thought that sooner or later, the Green Revolution would have a period of fatigue; productivity would diminish. That is really what has happened. The reasons are, obviously, based on the degradation of the ecological foundations of agriculture.

From now on, we have to move into a new realm. The goal of the Ever-green Revolution is to have productivity advancement in perpetuity without producing any accompanying ecological harm. This necessarily involves pathways that do not adversely affect soil health, water quality, biodiversity, the atmosphere, and renewable energy sources. The ecological foundations are not degraded to the same extent that the Green Revolution indeed cost us. That is the reason why we have to make this shift from the Green Revolution to the Ever-green Revolution.

The Ever-green Revolution is not a simple thing. It is, indeed, a very highly scientific and a technology-intensive one.

That brings these questions: How do you do this? What things are required? The Ever-green Revolution is not a simple thing. It is, indeed, a very highly scientific and a technology-intensive one. You have to develop a number of different types of biological software. Instead of a chemical pesticide, like DDT, you have to identify an insect that can feed on certain pests, etc. The whole thing is founded on connectivity, which comes in once you conceptually decide that this is point A; from here, you have to go to point B; point B cannot have the whole set of technologies that point A was able to cope with.

The point today is that you have to develop newer technologies, standardize them, and go forward. We also have to take into account other aspects, which the Green Revolution ignored; namely, social inequities, gender inequities, ecological and economic inequities. Within the Ever-green Revolution, no technology can function in isolation without the involvement of society.

FACILITATOR: I’d like to ask one of the other panel members here. P.C. mentioned something about a transition from an understanding of systems based on chemistry to systems based on biology. Would you care to elaborate on that paradigm shift in terms of the context that we are trying to talk about? Anybody?

CALVIN: It’s really a shift back to biology, in a sense.

FACILITATOR: Whether it’s a forward or a backward shift, it is a shift to biology, yes.

This revolution involves getting away from industrialized solutions to making things more local, more suitable to conserving the context they’re used in …

CALVIN: Whether it’s spreading manure or whatever it is. This revolution involves getting away from industrialized solutions to making things more local, more suitable to conserving the context they’re used in – that would be the way I would separate it.

FACILITATOR: Wayt or Ish? Care to expand on that? Or introduce a new element altogether?

I think it is important to bring back a focus on living organisms, living things, and the potential of living material to help us change directions.

ISHWARAN: I wrote it down when P.C. described that shift from chemistry to biology. There’s a story or a rumor about how the International Convention on Biological Diversity started using the word “biodiversity” more often, because there was somebody who said “‘Biological diversity’ is diversity of knowledge about life – biology being knowledge about life –
whereas ‘biodiversity’ talks about the diversity of life.” That’s a bureaucrat who sits in a US government office who made that distinction.

In reference to what P.C. said, I don’t think it’s a discipline issue. I think it is a shift more towards looking at life in general. Even the word “ecosystem” sometimes does not convey the importance of life, because an ecosystem as an entity includes both biotic and antibiotic components, as opposed to communities, which are a biotic component.

I think it is important to bring back a focus on living organisms, living things, and the potential of living material to help us change directions. I think that’s a good shift. It is interesting to see, for example, that the Directorate for Research in the European Commission is going toward a full-fledged change in reorienting everything towards bionomics, biology, and biodiversity. It’s a shift that, hopefully, will make you do things differently compared to even the ecological approaches of the past.

A point about context: In my presentation yesterday, I had a quote about situations of social value creation, “Context is king.” I think the interesting thing that came out of P.C.’s presentation and the discussion in the morning is that you define “context” in terms of connections and linkages, not in geographical space, political entities, etc. P.C. described how villagers in India got connected to Egypt. I think those kinds of things are important in the future, because things won’t change if you try to hold them as spatial entities and avoid making other necessary connections abroad or elsewhere that could help that context.

I think a planetary-context point of view doesn’t have to include the whole Earth all the time, but I think the context definition must be thought through in terms of wherever you start. What are the linkages elsewhere in order for you to fix your problem?

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**GIBBS:** I’d like to build on that. It seems to me that there might be a little bit of tension here between this increasing appreciation for a “connectedness” of many different systems on the planetary level and the concept of “sustainability” that we struggle with. I think, at least in the popular mind, “sustainability” has to do with finding equilibrium, a safe, static place, where we can hang out as a species for the next indefinite period of time. Sciences are, increasingly, breaking down barriers between disciplines that have prevented them from exploring the connectedness among different regimes and starting to learn more about how, on different scales and in different chemical/geological/biological systems, there are feedback mechanisms that introduce fluctuations of all different kinds. An increasing lesson of science is that there is no safe place, really, in perpetuity. To get back to a point that David [Wasdell] made, there are always going to be vulnerabilities to humanity and to life on Earth as a whole. Some of those are going to be just a function of the fact that it’s a highly interconnected and highly nonlinear system.

I’m wondering whether it would be helpful in this discussion to elaborate on the concept of sustainability and what that might mean. Does that mean, really, having enough knowledge about the interconnection among systems to anticipate their changes and to design a society so that you can roll with them? Sustainability is more of a process than an end state.

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**We see major soil subsidence issues in New Orleans … the area was sinking so slowly below the river level that no one generation really knew what was happening.**

**CALVIN:** Let me bring up the archeologist’s perspective on this. Jared Diamond’s book, *Collapse*, covers a number of these points. What archeologists tend to say about sustainability is that hunter-gatherers certainly depleted the game here and there but they could usually move on. It’s not that they were terribly conscious of preserving their environment; it’s just that they weren’t so crowded. They just could move around and cover a lot of areas.

When you settle down, you start getting problems of tilling the soil. For example, as Dave Montgomery was telling us, once you move into the hillsides, you’re into an entirely different regime whereby you start losing a lot of soil down the river and putting it on the ocean bottom where you can’t use it very well.

As you begin to try to solve your water problems by importing water and spreading it over the ground, you get into issues of salinization, salting up the soil in ways that wouldn’t occur otherwise. Colorado River water is said to have been passed through the
soil about a dozen times before it gets down to the Gulf of California.

The other thing that you see is that once you start using pumps a lot, unless you have an enormous source of water, say, like Bangladesh has, then you get into issues of subsidence of land, lowering the water table, entrenchment of streams, and such. You start finding these groups having to climb way down into the river, haul a jar of water up the hill, and go spread it, when they didn’t use to have to do any of that; they’d just divert it over into the site.

We see major soil subsidence issues in New Orleans. New Orleans’ vulnerability was very much one where the area was sinking so slowly below the river level that no one generation really knew what was happening. A big difference today is that we have science; we have history; and we have lots of ways of passing stories on from generation to generation that don’t get lost as easily as they used to, thanks to written information. We have a scientific enterprise that lets us understand the mechanisms of these things so that we can intervene and redesign appropriately.

To me, the latter part is one of the keys to all this, because the only way of doing some of these things efficiently enough so that you can support the existing population is to intervene in a very smart manner. Knowledge is no guarantee that you’ll be able to do that, but it’s the only good way to proceed in a lot of things.

FACILITATOR: I think it was David [Wasdell] who introduced the word “Gaia.” If you used that word 15 years ago, people would laugh at you, saying, “You’re out of your mind. What does this mean?” It’s a nice, touchy-feely way to describe things, but there’s really no scientific basis to it.” But it looks to me as if more and more of the scientific community are beginning to, perhaps, embrace the notion of Gaia. Would any of you care to comment on that? First of all, is everybody clear on what it means?

FACILITATOR: True. That’s the next aspect of the conversation I wanted to get us into: How do we locate ourselves within this context?

FACILITATOR: Bill? You were shaking your head rather vehemently, saying that you did not understand or you didn’t accept…?

CALVIN: I don’t understand the popular usage. I perfectly well understand what [Lynn] Margulis and Lovelock had to say.
FACILITATOR: I'm sure you do.

... one interpretation of Gaia would be a global ecology or an all-encompassing ecology.

CALVIN: One of the original notions is that there are a lot of feedbacks within Nature that tend to keep the oxygen in the atmosphere at about 20%. These feedbacks keep the average humidity where it is; if it goes up there are mechanisms that tend to bring it down. That doesn't mean there's a living system doing all that, but they also point out that living systems are part of the regulatory mechanism.

Why you should try to sell to the public a name that has no connotations for them to start with, I don't understand. I guess one interpretation of Gaia would be a global ecology or an all-encompassing ecology. If you use the word "Gaia" in that way, which is what I assume people are doing, fine; it's nice to have a short name for it. But it has nothing to do with the original concept.

FACILITATOR: I didn't mean to suggest that we should go on a PR campaign explaining the idea of what Gaia means to the planet. I was curious whether the group here accepted the idea that there is something to the notion that Gaia puts forth. Of course, it talks about Earth being a living system in a more general sense, emphasizing the interconnectedness, and the fact that we are part of it rather than apart from it. That's what I was getting at. Wayt? Do you have anything to add?

... the scientific enterprise seems to be not nearly as efficient as it could be in studying these connections, and especially in communicating them to the public.

GIBBS: No, not really about Gaia, except a comment about this original notion that some people took away from Gaia that it's homeostatic, or an anthropomorphic or teleological interpretation; it's there to support life, specifically our kind of life. I don't know how much that's current scientific thinking anymore.

But there is, I think, a difficulty in the way science is still taught and conducted that limits the pace at which we can understand these connections among systems. To me, the scientific enterprise seems to be not nearly as efficient as it could be in studying these connections, and especially in communicating them to the public.

I know, from the perspective of a science journalist, this is not the way we often think about things. We typically bend things into categories as well and draw pretty clear distinctions between hard sciences and sciences that involve human beings and social systems. One major challenge for the future is to surmount those traditional limitations.

... the United Nations has declared the decade from 2005 to 2014 as the UN Decade of Education for Sustainable Development.

ISHWARAN: I'd like to come back to what Wayt said about sustainability and what people expect the end point to be. It's not the end of a Hollywood movie where everything ends happily and nobody worries about things after that. I wouldn't define it as a process, either. Process definitions are also complicated because people think that you keep on doing things; there's no product, no output – you just keep on participating in something, and everything is okay. It has to be seen as a moment or a trajectory where things might have to be changed as you go along.

And the best analogy I can come up with is like portfolio management. If you have investments in stocks, bonds, mutual funds, houses, other capital assets, and so on, you don't keep those fixed; you can play around with them. I think that's a good analogy. Where I come from, the United Nations has declared the decade from 2005 to 2014 as the UN Decade of Education for Sustainable Development. I don't know whether we have learned enough about sustainable development to attempt education, but then it has happened. The decade is there, and how do we use it?

One has to start telling school kids and young people, as the Foundation For the Future is doing with your Young Scholars’ Program, what sustainability means. We can't even agree on what it is here in this meeting. I think you are coming into those kinds of situations where it is much more important not to give wrong or false kinds of images, rather than giving a very clear, right image. I think people should not get the idea that this is a thing that is a utopia or eternity or something like that.
I’ll give you an example. The last time around, environmental education became an international effort. It became, at least in many parts of the world during the Cold War, an instrument to undertake a critique of the industrial civilization, meaning that we shouldn’t pursue development in particular ways. Those things might have been ethically and morally laudable for those who attempted that, but what it also did was that environmental education did not really take off as a subject area in many parts of the world because it became a very value-laden kind of curriculum, which was difficult to teach. It didn’t go into, say, for example, field biology or field ecology directions, which are now beginning to happen. I think in sustainability, also, we are going to get into that. I think the learning-by-doing approach is a good one, but that takes a lot of time. I think people must get reasonable images into their heads as to what these things mean.

You talked about homeostasis, also self-regulating systems. A human body is a homeostatic system, but human bodies can and do die. I think, ultimately, these complex kinds of notions are very difficult to put words around. People do get images in their heads. I say that again: I think it’s much more important that people don’t get the wrong image in their heads, rather than having a very clearly written definition, even if they’re influenced by the Peter Principle. There’s a statement that in modern times, if you’re not confused about a lot of things, you’re not thinking clearly.

FACILITATOR: A question for the group at this point. I can understand the difficulty involved in saying: This is what “Gaia” means … Does it have to be that you have a total comprehension before you take a stance? And without that total comprehension, you have a paralysis of inaction?

CALVIN: Okay. Let me try to extend.

FACILITATOR: I was going to pose the challenge to the group: Let’s say that you are in front of a class of sixth-graders. Explain it to them. Take a shot at it.

CALVIN: I’m not going to take a shot quite that way. I’m going to tell you one of the hazards of defining it when you have this overarching term. Since it takes actions, and people assume actors are associated with actions, one of the dangers turns out to be creating misunderstandings. Let’s take global warming as an example. The physics of putting more CO$_2$ into the atmosphere and creating a greenhouse blanket of insulation have been quite clear for a while. The assumption was that there were things that take CO$_2$ out of the air, like increased plant growth, which will, perhaps, do it. It turns out not to work very well. It also was said that the oceans will buffer it; they’ll take it out of circulation, and all we’ve really got to do is to wait and these levels of CO$_2$ will come back down. After all, weathering of rock brings it down but it’s just very slow. But plant growth is good.

The fact that these things did not work out is a reflection of overgeneralized, too-early information about the thing, and that we didn’t pay enough attention to the parts and pieces of the thing and what they, in fact, were capable of. We discovered by about the mid-’60s that the oceans were not going to buffer the CO$_2$. That’s also the era, starting in ’58, when we had year-by-year measurements of the CO$_2$ levels. That was where, by the early ’70s, the notion that we were having global warming and it might get us into real trouble came from. The whole notion that there were regulatory mechanisms up there that would take care of global warming may be one of the things that helped postpone action on it for almost 40 years now.

FACILITATOR: I think focusing on the fact that it may be a self-regulating system, as opposed to simply emphasizing the interconnectedness of things, may be where the emphasis was misplaced. I still want to ask you to try to explain it to a sixth-grader, however you wish.
ISHWARAN: I will try; however, I’m not going to try exactly the way you said it, but I will try. I think interconnectedness and self-regulation in a system would be related, but the relationship might be out of phase. A self-regulating system with all kinds of interconnections might collapse, like all of us will die.

The second point is that you said even if we cannot say what it is now, we could say what it is not. There was a place in Sanskrit literature where we tried to define God as not (Not this, not this, etc.). When I hear this, I’m getting into doubts, wondering what we are talking about here. Is sustainable development a religious notion or is it something much more sensible? I think it might be easier to define what it is not, but I think one must avoid that pitfall.

Now, I’ll come to the last point about how to explain it to a sixth-grader. The guy who used to go to all the sites evaluating sites nominated for World Heritage status, a UNESCO list of the best places in the world, asked me, “If you really want to push this site for World Heritage listing, how would you tell it to your mother?”

If you’re going to talk with a sixth-grader about this issue, I wouldn’t mention “sustainability” at all. I would say, “Come, let’s talk about your grandchildren’s planet, and what it looks like.” We could talk about it using simple examples they can relate to, and if they start wondering what it is all about, then you can bring in this notion called sustainability. You can tell them you can relate to it in this way rather than telling them to do it in a particular way. I think it’s almost like a Japanese martial art tactic: Don’t hit the target; hit around it.

GIBBS: I think the next group probably will get into this more because they’re going to talk about persuasion, and how you talk to children has a lot to do with how you persuade people. How we can talk about interconnectedness is another big question. How do we talk to adults, to the population, to policy-makers? I really take to heart Bill’s comment about talking to people who are expecting actors to act, because they ask questions that are hard to answer. They want predictions, forecasts. They want details: What will happen here in the part of the world that I’m responsible for during the time that I’m responsible for it? Those are questions for which we have very few answers. Is there a way to talk about connectedness that satisfies that need? We don’t know the specifics. We can’t make known, precise forecasts; we’ll look foolish if we do. But we understand these phenomena. Maybe what we need is a new set of metaphors for describing these systems in the ways that they interact. I appreciate that aspect of David Wasdell’s work in trying to sketch out and graph and visualize the interactions among feedback systems and things like that, because they’re not intuitive, I think, to most people.

CALVIN: Can I give a sustainability example that just involves leads and lags, as they’re called in engineering? Take the example of a new restaurant in the Berkeley area. This is a story that Rich Muller likes to tell, since he once invested in a restaurant. He says these places are always being created. Some of them get popular, and they get more and more crowded. Over the space of a year they’ve served lots of people because they turned out to be both inexpensive and a good enough place. Then, all of a sudden, when there’s standing-room only, the place goes bankrupt. Why does that happen?

There’s a lag between getting your income now and paying your bills next month. As long as you’re on a growth curve, you’ve always got enough money to pay your bills. But once you’ve reached the capacity of the restaurant and things aren’t growing anymore, all of a sudden you discover you haven’t been charging enough for your food. You finally get into a place where your creditors force you into bankruptcy. Spreadsheets are helping us get around this sort of thing, just so people can plan a little bit better, but this is a common kind of thing that I think we’re getting
into with some of these sustainability issues. We're sort of paying our debts later, if at all. We're going to discover that, at some point, we get into some of these situations where nonlinear things, like bankruptcy, kick in on an environmental scale because we run out of soil or other resources.

We have evolved the notion of “Think globally and act locally” … Do we have the luxury of understanding it completely and the time to do so?

FACILITATOR: The idea of connectedness, if one were to take into account all the variables involved, is way too large. On the other hand, you could probably demonstrate in subsets the connectedness of things. In terms of knowledge or science, is the proposition complex enough and will it ever be capable of explaining in its totality the notion of connectedness as one might intuitively grasp?

We have complexity theories; we have tipping points; we have dynamic systems; we have comprehensions of nonlinearity. But is all of this put together adequate to explain what is involved and what we already understand intuitively as something that comes close to the idea of an interconnected system? We have evolved the notion of “Think globally and act locally.” That's based, essentially, on less than adequate knowledge already, at least based on what we're saying. Will we ever understand it completely? Do we have the luxury of understanding it completely and the time to do so?

How do you localize stories of connectivity, nonlinearity, etc.? … what we understand … brings the clarity to speak about it with others in language they relate to …

ISHWARAN: There is a thing that exemplifies the popularity of Manchester United Football Club in Singapore. Somebody called that “glocalization,” because Manchester United is a football team located in the UK. But it's very popular in Singapore because of the T-shirts and all kinds of paraphernalia that go with it, as part of the connection Manchester United has made in terms of promoting its image not only as a football club, but also as a provider of a brand that identifies with certain characteristics, for example, excellence in soccer. Those things are happening.

Wayt asked a few minutes ago, “How do you tell the sustainability story to a particular policy- or decision-maker in a particular locality?” How do you localize stories of connectivity, nonlinearity, etc.? For me, I don't think I will try to use that kind of an attitude when I speak with somebody about a specific problem. I think what we understand and what we have in our minds about what a particular problem is and how that to be explained brings the clarity to speak about it with others in language they relate to; that's most important.

If you speak more than one language, telling this story has another set of challenges. I'm an English speaker. I don't speak my mother tongue very well anymore, but I still speak it. I think in English, and I'm married to somebody who's French; most of the time we speak in English. Here's a person who thinks in one language and converts into another language to speak to me because she wants to.

I think if I am going to speak to this individual who has a problem in a particular context, if I want to be helpful to that person in terms of assisting that person to solve his or her problem, I should make that effort. If I'm just speaking the language that I have used to understand things for myself, I'm just looking after myself. I'm speaking in a language that makes me feel very comfortable, but I'm not making that leap to become interconnected with those people, too. You have to make that connection to try to speak that person's language to bring your ideas in a very clear manner.

That's why I wouldn't start with sustainability. I'd start in a different way and come to it, rather than start with it. This probably will come in the learning part of the group.

FACILITATOR: Right.

ISHWARAN: I think you understand things for yourself in one way, but then when you have to explain it to somebody you might have to try different tactics.

When we talk about connectivity and self-regulation, we must keep in mind processes and organisms that match the connectivity in some way or other …

KESAVAN: When we talk about connectivity and self-regulation, we must keep in mind processes and
organisms that match the connectivity in some way or other vis-à-vis: Are we trying to pose the connectivity in some unique way, such as artificially? This is a very natural thing.

Also when we try to look into self-regulating mechanisms, we have to keep in mind that self-regulation is not a single process, if it is a biological system. It is a representative of complexity, with different things happening through signaling, processing, and so on. Unless we take a microscopic view and go into the very basic units of organizational top levels, we may not be able to appreciate how the interconnectivity and the self-regulating mechanisms would remain intact, and for how long. All this depends upon any one of the single processes out of a multitude of processes going wrong; the whole thing would break down. These are all important things, including the naturally occurring linkages and the self-regulating mechanisms vis-à-vis what we, in our mind, in a transient manner, believe to be interconnected or for which we can establish interconnectivity. That is artificial intelligence.

FACILITATOR: I think we'll probably open this up to the second group in a moment here. I've used this analogy a thousand times, and it looks as if I'm motivated or compelled to do it again. With the degree of difficulty or restraint we're exercising in trying to take a shot at describing this context so that the other group can do its work, they have a challenge in front of them. What is it that we're going to communicate if we don't know what it is that we're trying to communicate?

It reminds me of what the US Supreme Court said when the question of pornography came up. They were asked to define pornography. They said, “We can't define it, but we'll know it when we see it.”

Is that the closest we can come in terms of describing the context of “Gaia,” “connectivity,” or “sustainability,” and all the ramifications of each?

FACILITATOR: Would the panel care to comment on this before we move on to hear comments and questions from the outside group?

CALVIN: The high level of connectivity makes you have to analyze each of the connections for what it can do to you. Leads and lags were one example. Typically when the growth of one thing is faster or slower than another, you start getting interesting sets of problems, for example.

What Reverend Malthus discovered in 1796 was that the resources you have may grow, but they don't grow at a rate that's proportional to how big they were last year.

The human population and other animal populations can do exactly that. That is to say, the more babies in one generation, the more mothers there are the next generation, and therefore you get an even larger number of babies. However, in natural resources, the size of the farmer's field isn't increasing in a similar kind of way. Its increase does not depend upon that pre-existing size. These connectivity interaction problems are seen all over the place. You really can't get away from the dynamics of those things; just constantly treat them as a push-and-pull kind of thing, like a tug-of-war.

FACILITATOR: Any last comment?

GIBBS: I'd just like to expand or riff on that a bit. There seems to be a natural instinct among many analysts as well as the public at large to extrapolate in linear ways from their experience, from past trends. There's a real difficulty with understanding systems that behave in nonlinear ways, the hidden inflection points, where you have trends that cross.

This is another way of talking about what Bill was saying. These are concepts with which humans don't seem to have a natural facility, and they're not emphasized very much in our educational system. It might be an important thing to have lots of exposure to these for the public and in education, to instances that illustrate how nonlinear systems would work and fail to work, and how abrupt changes can happen, to cultivate a kind of intuition that can then be tapped by scientists, for example, as they do their work. They're on the lookout for these and they're always looking for inflection points, crossover points, tipping points, and unstable equilibria, things like this that also resonate with the public and with policy-makers.
ISHWARAN: You raise points about what these words mean. I don't see solutions coming through. I think we're trying to explain things that we believe are connected. Then we give names to them, and the names we give sometimes don't capture the full range of what's in our minds in terms of these explanations. I think that mismatch will continue to be. That's where I think these kinds of terminologies can continue to be used as operational tools to talk about things among people who agree with the terminology. But the moment you go out of that group, you have to find other ways to explain what you're thinking about, rather than sticking to the words.

Storytelling is becoming a tool for management practitioners and learning in terms of understanding what one should do. There is a story about why a second language is important. It's about a dog that was chasing a cat and its kitten. The cat and the kitten ran like mad. Suddenly the cat turned around and started saying, “Woof, woof, woof, woof,” and the dog ran away. The cat told its kittens, “See, that's the advantage of a second language.”

FACILITATOR: The discussion is now open to the other members of the participant group.

TREDER: I found observing this discussion from outside the fishbowl to be very frustrating, almost to the point where I felt physically uncomfortable. As much as I try to be a holistic thinker and view systems, I can't get away from being goal-oriented … I was thinking that there's nothing being accomplished here.

FACILITATOR: You want to take a crack at it?

MUSSER: Actually, I wouldn't quite be as harsh as you. I think their conversation took a certain turn because of internal dynamics. I agree that we do need an operational definition. Let me propose one, and you can shoot it down or we can work with it. We need to use up the Earth's resources at the same rate that they're replenished or replaced. Can we just use that simple idea?

TREDER: No.

CALVIN: Just remember leads and lags.

FACILITATOR: Anybody want to comment on that definition?

KESAVAN: It is very difficult to know the rate of renewal of the Earth’s resources that you are using. It is highly theoretical, esoteric. The second and the most important point is why we have to be flexible in our understanding of it. Already you know terms like “ecological footprint,” “ecological overshoot,” and things like that. In most parts of the world we are in the era of ecological overshoot, which already indicates that kind of attitude towards that kind of definition of sustainability is not sustainable.

TREDER: Yes. I was going to say essentially the same thing in different words, which is that if you followed that definition, which is a good start, to its logical, absurd conclusion, you could say, “Half of the world can use up all the fresh water, as long as the other half of the world saves all the fresh water.” That, obviously, wouldn’t actually function in a system, but it would meet that definition.

MUSSER: It would be sustainable at a global level, but it would not be equitable. We've been asked to define “sustainability,” not “equity.”
POLAK: Part of the problem of sustainability is that it has to be defined locally as well as globally. For the example of India in the big picture, India has more water falling on India over the year than the people of that country need. The problem is that it comes at the wrong place at the wrong time. It is in balance as India, but there are desperate water shortages in parts of India, especially at times of the year. That same statement can be made for many countries in Africa, in that during the monsoon they have a problem of how to get rid of the water and during the dry season there is not enough water. What is sustainability as far as water is concerned?

The other thing I would say is that I was at a conference of the hydro-geology scientific community in Spain. Many of the hydro-geologists would disagree with the notion that you should use only groundwater, as much groundwater as comes back every year, for a variety of reasons; it’s complicated.

MUSser: Such as?

GIBBS: I’d like to make a comment, too. I’m not sure that definition works in the face of rapid technological development as we’ve been experiencing. Take the example of energy supplies. The emissions produced by poor use of fossil fuels notwithstanding, one could make the argument that the replacement rate for fossil fuels is essentially zero. That does not mean that one should never have used fossil fuels. One can use fossil fuels wisely for centuries, possibly, if one did it wisely. Then replace it with new technology, for example, fission nuclear reactors.

TREDER: Perhaps what we’re discovering here is our initial statement that environmental sustainability should be the Number 1 overriding issue. Perhaps we’re missing out on something there. Following George’s simplistic version of the definition of sustainability, I said how you could have a definition, which he said would not be equitable. Then it occurred to me, the professor down in Texas who’s been getting all the heat for saying the Earth would be better off with 90% fewer humans....
clarify the definition for the context of environmental sustainability to include explicitly the survivability and thriving of the human population.

**FACILITATOR:** I think the leader of the group that came up with this was, if I recall, quite articulate and passionate about a planetary view of things. I’m wondering if he’d like to have the last word. But first, Paul.

**POLAK:** I just wonder if we can come up with a version of what George recommended that would be acceptable. The components, it seems to me, would need to be regional and global. Here’s the kind of thing I was saying: Treat each resource in a region so that the biodiversity can survive in a healthy way over the long haul; treat resources similarly for the globe to avoid calamitous global consequences to biodiversity over the long haul. The complexity of this is that you have to do things in a sustainable way, but to be sustainable is to be both economic and….

**TREDER:** Social.

**POLAK:** You have to keep in mind how what you do in each region impacts something like carbon. You might have a sustainable strategy on energy in one area, but it’s not sustainable globally, for both calamitous reasons and for reasons of biodiversity balance.

**FACILITATOR:** David?

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**WASDELL:** Thank you, Sesh. I’m going to limit my comments to issues of process rather than content for this. My sense was not that you did a very bad job and you’ve given us such awful rubbish content to try to follow that we’ll have to put it right before we can get to our own work. I would take some issue with my friend Mike here. Seriously, I think you had an immensely difficult task – the complexity, the multi-dimensionality – to see the container, the contextual process, as a whole. I’m reminded of the story of the difficulty of seeing the forest for the trees. In this case it was a debate about how to find the stomata on the back of the leaves. It is very difficult indeed to get to that level of dimensional complexity to view the situation as a whole. I appreciate that.

There’s a consistent move to downgrade levels and work with parts rather than wholes; to move it into definitions of words rather than really working on concepts; to try to deal with the issue of communication to someone who doesn’t understand the concepts, rather than to work with the difficulties that you faced as a group.

I had a phrase like *reductio ad absurdum* as a defense against anxiety. It is both dimensionally challenging to live at this level, and when dealing with that level faces you with levels of threat that are very difficult to handle emotionally, then one of the things we do is we move to our left brain and ditch the rest. We downgrade the dimensional complexity that we work with, and we end up talking about definitions of words.

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This is a microcosm of how social systems deal with threats from the environment. I think the Pentagon is probably the most defended group on Earth.

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This is a microcosm of how social systems deal with threats from the environment. I think the Pentagon is probably the most defended group on Earth. You established an all-male Pentagon with a centric-periphery mode of communication between a chair and four members. It was not a fishbowl, not in my understanding of a fishbowl. I saw a boardroom with a President and a Vice President pulling the strings on the controlling officer in the chair, making quite certain that issues that might really threaten the administration could not be raised. It then became the Supreme Court, which was a nice shift of metaphor.

It seems to me we are really struggling here with how to address the issues of global complexity as the context within which we can then work with the problems of engaging that sustainably. It is a process issue as well as a content one, and I think we are struggling here at the edge of our competence. If we use the learning from how we responded to the question as well as what response we made to the question, we bring in both the process and the content. There’s immense learning from what happened there. We can build on it.

**FACILITATOR:** Very good. I think that will conclude this fishbowl. We’ll take a break, and then we’ll reassemble for the second one.
Learning and Education

**FACILITATOR:** Sesh Velamoor

**PARTICIPANTS:**
- George Musser
- Paul Polak
- Michael A. Treder
- David Wasdell

This fishbowl is dedicated to discovering the methods that would enable the process of learning and education about the interconnectedness of everything …

**SESH VELAMOOR (FACILITATOR):** At this point, let's please have the second fishbowl group in the front and center of the room. That would be David Wasdell, Paul Polak, George Musser, and Mike Treder.

This fishbowl is dedicated to discovering the methods that would enable the process of learning and education about the interconnectedness of everything, beginning the integration and comprehension of elements of planetary sustainability, and starting to build resilience to vulnerabilities identified as we grow through changes in the biosphere.

**MUSSER:** I’d like to say something before the rest of the conversation starts. I wrote on the board a few thoughts that occurred to me in the last session as I was inspired by the group’s discussion. These are issues I think we will need to address in our little group regarding how to move humanity towards the sustainable goals that were mapped out before. I’ve tried to keep solutions out of this; it was hard, because I wanted to write down, “Oh, I think we should do this.” I avoided doing that and, instead, just identified a few issues.

I’ll start off with something Bill Calvin mentioned, which is that there seems to be an inherent bias toward growth, such as the example Bill gave of the restaurant that appeared successful but failed due to inadequate profit margins. Another participant commented that there’s a desire among the public, at least, for knowing what to do before you do it. That’s a luxury we may not have.

There’s a tendency to extrapolate from recent experience and to do so linearly without taking non-linearities and thresholds into account. This is really a synthesis of some earlier remarks. Infamously, human beings are bad at assessing risks. We can’t focus on unimportant risks at the exclusion of important ones; that’s something we’ll have to deal with.

There’s a tension between the goals of resilience and economic efficiency that comes from lack of resilience.

There’s a definite bias in decision-making to the wrong time scales in both market and traditional political systems. I’ve put it in this way: There’s a tension between the goals of resilience and economic efficiency that comes from lack of resilience. That’s occurring not just in manufacturing; it’s also in the power grid. That’s one reason we’ve had issues with energy.

I think we’re going to have to bring up this big issue – this involves the values we talked about yesterday – who is the “we” we keep talking about in terms of taking actions? I think there’s an inherent human tendency to not do something rather than do it. I just wanted to…
share those ideas to help start our discussion.

**FACILITATOR:** We’ll have this group in the center discuss issues for about 45 minutes, and then we’ll open up to include comments from others in the room for about 15 minutes. If necessary, we can extend the session for as much as one hour and 15 minutes.

**POLAK:** I would have one short request, and that is for somebody to state as succinctly as possible what this group is supposed to do, just to help me re-think what we’re about.

**WASDELL:** I’m puzzled as to what we’re trying to do in this quartet. I think I would like to, as Paul would, spend some time to get that really clear, just at the beginning. Can you help me? I’ll try to respond to you and the others as well. What do you see as this quartet’s task, the fourth quartet? What are we here for?

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**POLAK:** All right. I’ll take a stab at how I see it. I think what George did is a good start. We need to have a clear idea of what limits the human capacity torespond effectively. That means talking a little bit about who we are as humans and why we respond so ineffectively. Another piece of it, for me, is to deal with who the key scientists are who know about this, and change their perception of what they should do in the world. I think that part of the problem is that scientists chase truths and don’t see themselves as activists, a mold that was broken quite effectively by Albert Einstein. If we are to break that mold, what do we, as scientists in this room, see as the most important actions we should take? That’s been part of my frustration as I’ve heard scientists present. They have been much more thorough in talking about the field of knowledge than what to do about it.

**TREDER:** During the lunch break, I took Paul Polak aside and told him how much I admired him and his work, and how it’s among the most impressive individual accomplishments I know of for anyone I’ve ever met. He said, “Why do you say that? What’s so unusual about it?”

I replied, “Because you’re putting your ideals into action in a way that I, and others, envy, and, I’m sure, many people wouldn’t even imagine.” That’s a value that means a great deal to me: taking ideas and making them work in the real world. My hope is that we can begin in this quartet by taking some of these big ideas that have been discussed over the last two days and move them at least in the direction of effective action.

The scary reports that we’ve heard from each other will, I hope, create that sense of urgency that I discussed in my talk yesterday. If 10 or 20 years from now we’re still sitting here talking, then Rome will have been burned down in the meantime. We have to be able to move from discussion to effective action. There’s a long, long way to go. We have to figure out what’s the first step along the way and where we go from there.

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**WASDELL:** What I really valued from that comment was the concept of walking the talk. What I see you affirming – and I would also affirm Paul – is the integrity of walking the talk in a way that communicates far louder than words. You’re there with people, hurting with people, listening to people, and enabling them, with some resources that you bring, to stand on their feet and become sufficient, more than sufficient. That’s beautiful role modeling. Thank you. If I do that a little bit better as a result of this workshop, then meeting you will have been a joy. Thank you.

It is okay – my eyes are filling up as well as yours – to have feelings. My son said to me once, “Dad, one of the
key things you do in life is to make it safe for people to cry. ’ I think if we leave out emotional intelligence at this level of our work, we can’t think straight.

**We wish to learn resilience in the face of threat … and to move to macro dimensionality – holistic thinking – yet, what prevents that from happening?**

How do we learn to learn? Perhaps by bringing in emotions and actually saying we are feeling people here. If we walk the talk as a quartet, what would it be for us, as a foursome, to model what we’re talking about and learn new ways of learning? We wish to learn resilience in the face of threat, rather than closing down our dimensionality, and to move to macro dimensionality – holistic thinking – yet, what prevents that from happening? How do we overcome it?

… to be willing to see what’s really there … to act effectively based on that information and be open to rapid change … is very hard given the way we’re wired.

**POLAK:** One of the main reasons I’m alive today is because my father was a survivor. When Germany invaded Czechoslovakia in ’39, we escaped because, for a long time before that, refugees were streaming across the border from Germany with broken heads. It was very clear to anybody with open eyes what would happen. So my father said, “We have to leave everything and get out of here if we want to survive.” He talked to family members and friends, and said, “We have to all get out of here or we’ll die.” They said, “But what will we do with the furniture?” Most of them died.

I think part of the human tendency is to close our eyes to real threats. For me, part of the function of that big brain Bill Calvin talked about is to provide an exquisite capacity for rationalization. People have a remarkable ability not to see the obvious. Part of the thing is to look at reality with open eyes. That means to be willing to see what’s really there and not what we want to see, and to act effectively based on that information and be open to rapid change. I think that is very hard given the way we’re wired. To me, there’s something very fundamental about that.

**TREDER:** I’d like to try, very briefly, to create a visual of what we’ve been talking about. I think in visual terms. Humans are capable of a number of activities. I think, very simply, these activities could be put into three words: think, feel, and act. A truly effective, whole person might be someone who does all three in equal measure and doesn’t isolate himself or herself in one of those three areas. This would be someone who can be open to feelings, thinking, and dealing with reality, facts, and the emotions of human interactions, and who can also put those thoughts and feelings into effective action. It’s simple, but for me, at least, it’s profound as well.

**WASDELL:** Yes.

**MUSSER:** I always have been moved by the story of your family, Paul. I put myself in the perspective of those people who said, “What do I do with the furniture?” They were making what turned out to be, in retrospect, the wrong cost-benefit analysis. At the time, was it really so clear?

… today the developed world ignores the fact that most of the poor people in the world are one-acre farmers; people also ignore the carbon issues we’re facing.

**POLAK:** Yes. Absolutely. Absolutely. It was just as clear as it is today that most of the dollar-a-day people in the world are one-acre farmers. It was absolutely just as clear as that. They ignored it; just as today the developed world ignores the fact that most of the poor people in the world are one-acre farmers; people also ignore the carbon issues we’re facing.

**MUSSER:** Then there’s a failure of either, or both, information getting to them or their ability to make decisions based on that information.

**POLAK:** It’s Number 2.

**MUSSER:** May I suggest that the first bullet point from our session here is that we need to build institutions that overcome this inherent human flaw? We’ve recognized that flaw using a part of our brain. We all are susceptible to it. We need to, somehow, build around it. Science represents that to some extent, but policy-making does not.
... just as the form of a structure has to be functional, the form of an institution needs to be functional, flexible, learning, and adaptable.

WASDELL: Thinking, for me, is also bicameral. I used to be a very, very verbal, linear, right-handed, word-oriented person. I was also into a lot of music and other things. As I began to work on some of my own processes as a human being, it was as if I had been using an IBM – or an Amstrad in those days – word processor, and then I opened up an Apple computer-type mainframe, and my expanded visual capacity was just overwhelming. I started playing table tennis left-handed and beating my son, who was a county junior player. He didn’t like that at all. All the competitive stuff in me was coming out, the testosterone, with extraordinary capacity.

I live and work with someone who was born left-handed but virtually blind in one eye. She was forced to become right-handed and was considered an absolute write-off in our educational system. She read about 40 books a week with virtually a photographic memory. She tells me now when she walks in, and I say, “Oh, I’m watching the television.” She replies, “It’s so and so and so and so; they’ve missed two lines of the dialogue.”

Between us, we’ve found that using both hemispheres to think and envision, to deal with feelings and actions, is holistic processing. The idea is to bring that together as a nano-institution, as a dyad in my particular working environment and as a quartet here, and make it a replicating nano-institution so that we can produce the capacity to replicate processes that can enable resilience in global response.

That, it seems to me, brings together what you’re doing in technical systems as a transferable skill into the need that we have in social systems. I’m going to bring you in from the “audio control desk” for a minute. We were talking about skills transferable from architecture to dealing with human behaviors and human systems. Similarly, just as the form of a structure has to be functional, the form of an institution needs to be functional, flexible, learning, and adaptable. If this is a nano-system, how can we now improve the way we’re working to walk the talk?

How can we translate what we have achieved here today ... to create something on the scale that will be able to respond to global challenges?

TREDER: How can we translate what we have achieved here today, at least in immature form in this quartet, to create something on the scale that will be able to respond to global challenges?

What are the processes involved in really competent learning and resilience building? How do I integrate my learning capacities and become more resilient?

WASDELL: I think there are two questions there. One is the process: What do we have to do? And the other is scalability: How can we replicate? How do you replicate advanced learning skills, addressing not “this is what you do,” but “this is how you learn to do it better.” Let’s stay with those two differences.

One is: What are the processes involved in really competent learning and resilience building? How do I integrate my learning capacities and become more resilient? The second one is: How do you scale it?

One of the problems is that uncertainty makes it difficult to take action.

POLAK: For the translation of process to action, for me a useful exercise would be to take one of the key areas discussed yesterday and today and think of different aspects of translating it into action. David [Wasdell] and Bill [Calvin] have talked about climate change and George [Musser] has talked a lot about what science knows and what science doesn’t know. One of the problems is that uncertainty makes it difficult to take action. I’ve tried to press, especially Bill, about what he would do. One of the things that would be very useful is if David and Bill could come up with a list of practical actions that could be taken now. Even in this state of uncertainty, what kind of carbon targets should we shoot for? Of course, you can’t say, because there are too many things going on. I’m talking about
this as someone who is not an expert or very familiar with the field.

It's very clear from what I've heard from both of you that the Kyoto Accords fall far short of what's needed. In this state of uncertainty, who is going to tell us what targets we should shoot for unless you do? What practical steps could we take? Would it be a breakthrough in energy technology? Would it be giving up cars? Once you establish that, then it's a question of communicating what course of action we should take. To change the world, we need to express what's needed in positive terms, not the doomsday stuff that comes out so much; people don't respond well to fear.

One of the keys to becoming an effective nano-learning system is becoming aware of the process that's going on while it's going on.

WASDELL: One of the keys to becoming an effective nano-learning system is becoming aware of the process that's going on while it's going on. I think that's one of the necessary, but not sufficient, marks of a good learning system. I've just noticed that you've asked someone from outside to tell you what to do, and it's the third time you've done it. Reverting to prayer is one of the ways of doing that: "Somebody, somewhere, tell us what to do. Give us a list." It's been thrown back to you, right? Bring your own "to-dos" in.

Something happened this morning. I was talking to my other half; we stay very much in touch during these events. She said in a local school there was an event, which is one of the national debates on radio, in which our ex-Environment Minister from the previous administration was one of the panelists. It was a school that was absolutely split down the middle on a proposal to put a wind turbine on the roof to generate some of its needed electricity. Parents and others were up in arms and having a fight about whether they should or shouldn't do it. The Chair turned to him and said, “What would you do? Which side would you be on?”

“The people who have the most information about reality have the responsibility to make clear recommendations from their point of view …”

POLAK: You're coping out. I am glad to participate and contribute what I know from poor villages and poor people. But you are a scientist who has, by far, more expertise in the field than I do. If you ask me what to do about poverty, I have 25 years’ experience. There's a lot I don't know, but I will tell you it's my job to come up with a practical course of action.

I think it's the job of the scientists who know the most about it to come up with a practical course of action. I will be glad to participate, and I have lots of things to contribute. What I'm talking about is the role of scientists. The people who have the most information about reality have the responsibility to make clear recommendations from their point of view, even though they may very well be wrong about what they think should be done.
TREDER: It requires a dialogue. As I said in my presentation, I view it as a four-way dialogue— not a dialogue, a quadrilogue—that has to involve government, business, NGOs, and, in this case, science and others.

I want to ask David Wasdell something for clarification. I think I heard you say that this grassroots movement of nano-institutions, groups working on community levels to become more sustainable, etc., was, at least I thought you were implying, the solution.

WASDELL: One of them.

... until we can get multinational corporations to stop building and marketing SUVs... all of the little grassroots stuff isn't really going to make a difference, in time.

TREDER: I want to make clear that, from my perspective, even if almost everybody in the world decided to do that, until we can get multinational corporations to stop building and marketing SUVs for people who drive to school and back, all of the little grassroots stuff isn't really going to make a difference, in time.

In poverty, sustainable agriculture, all areas, those who know the most and have the clearest view of reality ought to come up with practical action suggestions.

POLAK: Just one other quick thing. I'm not really saying that it's up to you, David, to solve all this for everybody. And I'm not saying it's up to George [Musser] or Michael [TREDER]. I'm saying in terms of a model, we have several things on the table and we have people with expertise. The people who know the most can look with open eyes at reality and take an activist role in giving practical suggestions, even though it's very difficult and it's a field of uncertainty. All of us will participate. It's not only that; it's about David Montgomery and soil erosion. He gave a long talk about the problem but said very little about what he would do with that area 100 miles from here. When I asked him, he had some very practical ideas; it was very clear what to do.

In poverty, sustainable agriculture, all areas, those who know the most and have the clearest view of reality ought to come up with practical action suggestions. That's all I'm saying.

MUSser: I think you're onto a very important point: Those who know have an obligation to explain what to do. There's a responsibility that comes with their knowledge. The scientific community has not been silent about what to do about global warming. Although in here we may not have gotten a detailed list of things to do, there's been a lot of discussion about what to do about global warming, from Kyoto to individual efforts as well. I don't think there's been a lacuna there.

One thing that has become an issue is, suppose they did give a list of things to do now. “Don't drive an SUV,” to give an example, or “Don't run your dishwasher without any dishes in it,” those kinds of things. I think there's a tendency of the public—maybe I should put this on the list of issues we're identifying—to focus on solutions they don't like, rather than focusing on the problem. For instance, they say, “I need an SUV. I drive in off-road areas all the time,” or “I need it in the winter.” I think we've seen that on a society-level basis.

Our President says, “I don't want to ruin the economy,” as if that were actually being proposed, as a reason not to stop global warming, conveniently neglecting the problem itself. He's focusing on solutions he doesn't like, and using that as an excuse not to deal with the problem itself.

WASDELL: It really is important not to leave the furniture behind, isn't it? I think that was the comment from Paul Polak's story. What I'm hearing here is that those with the knowledge must take responsibility for its application, and that the scientist who knows, but does nothing, is an abortion.

POLAK: Sort of. I wouldn't say it quite that way.
The issue of how we learn is about bringing in knowledge. It is also about initiating from our own knowledge and taking responsibility for bringing it forward.

WASDELL: The issue of how we learn is about bringing in knowledge. It is also about initiating from our own knowledge and taking responsibility for bringing it forward. It’s not about dependency on others; it’s also about interdependency, taking responsibility, and taking action.

I think that’s the issue about praying; it tends to move us into a dependent mode. If we actually take back the responsibility to be fully human and incorporate what that responsibility means, then we become proactive, interactive, and interdependent, not just as whole humans but in the wholeness of our interpersonal relationships as well.

You have to define what you want to accomplish and exactly how you will do it, and then do it.

TREDER: I’m going to have to play devil’s advocate, not unwillingly. It’s not just about “we.” This is completely against my hippie upbringings, but it’s also about “they.” We talked earlier today, I think it was, about the need to develop ways to convince or persuade, educate, and encourage action – different action – and change, from those who make a difference. As I said earlier, no matter how hard each of us tries to be a holistic individual, as long as those with the gold are making the rules, things will continue to get worse. We have to go beyond “we” and talk about what we are going to do about “them.”

WASDELL: That’s right.

TREDER: I’m sorry, but that’s a requirement, I think, in order to achieve effective action.

You have to define what you want to accomplish and exactly how you will do it, and then do it.

POLAK: For me, that is assumed. I’m working on four revolutions, and that’s not talk. On the design revolution, the thing I’ve defined is to change how design is taught in the West, to change how it’s taught in developing countries, and to create a platform for 10,000 of the world’s best designers to address the problems of the other 90%. I’m doing stuff with universities. The Smithsonian, next summer, will include an educational program for children. I’ve talked to your excellent people here about participating in it. That’s what I mean by taking action.

FACILITATOR: Okay. I would point you to some software that now is available where the collaboration for solution of design issues such as this can be facilitated. We can discuss that offline.

… children could have a very big part to play. They may not have half the obstacles that we are naming.
what I mean by taking action. You have to define what
you want to accomplish and exactly how you will do
it, and then do it.

MUSSER: I've been collecting a few action points
from this discussion; I'm up to four. I'll try to syn-
thesize those at the end and bring those points back
together.

Actually, I wanted to riff off what Paul said a little
bit. I think education is a very important part of what
we're doing; I don't think anyone would disagree. Very
specifically, I think there's a need to bring the public –
partly through education – into the scientific process.
There isn't a disconnect, as the one I described earlier,
between the advice of the experts, which I can reject
because I don't like the conclusions of the experts or
the action plan that the experts have come up with. If
the thought process were more accessible to the pub-
lic, then I think it would be harder for the public to
offer that kind of rejection, specifically in education.

One way to do that, I think, is to either teach cer-
tain subjects differently or to augment the teaching of
the subjects. My recollection from school, and please
correct me, any of you who have had other experi-
ences, is that there always was “the answer.” It may
have been in the back of the book; it may have been
in the teacher's mind; it may have been my dad help-
ing me at night with it. But every math problem I did
up until graduate school, probably, every problem,
every question I was asked to comment on, there was
always an answer.

We're in a situation where there aren't answers. I think
kids need to be exposed to that early and not have it
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kids need to be exposed to that early and not have it
drilled into them that there always is an answer. They need to understand that things are not always that way.

… what we've been treating as hardwired
capacities of human behavior are learned
and therefore transformable, rather than
being hardwired and irredeemable.

WASDELL: That is just so important, isn't it? Our
education actually passes on the defenses of the pre-
vious generation, so that the next generation doesn't
threaten it. We even have that institutionally in the
east end of London where the Society for the Propa-
gation of the Gospel decided to educate the working
classes, but not above their status, lest, like the Sepoy,
they rise and destroy us.

I want to pick up on the hardwired idea. The issue
of being hardwired is, for me, the most fundamental
question here. I started out looking at some of the
most dysfunctional behaviors in groups and orga-
nizations, facing just what we're facing: high stress,
rapid change, and very low resources. The traditional
answer as to why the splitting, the scapegoating, the
denial, the going back to previous solutions, not fac-
ing reality, cutting off information, killing each other,
excreting a group and thinking we feel better, and all
such things going on, is that these are human instinc-
tive behaviors. You have to learn to cope with it; it's
straight out of Freudian, Jungian, Kleinian, or Bion
material, for those of us who know the language. The
instinctive behaviors are hardwired.

The joy of the last three decades has been to chal-
lenge that, and to find that what we've been treating as
hardwired capacities of human behavior are learned
and therefore transformable, rather than being hard-
wired and irredeemable. These capacities are learned
in common. The question was: What happens to us
under conditions of high stress, rapid change, and
low resources to make us respond in this crazy way? I
was just in the right place at the right time asking the
right questions.

… learning, from a very early point, right from birth
into post-natal and childhood periods, is a
continuum; it isn't a starting point.

We began to recognize that learning, from a very
early point, right from birth into post-natal and child-
hood periods, is a continuum; it isn't a starting point.
We really felt that behaviors were hardwired later in very deep experiences of our excruciating pain, rapid change, breakdown of resources, and primal eviction – thrown out of the utopian, in retrospect, environment – into a world of alienation. Those laid the foundation for what we then recognized as the craziness of human institutional behaviors. In other words, we behave as a species in post-traumatic stress disorder.

I think one of the beauties coming out of Bill Calvin's work, for me – and it's been a joy – was recognizing the increasing cranial diameter outstripping the birth canal. In Neanderthal times, the average cranial size was smaller than the birth canal, but this was different. In Cro-Magnon and then in *Homo sapiens* periods, it's larger still. Some of you disagree, but there's an enormous amount of research now coming in on this.

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**There is a transition for *Homo sapiens* in which extreme trauma is the norm. The result is that we tend to live in fetal assumption societies …**

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There is a transition for *Homo sapiens* in which extreme trauma is the norm. The result is that we tend to live in fetal assumption societies where we're creating new wombs, social wombs, and religious behaviors with rigid boundaries like Plato's cave with northern lights on it. To actually cross that boundary into the world outside is like having to face birth all over again. Renaissance man faces, in a sense, a rebirth, a reengagement, a reworking of the fundamental defenses that block our engagement with reality. Once you do that, then you find there is a whole range of defenses in society – like splitting between *us* and *them*, between inside and outside, between those who are for us and those who are against us – that begins to dissolve, and we begin to see systems that become much more mobile, much more flexible, and much more able to engage reality.

The challenge to the hardwiredness of human behaviors seems to be one of the critical breakthroughs in enabling systemic learning.

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**POLAK:** By “hardwired,” I don’t mean that all behavior is predictable. I'm hardwired to have sex with every woman that I see. That doesn't mean that I do it. In other words, there is a capacity for a lot of things. There is a capacity for violence; that doesn't mean that we have to be violent. Everybody in this room, I think, can commit mass murder under certain circumstances.

I believe the term “hardwired” means that the process of natural selection has given us the capacity for certain behaviors. We also have the capacity to translate that possibility of committing mass murder into tremendous creative enterprise. By “hardwired,” I don't mean that we absolutely have to be rationalizing everything. I'm just saying that we have some instinctive mechanisms. We also have the capacity for incredible creativity. Which behavior we actually do is the question. We have instincts, but it doesn't mean that we will always avoid the truth. We have the capacity to see the truth. All of us have the capacity to see the truth as it is, and to act on it, also.

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**TREDER:** For me, this has been a remarkable excursion, a spelunking expedition – with “spelunking” defined as climbing down and exploring inside caves – where we’ve been delving into the inner workings of human society in a microcosm here. Can we come back out of the cave a little bit and remember where we began with “A” as the problem? We said “C” was the challenge of enabling planet-level systems thinking that would be resilient and able to respond to unforeseen situations and events. Prior to that, “B” and “A” were to increase resiliency and reduce vulnerability. We haven’t discussed “A” at all here. We’ve spent a lot of time on “C,” which I think is as it should be. As we’re trying to wrap up in our final 600 seconds, do we want to bring “A” and “B” a little more to the forefront?

**WASDELL:** Part of the process, then, of this replicating nano-system is what I would call second-order learning. It’s not just getting information the way we always learn; it’s learning to learn to do it better, and then reviewing that process to become a third-order
learning system, which is reviewing how we're learning to learn, building in advanced learning protocols to the way we educate, the way we act, and moving up system level. What we have in this room is a learning context, an information-gathering context. It has certain advantages and certain limitations. To be aware of the process in the point at which we're using it is critical. It's equally crucial to be able to be flexible so that the function we have determines how we go about it, rather than assuming: “This is the way we do it, but we're not going to leave the furniture behind, even if it's not appropriate.”

TREDER: And reducing vulnerability.

The higher the level of system we work at, the more dominant, the more dysfunctional behaviors become.

WASDELL: Right, reducing vulnerability. As we move up system level, the macro systems respond in sync with the most common unconscious dynamics. They collude in denying those unconscious dynamics. The higher the level of system we work at, the more dominant, the more dysfunctional behaviors become. Understanding how systems act out their common unconscious, the roots of those common unconscious processes, and how we transform those unconscious processes to enable macro systems to become high-order, high-integrative learning systems seems, to me, the active agenda that emerges out of this.

We have to be able to work like Google Earth, zooming down to any level and acting very locally in multiple points.

Finally, it isn't a question of top-down or bottom-up; it's a question of fractal responses. We have to be able to work like Google Earth, zooming down to any level and acting very locally in multiple points. We need to be able to scale, to go massively to scale, and do it at every level of the system at the same time to create a fractal, integrated, third-order learning response to develop resiliency in the human genome, in the human action, in the human society, in response to what is unknowable about the threats and vulnerabilities that we have. Now, that's action. But it's a sophisticated action in the knowledge economy as distinct from sophisticated action in the wealth economy or the things economy or whatever. That's about as far as I can go. Please, can somebody take us further in summing up these last few minutes?

TREDER: To communicate that learning, to use Richard Dawkins' idea, the spreading of the meme, you've beautifully stated the meme with which we would like to infect the world. What's going to be our means of spreading that? How can we most effectively infect those who need to be overcome by this meme?

MUSSER: Let me spell out some of the action items that we've brought up today. This is, by no means, a complete summary of our conversation; it's just a few of the action items that popped up. One was that we need some kind of institutional prosthesis that accounts for the short-sightedness of our ability to see what's coming. Some of you seem perplexed with this idea.

TREDER: Like a false leg?

MUSSER: Yes. Or maybe a better metaphor would be some kind of a telescope or instrument that extends our human ability.

TREDER: All right, yes.

… we need to make the field of design more relevant to the problems of poverty, and … to the problems of sustainability of environment, as well.

MUSSER: Because we're conscious, acutely, of our inabilitys that prevent us from taking action on these questions, as the example Paul Polak gave from the former Czechoslovakia. I think that has to happen institutionally, in a collective way.

Then there's the whole issue that those who have the knowledge need to apply it, share it, draw conclusions, and guide us with that knowledge. Then there's my point about bringing the public into science, so that they don't demand certainty when there is none, or reject a whole line of reasoning based on the conclusions that come out. I think that comes back to education.

Then I think – and this is one of Paul Polak's points – that for education, for incentives, or for both, we need to make the field of design more relevant to
the problems of poverty, and, I would add, to the problems of sustainability of environment, as well. Then I wanted to bring one of Mike Treder’s points in, which is that we need to treat corporate actors as well as individual ones. We talk a lot about what we, as individuals or collective groups of individuals do, but I think there’s a specific need to focus on money-making enterprises. Does that make sense?

POLAK: Yes.

TREDER: Yes.

FACILITATOR: With that, we’ll open the discussion to the group outside the fishbowl. This time, I’m going to expand access to the observers in the room, also.

CALVIN: I have a list to put on the board, but everybody else can talk while I’m doing it.

OBSERVER 1: I thought it was very interesting to see this learning group, especially when we got into some powerful stories. Things changed, for me, when I heard Paul Polak’s story. I think that kind of power story is an important piece. I think in some ways that illustrates, also, a paradox that I’ve been seeing and holding the last couple of days of the cutting edge of knowledge, the idea of a grand technological breakthrough or something like that, which certainly holds opportunity and surprise; maybe the trajectory can be transcended by something we haven’t thought of yet. Pursuing that is an important piece.

On the other side, I see the work that Paul is doing, which is very low-tech yet massive because it’s touching millions of people. I’m delighted and holding that paradox of applying what we already know, even simple things we already know, and, at the same time, having some hope for some breakthrough ideas.

I really like this idea about education. I think that one of the key problems is that we overreact to things that don’t deserve the reaction, and we dramatically under-react to things that really do. How do we get a closer fix on reality? In that aspect, I think there are the strong signals and the subtle signals. We miss the strong signals, but even when we get the strong signals, I think there are some really important subtle signals that may go to the heart of the matter. I choose the word “heart” intentionally. I had this amazing synchronicity happen. As I was surfing the web looking at something that one of you folks mentioned, I came across this quote from Rabindrath Tagore: “Once we dreamt we were strangers. We wake up to find that we were dear to each other.”

It seems to me that that’s a piece of this. In P.C. Kesavan’s work, in Paul Polak’s work, in all this work we’re hearing about this heart-to-heart connection that is really easy once we clear away the obstacles. I think that, paradoxically, both of those things are really critical. We need the big top-down system fixes and technological breakthroughs, but even more important, I think, we need the change of individual human hearts.

FACILITATOR: Ish?

ISHWARAN: That was a quartet discussing learning approaches to a problem that its previous generation did not properly define. Correct? I think there were some interesting points coming out there. Firstly: think, act, and feel.

FACILITATOR: Think, feel, and act.

ISHWARAN: Where do imagination and dreaming fit? Secondly, there’s the idea of being hardwired. That’s a hard story we heard from Paul [Polak]. But I also have experience. I’m from Sri Lanka and Tamil Nadu, India, and I have seen about three sets of riots, people who did bad things to each other. I know people who knew that they should leave a particular area but did not leave for various reasons. In the face of adversity, how do people decide whether to stay, leave, face, or escape? It’s not an easy act to justify in one way or the other. I don’t think it’s based on rationality alone. There are so many things that come in there.

The UNESCO conference, to which I think Bob Citron may have referred – the 1968 conference that led to the formation of the Man and the Biosphere Programme – was called Conference on the Conservation and Rational Use of the Biosphere. But by the time we arrived in Rio, the word “sustainability” had come up. It appears that rationality and sustainability are not the same. If you have a mathematical equation describing rationality and another one describing sustainability, what’s the difference? Is there a constant somewhere there, or is there an additional variable coming in? Nobody knows.
“Rational” has always been related to science, rationalism, etc. One would think that when somebody acts rationally, he or she is using the best maximum available knowledge and action derivatives based on that knowledge. But if people are rationalizing acts that are not the best for the moment, then there is a problem with that word. Rationalizing is not the same as using rationality, right?

POLAK: Right; it’s not.

ISHWARAN: There is, again, a problem of words. Coming to sustainability, how are you going to learn sustainability? What you say might be important. David [Wasdell], I like what you say, but you use a lot of systems language that might be difficult to convert in terms of how we go about doing it. It might be very clear to you, but we might have to break that language down to something more understandable for non-system sciences people.

Learning, as opposed to teaching, is different. Learning can go in all kinds of unexpected pathways. I don’t think we should try to straightjacket it. We should be able to learn from how others respond to what we might perceive as threats. In UNESCO recently there were two events; both were climate change related. One, from my division, was a carbon sequestration forum. Soon after that was a World Heritage and Climate Change Conference, which was a specific, more legally and convention-oriented enterprise. In the business groups, there’s a lot of interest in how to use climate change not only as a threat, but also as an opportunity; I think carbon sequestration is giving business groups an opportunity. In the university days, when we would get drunk, we sang, “Never mind the weather as long as we’re together.” That reminds me of the bond between business groups and the carbon issue.

I think the business people are moving to the carbon challenge much more interestingly and intelligently than some of us who have been in conservation work for a long time. I think there’s a lot to learn from that group. There’s a general tendency to dismiss business as a bad thing. I know this coming from where I work, thinking, “Business people are always after profits; they don’t think about community and society.” That may not be the case; I think people are thinking about it. Learning about that ill-defined issue might help to take opportunistic pathways and expand the scope very broadly.

FACILITATOR: In terms of needing to expand the scope, this week, I believe, the results of a poll – related to the United States – was published on the Internet, where some 62% responded that they thought global warming was an issue, but not an urgent one.

POLAK: One quick comment about learning from corporations and the business world. A group of eggheads got together and came up with a concept for TiVo, which is a different way of watching television. To communicate it effectively, they hired a very sharp branding group. One of the things that I suggest be considered is engaging a design group and a branding process for the education piece we’re exploring. There’s some pretty good stuff that’s being done. In fact, there are three design firms that are, on a pro bono basis, helping us design a branding campaign for our approach to poverty, to help communicate it. I wonder whether that is something that would be worthwhile to consider.

ISHWARAN: If they’re doing pro bono work, I’d like to know the names.

FACILITATOR: I have a question for this group. One of our seminar observers quoted Rabindranath Tagore. One of my favorite poets is John Donne, who wrote “For Whom the Bell Tolls.” What is it about the work of poets that grasps the substance when we’re talking about learning and teaching? He asked the question, “What happened to imagination, dreaming, and creativity,” and so on, in this equation. What is it about the poet that grasps that and then articulates it so beautifully, as opposed to our struggling with communicating or teaching that same thing? Is there something to learn from that?

WASDELL: What is it about the poet that grasps that and communicates it rather than our struggling? I think
the answer lies in the left hand, right brain. It was there in the body language. It is thinking holistically, allowing what is pulled out of us in our education.

Someone once said to me, “I can’t live with you, if you’re that creative.” I used to write a lot of poetry, and I loved this woman very much. I said, “Okay, I will write no more poetry.” My marriage lasted 25 years and then I managed to escape. The veto of creativity was built into that relationship. It was a very painful time. We need the poets. Also, we have this testosterone-filled group of men here. What we are lacking is brought in by the poet, but also by the feminine, by our own femininity.

TREDER: Flowers on the table would be nice.

WASDELL: Isn’t that a testosterone-type of comment? Also, we’ve now widened the outer group to include observers, not part of the seminar, some of whom have offered some valuable comments. Who else in the room has got stuff they’re holding that we’ve missed?

FACILITATOR: It’s wide open for anybody who wishes to say anything.

GIBBS: I want to hear what Bill Calvin has to say about the list he’s created.

... you could scare, you could educate, or you could make these global warming items ethical issues, similar to the way the anti-abortion people have done ...

CALVIN: Paul Polak has finally prodded me into making an action list. I divided it into the urgent and the slower. First, the most obvious one is that you’ve got to replace CO₂ emissions by about 90% or something like that. You’ve got to start generating both the type of power produced at a power station with something like nuclear, and you’ve got to replace gasoline engines in cars with something that doesn’t produce CO₂. Those steps are going to require a lot of dollars. If you want to keep China from burning all of this coal, you’re going to have to help by inventing technologies that are cheap, efficient, and non-CO₂-making.

Secondly, for climate research, you’ve got to start pouring a lot of people and talent into the field. An increase of 25% a year in research dollars would be a good way to start. To some extent, we’re starting to see that.

The third one I’d put in the urgent category is doing the civil engineering projects wherever you can identify them. This may be as simple and trivially easy as preventing floods from fjords in Greenland, to producing the kinds of things that will reduce the floods that will be associated with higher sea levels.

Under the less-urgent category would be things like relocating your cities away from the coast, spreading them out so you don’t have all your eggs in one high-risk basket. Certainly education is on the agenda, particularly concept formation in the kids, as well as developing the kind of capacity we need our legislators to have in order to cope with the issues at hand.

Ensuring an ethical approach would be the other thing. When I was just sketching out ideas, I considered how you could scare, you could educate, or you could make these global warming items ethical issues, similar to the way the anti-abortion people have done, for example. Doing something like that for climate might be a far faster way to get somewhere rather than trying to educate the masses so they can deal with these concepts.

The other things I have on my list are all the things related to poverty, helping to reduce pollution, and helping to produce sustainable agriculture. On a sustained-approach basis, the urgent ones I tried to spin off are the ones I named first.

TREDER: I want to see if I can get a response from the room here. To me, Bill’s list looks like a really great recipe. If we could get it into action, it could make a great deal of difference in the real world, in real time. How many people in the room believe that everybody, together, could get this list accomplished, given the present political situation and other conditions in the world today, in the next ten years? Raise your hand if you think this is a possibility.

MUSSER: To finish or to begin it?

TREDER: Achieve 90% CO₂ reduction within ten years.

CALVIN: Through new technology?

ISHWARAN: Globally, or in the United States?

TREDER: All right. This is kind of a trick question; it’s a process. The second question is this: If we were convinced and we were able to communicate that conviction to those in power, that we cannot survive, that we will die – billions will die in terrible storms, in famines, etc. – unless this plan is put into action immediately, then do you think this action plan
would have a better chance? Would more people raise their hands and say, “Yes, that will happen”? If so, we go back to my favorite word, which is “urgency.” How do we communicate the fact that this is not just idle talk; this is not just eggheads sitting around? This is real, and it’s going to require real response.

POLAK: I would say from my personal perspective, the probabilities don’t matter. Once I decided that this was important to do, I devoted my life to doing it. I don’t know whether it will happen or not.

OBSERVER 1: What caused the shift for you?

POLAK: I don’t know. It’s just important; it gives me a connection to something deeper, and I follow that connection. I very much appreciate you doing this, because I think it’s so important. The next step is to say, “What would it take to do the 90%?” I’m just saying it doesn’t matter to me if we can do it or not. I’m willing to commit some of my energy to this because it sounds important. If it gets done, it’s because people will be committed to trying to make it happen. I want to say “thank you” for doing that. I think it’s very important.

CALVIN: Can I add a quick word? I included in the list all that increase in research dollars simply because climate science is still a young science. It’s basically applied physics; all that part is known. What we know now compared to what we knew 20 years ago is quite a bit different. Yes, there’s a lot we don’t know, but you can’t use that as an excuse for not moving forward. There’s an adage in medicine that says “the physician who waits to treat a patient until absolutely sure of the diagnosis may wind up with a dead patient.” We have to get our legislators to think that way.

POLAK: Just one other thing. You realize that once you’ve started, you’re suckerized into a never-ending process. Bill talked about dynamiting those fjords. You need to make a list of those things in order for people to start doing them.

CALVIN: Let me tell you, when I wrote my Atlantic Monthly magazine cover story eight years ago, “The Great Climate Flip-flop,” I actually listed blowing apart the ice dams. One of the letters to the editors said, “You’re proposing nuclear weapons and polluting the environment!” I said, “No, this is highway-construction amounts of dynamite.”

OBSERVER 1: I’m really interested in that personal tipping point. Paul Polak said that once he crossed over, he just can’t not do what he’s doing. It seems to me, that’s what we need to engage widely.

Dee Hock is the fellow who created the Visa credit card network. At the height of his success, he walked away from that because he had this very pessimistic view of what was going to happen in the world. He felt that he just simply wanted to sequester himself and eat, drink, and be merry on his own little island until the demise came. One day during a family event, he was playing with his 4-year-old grandson and had this image of the world unfolding as he thought it was going to 30 years hence, with him now gone. In his image, his adult grandson looked up at him, saying, “Grandpa, couldn’t you have done something?” I think there’s something for us in that.

In fact, a project I’m working on is called, “For the Grandchildren,” which is, hopefully, using that idea as a portal into engagement, a waking up. If we can get everybody in the world doing what Paul has done, making a shift so they can’t not do something, then I think things could happen quickly.

OBSERVER 2: I’d like to make a couple of observations. This is my second time attending a Foundation For the Future workshop by my own initiative, because I’m really interested in the impact on the future of humanity.

Number one: I suggest in the future for these workshops it may be a good idea to invite more representatives from across different sections of our community, including more women. Because I see the issue of China coming up quite frequently during the workshop, maybe some representatives from China could be invited to represent that perspective with fresh, new input. I’m really glad to see more of the Indian views and perspectives being represented. China and India will have two major impacts in terms of the future of environmental issues.

I would also like to see a better mix of age groups. So far, there are far more people in their 50s and 60s and only occasionally people in their 20s or 30s. I think different age groups would try to turn the plans into action, making it more feasible to get differ-
ent groups’ input. Eventually, to take action, you are closer to what the mainstream is thinking.

Number two: I want to comment in terms of the action here. At the end of this month, Chinese President Hu Jintao is actually coming to the United States to visit. There has been some discussion about major crises ahead, one of which will be the energy crisis in the coming couple of decades. It would be nice to have a joint research or development project shared by India, China, and America to develop experiments with different alternative energy resources, which could have quite an important impact worldwide. Imagine China or India pursuing the living standard now present in the United States; you’re talking about at least tripling the total resources consumed. This is a tremendous, immediate problem facing us. If you can get that cooperation going, that could have quite a long-term impact. The question is: How do you overcome the political, social, and geopolitical barriers? Whether you are competitors, potential partners, or whatever, I think that’s really quite critical.

FACILITATOR: Thank you. David?

If we delegate power outwards, we end up with impotence in our own positions. Taking people power demands “Create movement, or else!” of the political regimes.

WASDELL: The question was: Who is in power? If we have to get to them to get them to do, then we have already given away power. My sense is something about taking power yourself – each of us taking our own power – rather than being immature and donating it upwards, outwards, to others somewhere, and thinking that they should do it.

Power systems and power companies are not the only ones involved in fossil fuel energy. Power is also political and economic. If we delegate power outwards, we end up with impotence in our own positions. Taking people power demands “Create movement, or else!” of the political regimes. Power resides within us, not the United States. It’s something about a shift in the whole thinking about power and empowerment. I think that’s probably going to be my last word. I’m glad we have China coming in.

ISHWARAN: I guess there is an arrangement now between the United States, China, India, Japan, South Korea, and Australia, to find alternative means to reduce carbon emissions. How good that is, how much they are focusing on energy, I don’t know. But there is an arrangement parallel to Kyoto-related targets and emissions.

FACILITATOR: Thank you all for your excellent dialogue and input.
Closing Session

FACILITATOR: Sesh Velamoor
PARTICIPANTS: Plenary Session

**At the end of each seminar and workshop each participant and observer gets exactly one minute for a concluding statement … no holds barred; anything goes.**

**SESH VELAMOOR (FACILITATOR):** We now approach the last step of the seminar. At the end of each seminar and workshop each participant and observer gets exactly one minute for a concluding statement. We typically use an hourglass or minute glass to time the comments. It can be no holds barred; anything goes. Your comment can be about the workshop; it can be a specific idea; it can be about your hope; it can be a vision; or anything at all. Who would like to start? Let's finish with the participants first, and then we can go around the room. We'll be wrapping up right after this step.

**ISHWARAN:** First of all, thank you, Bob, Sesh, Donna, and everybody, for asking me to come here. I have an interest in being here because I am planning to do something similar, if not replicate this seminar, in Paris with the Foundation For the Future. Being here gives me an idea of how you do it, which helps me to plan my thing in Paris. I think it has been a very useful two days. Sometimes you do feel frustrated about the range, the scope, and the breadth of visions and ideas coming, but that's part of a seminar arrangement. I did learn a lot and I think it's a very interesting forum.

I'll just finish with two things. I think what you're doing, looking at the planetary side as well as the sustainability development side, is very important to UNESCO, particularly for this education decade. I'd like to continue exploring, particularly, what you do with kids, and whether there is a connection there.

Secondly, I would be very interested in anything else you do in this regard, particularly on climate change/carbon-related issues. We are creating opportunities for some of our UNESCO-designated sites to be involved in contributing to mitigations and adaptations. If there's any way we can come together in that with not only the Foundation but also other organizations, I'd be happy to talk about it. Thank you. I hope to see at least some of you in Paris.

**MUSSER:** First, let me say I've never been to an event quite like this one before, in a number of ways. Thanks to everyone who put it together. I've never been to such a well-organized event, certainly one that involves scientists. If every meeting could have little hourglasses like this to prevent long discourses going on, wouldn't that be a wonderful thing? For the way the packets were personalized, I thank Kathy, Donna, and everyone else. I think they deserve a wonderful round of applause.

Also, it's an event during which I think the content that I've picked up is less important than the process. The mere idea of a fishbowl – I've never seen that done anywhere else – is really interesting. I'll have to think...
about what it meant and what I learned from that fishbowl process on its own. One thing that occurred to me is how a fishbowl mirrors certain kinds of democratic decision-making. Congress is a fishbowl, for better or for worse. When there is no fishbowl, as in a dictatorship, problems arise. It’s good that we were able to observe the thought processes of other people. Maybe we should do that more, not just in settings like this, but maybe I should pay more attention to how Congress talks rather than simply what they say at the end of the day. Anyway, thanks for putting it all together.

**FACILITATOR:** Thank you. Wayt?

**GIBBS:** I also would like to thank the Foundation very much for the opportunity to participate in this. I did feel that I learned a lot, actually, from many of the presentations yesterday. A lot of that material was new to me. Speaking of different actions that we can all take, there are two that I certainly plan to take. One is to make sure that George and I use this platform to do what we can through *Scientific American* to influence policy-makers and to educate the public and its educators.

Second, as far as education goes, I’m very much with George in thinking that we need to change how we teach kids about science as we enculture them into thinking of the consensus-building process that science represents — that’s very powerful. Certainly I’ll be doing that with my 3-year-old son and his classmates, to the extent that I can influence the process. Also, I think we can have some influence in the press in how science is taught, and can try to push that forward so that it’s much more about learning a way of thinking about science so that you don’t get blindsided; you can see the truth when it’s staring you right in the face; you can understand why it is that so many scientists think a certain thing is true; you can think creatively about ways to address problems; and you can contribute to the solution. Thank you.

**TREDER:** Sesh said, “no holds barred.” Before I get to that part of it, let me first thank Walter, Bob, Sesh, Kathy, Donna, Jean, and everybody else. This has been a fabulous event. The thought that comes to mind for me as far as this Foundation goes is that if we don’t try, we know we’ll never succeed. This Foundation is enabling people to try things that they wouldn’t have been able to try otherwise because they didn’t have the knowledge or they didn’t have, in some cases, the resources. I commend you for making some solutions attainable that, otherwise, might not have been.

However, I’m still very pessimistic. Yesterday I felt better than I do today. Today I’m really concerned about the future of the planet and of the human race. Events are accelerating, and I’m not sure we as a human race are keeping up. Like Einstein said, we’ve grown technologically but we haven’t grown emotionally. I hope this type of process can be replicated elsewhere and that I will be surprised. I hope I will be surprised to see that maturation on the part of the species that I believe is essential. Thank you.

**KESAVAN:** I would, once again, like to thank all members of the Foundation For the Future for getting me here, and also arranging a very thought-provoking discussion. Coming as I do from a developing country, seeing almost every day how poverty can be so cruel, I tend to think on behalf of one billion people on this planet who have no food. They are not sure where their next food will come from. I strongly feel that for the security of the planet we have to provide food security to these one billion people on the planet. In short, our science and technology should provide for basic human needs; only in that way can we be sure of securing the planet.
people from hunger. That is the first thing.

The second thing, for whatever reasons, is that there is ever-growing violence in the hearts of some people. They are not hungry people. They have some kind of goal. I do not know what it is; but it is fundamentalism. All the people who have risen against humanity are not the hungry people; the hungry people are quietly lying down. It is the people with some kind of a hateful feeling. I don't know. I don't want to go into it for obvious reasons. That is the real threat. Thank you very much.

We've got to slow things down a lot and we've got to make our society far more resilient to natural disasters of all sorts, not to mention terrorists.

CALVIN: Now that everyone’s been thanked, let me add my thanks. I started following climate quite by accident, really. I was interested in human evolution, but for about 22 years now I've been following climate and getting more and more into it without really being a researcher in the field. I've seen that these abrupt things that happened in the past weren't gradual at all, and that surely they are likely to repeat again, and that we have to start thinking about what we're going to do about it. I haven't had a real sense of urgency until, probably, the last year or so. I saw that the tsunami killed a quarter-million people, and the New Orleans flood killed hardly anyone, at least the hurricane didn't, but the aftermath and the incompetence of the response killed quite a few people. Then last week when Science published three or four papers on what was going to happen as Greenland and Antarctica melted, the acceleration of the rates of things on the scale of the last decade and, indeed, on the scale of just the last three years, has just grown sufficiently alarming. I know sufficiently much about how ice sheets collapse that I've begun to think that we really have to act very quickly. The amount of CO₂ we've already put into the atmosphere is over about 150% now of the standard excursion between ice ages. Unless that stops very quickly we'll have a much more rapid collapse. We've got to slow things down a lot and we've got to make our society far more resilient to natural disasters of all sorts, not to mention terrorists.

POLAK: In addition to thanking all the people who organized the conference, I want to thank the participants for not pontificating too much, because that's been a remarkable thing in this meeting. In many meetings I've attended you can't get people to stop. This has been very good in that regard.

I guess I want to say I feel very hopeful about things. I'm not at all depressed – maybe because I'm 72, so these things that will happen won't affect me so much. More seriously, I think that ending extreme poverty is very doable and that it will likely happen, and can happen, within 20 years. We have to totally change how we think about poverty and what we do about it, but I think that will happen. I think it's also possible for all these other things to happen.

I want to go back a step. I had a lot of fun at this meeting. It was fun learning new things. I got a crash course on climate change, for instance, and I didn't have a clue about how things such as no tillage would affect erosion. That was really great. I'm hopeful about all these other things because I think that if you put it into practical terms and be clear about the steps that are needed, it's very possible that we can do something about it. I feel very hopeful, and I'm very appreciative about the fun I've had at this conference.

FACILITATOR: David?

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again that the limits to my own capacity to act have been set by my own levels of fear, and learning to push through to another level of that has been a huge personal breakthrough. It took a lot to do that presentation, and I stank after it. But I did it. I didn’t sleep much. I think I’m going to face much more challenging environments, even, than the Foundation For the Future as I face battles and engage with power systems in my own country and elsewhere over the coming months. Thank you for a lesson in knowing that it’s possible to take my courage into my own hands and be me with less fear than before. That’s been a joy. That’s what I want to say.

FACILITATOR: Thank you. Paula?

I’m especially interested in the kinds of thinking that young people will need in the future … more holistic thinking, ethical thinking, critical thinking …

OBSERVER 3: I am a teacher. I have attended the Foundation For the Future seminars and workshops for probably five or six years, and they have deeply influenced the way I work with students in the classroom. I’m especially interested in the kinds of thinking that young people will need in the future. I think education has a tendency to be too little, too late; they’re maybe 20 years behind the times. I believe we need more holistic thinking, ethical thinking, critical thinking, and to be able to see implications of decisions. I’ve been having Sesh come into the classroom a lot to work with kids. Besides what I’ve learned from all of you, I’m very appreciative for this opportunity to just observe and then to see how we can apply the information firsthand.

One thing I did want to say is that testing and assessment are needed for the accountability; however, they have an unintended consequence on our educational system. There is a narrowing of the curriculum all over the United States. Some of the social studies are not being taught anymore. I’m questioning that, with the influence of some political groups. I think you’re all aware of what’s happened in Kansas and what’s happening to good science education. It’s more than a body of knowledge; it’s a way of thinking. As scientists and people, don’t just go off in your ivory towers; get into classrooms, or have an influence on the kind of education our young people will need in the future.

The last thing I want to say is that we actually used “Crossroads for Planet Earth,” the Scientific American issue that was published last September, as the basis for our seminar. Students divided into different groups, and certain kids were exploring population demographics, water, agriculture, and all of those things that they researched in-depth. I’m going to share with them what I experienced this weekend. I think they’ll be very happy to hear some of the line of reasoning and some of the conclusions, tentative though they all are. This will be something that I’ll really enjoy sharing with them after we get back from spring break. Thank you very much.

Here are just some of the ideas that kids have gotten after experiencing this: “The Young Scholars’ Inquiry Program really gave me another option of what to be in the future.” “This showed me possibilities that I can make the world a better place.” “From the seminar I have learned about the importance of interconnectedness. I have also learned that there is hope for the future.” “Listening to all these different ideas has made me think about new things and change some of my views on things I thought I knew about.”

The last thing I’m going to say is that I am hopeful, because I do touch the future. I get all teary whenever I say that. As Christa McAuliffe, the educator who went into space, said, I think these young minds that are coming up and their ability to work in ways different from the way their elders worked can really develop a community of inquiry where they don’t each have to know everything, but they know they can work in cooperative ways to form this web of ways to think about the future. For that, I truly am hopeful.

My daughter, who is 38, is living in Amsterdam; she’s lived there for 14 years. I am hopeful as I think of her as a world citizen. She’s moving beyond nationalistic borders, as are a lot of her friends. I’m sure all over the world young people are doing that. That’s another very hopeful thing, because when people get to know one another, perhaps they can change the way they do things and the way they think about one another.

FACILITATOR: Thank you.
I’m going away both discouraged because I have a greater understanding of the reality, and also very encouraged; on balance I’m more encouraged.

OBSERVER 1: The first thing I’d like to say is that I have a deep sense of gratitude, first to the Foundation for holding this space, for creating this opportunity, and also for the opportunity to get to be inspired by each of you. I just really value and appreciate the chance to be here and breathe in from each of you, and also to work with teachers such as those here today and to be inspired by those wonderful lights in their classrooms. That’s really great.

I mentioned the story of how Dee Hock came back into and reengaged with the world, and a favorite quote came to mind that I think is appropriate here. He says, “It’s far too late and things are far too bad for pessimism.” Then he goes on to say, “It will be no failure to fall short of realizing all that we dream. The failure would be to fall short of dreaming all that we might realize.” I’m going away both discouraged because I have a greater understanding of the reality, and also very encouraged; on balance I’m more encouraged.

… I will work with my nano-staff to take nano-actions and make contributions, hopefully, to have some positive influence inside China.

OBSERVER 2: First, I would like to thank the Foundation very, very much for giving me the opportunity to participate in the workshop. I found it a very stimulating and enriching experience. I’m taking away a lot of very interesting experiences, ideas, and sharing. Lately I’ve spent more time in China, and, within my capability, I will work with my nano-staff to take nano-actions and make contributions, hopefully, to have some positive influence inside China. I hope in the future to have the opportunity to continue to learn and work with everybody here. Again, thank you very much. It’s an honor to know everybody here, too. Thanks.

POLAK: I have one request. Can we hear from the cameraman? What are your impressions of the conference?

The power of human creativity is enormous, and if tapped collectively, we may just find a way to overcome the obstacles to humanity’s survival.

CAMERAMAN: I’m still hopeful. The power of human creativity is enormous, and if tapped collectively, we may just find a way to overcome the obstacles to humanity’s survival. If we persist in searching for and implementing solutions, and not limit our thinking of what’s possible, the outcome could be awesome, beyond expectations.

FACILITATOR: All right. I guess that about does it.

TREDER: Can we get a closing statement from Walter?

FACILITATOR: Yes, but first we’ll handle a few minor details. My job is made tremendously easy by the people who don’t directly get involved with you but who do so indirectly on a minute-to-minute basis. I’d like to acknowledge our staff for their remarkable support, assistance, and coordination behind the scenes. Thank you all.

CITRON: And thanks to Sesh.

FACILITATOR: As we plan future workshops and seminars, we are continuously trying to improve things. If you have suggestions for ways you believe these events can be enhanced, please do tell us that in your evaluations of this event. We endeavor to get the results of these seminars and workshops out to the general public as soon as possible. We’d like your input to help us do the best possible job in conducting all of our events and sharing the outcomes with all who may have an interest.

We do incorporate many of the ideas shared by participants. Recently we’ve been trying some things in our Young Scholars’ Inquiry Program. By the way, if you really want to get inspired, you might enjoy taking a look at this program. There have been a lot of references to young people, some perhaps in the context of saying they’re a challenge; they need to be approached differently; or something else needs to be done. In fact, I think we have some tapes of the Young Scholars’ Inquiry Program, which is conducted almost exactly the same way that we did this one.

You might be pleasantly surprised as to what these young people are capable of doing by way of background research, the way they articulate, and the way
they participate in these kinds of things. I think it’s far more optimistic than one might gather if one were to think about sixth-graders and ask, “How are we going to communicate with them?” It’s not all that difficult. In addition, I never tire of saying this: We have sitting in this room a national treasure, or at least certainly someone who could be elected to the International Hall of Fame when it comes to teaching, and that’s Paula Fraser.

I think what the Foundation has done with education and where you want to go with the Young Scholars’ Inquiry Program is just phenomenal.

OBSERVER 3: I’m going to say something, just so you can’t have the last word, Sesh. At the beginning, when I would attend these workshops, education was not mentioned too much. Sometimes people come here and they have certain preconceptions of how the Foundation might be, but the Foundation has been caught, sparked, or inspired with this idea. I think what the Foundation has done with education and where you want to go with the Young Scholars’ Inquiry Program is just phenomenal. I want to say how much I appreciate you for growing into it. It’s really quite wonderful. Thank you.

OBSERVER 1: Sesh, I have an overview of that program downstairs. As soon as we break I’ll bring it up, if any of you would like to take a three-page overview.

FACILITATOR: Again, I’d like to repeat the proposition that if any of you are able to motivate and mobilize similar possibilities in your locales, we’d be more than happy to work with you. The objective is to enlarge this Young Scholars’ Inquiry Program and extend it to other areas and other parts of the world. With that, I’ll turn it over to Bob and Walter for concluding remarks.

CITRON: Thank you very much for coming. I hope everybody has had a chance to look through this album of the Young Scholars’ Inquiry Seminar. We have a DVD; it’s unedited, but it’s quite spectacular when you see and hear these 10-year-old children who have been doing research in exactly the areas we’ve been discussing here and in other areas we discuss in other seminars and workshops, as they articulate their feelings about the long-term future, the research they’ve done, and what it means to them personally. If anyone would like a copy of the DVD, just give your name to our staff, and I’ll make sure that you get copies of the DVD.

I want to say how appreciative I am of all of you for coming, especially Ishwaran, who came from Paris, where we’re running a seminar with UNESCO, with his cooperation, later this year. We are also in the midst of planning a workshop on global warming and we’ve had some meetings with the climate people here in that regard. With that, I’ll ask Walter to close the seminar.

KISTLER: I’d certainly like to thank you all very much for coming here. Our Foundation does really appreciate people like you who make the effort, and the time, to spend two days with us, because that is what makes our Foundation. This meeting was specifically appropriate and interesting for us, and for me maybe even most of all, because the purpose of the Foundation is to anticipate, to look at, to study the pitfalls, the dangers, and the problems that lie ahead. We address not only those that lie just a few years ahead that, we assume, politicians are concerned with, but also those that are long-range problems, maybe 10, 50, 100 years from now, for which it’s very important that humanity be prepared. I see that our duty is to educate people and get them prepared, because we are a democracy, here in United States, and nothing gets done if Congress and the President cannot convince people that it’s needed. One specific, very important case is just the case we talked about, global warming.

The question came up about whether we can reduce emissions of CO₂ gases. In my view, we could very well do that, except for what, I think, is just carelessness and recklessness in how we behave. You see SUVs driven by one person; the car could be four or five times lighter and use ten times less fuel, and that would really be no big problem.

Another thing is our power plants. I know all about these power plants because my prior company, which made instruments, survived and prospered because of all the coal-fired power plants that were built in those days, all using thousands of tons of carbon, emitting many more thousands of tons of CO₂ into
the atmosphere. France is able to generate 60 to 80% of its power with nuclear energy. Why couldn’t we, the United States, be able to do that? It’s ridiculous.

*It's a matter of convincing the public, and that's what our Foundation attempts to do as we study problems and publish the outcomes of our meetings …*

By doing all these things we could reduce our CO₂ production to 1/10th or 1/20th of what we currently do. Other countries would then probably follow us, and we could easily avert the biggest problem and the big catastrophe that may come about. It’s a matter of convincing the public, and that’s what our Foundation attempts to do as we study problems and publish the outcomes of our meetings, as Bob has managed nicely with our publications, to get the public informed. Once the public is informed, they will make correct decisions, normally. It’s just a matter of informing them.

Again, I’d like to thank you all very much. Of course, I have to specially point out my appreciation to Sesh. Running these events is a big job. I think you all may feel the same way. Have a good trip home.
Appendix 1

Seminar Agenda

APRIL 6, 2006
Kane Hall, University of Washington, Seattle, WA
• Cocktail Reception
• Walter P. Kistler Book Award Ceremony

DAY 1 | APRIL 7, 2006
Foundation For the Future, Bellevue, WA
• Welcome
  — WALTER KISTLER
• Introduction to the Foundation For the Future
  — BOB CITRON
• Seminar Objectives
  — SESH VELAMOOR
• Self-introductions
  — EACH PARTICIPANT
• Video Presentation: Cosmic Origins
• Presentations
  “Human Journey on Planet Earth”
  “Human Impact on Planet Earth”
  — BOB CITRON
  — GEORGE MUSSER
  Keynote 1: “Facing Bifurcation: Crossroads in Context”
  — DAVID WASDELL
  Paper 2: “When Climate Flips, Will Civilization Bounce Back?”
  — WILLIAM H. CALVIN
  Paper 3: “Biosphere Futures”
  — NATARAJAN ISHWARAN
  Paper 4: “The Big Potential of Small Farms”
  — PAUL POLAK
  Paper 5: “How Should We Set Priorities?”
  — W. WAYT GIBBS
  Paper 6: “Dirt: The Erosion of Civilizations”
  — DAVID R. MONTGOMERY
  Paper 7: “Nanotech Manufacturing: Driving Toward a Crossroads – and a Crisis”
  — MICHAEL A. TREDER
  Keynote 2: “Crossroads for Planet Earth: Harnessing Science and Technology for Reconciling Human Security and Environmental Protection”
  — P.C. KESAVAN

APRIL 7, 2006
Kane Hall, University of Washington, Seattle, WA
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  Keynote 2: “Crossroads for Planet Earth: Harnessing Science and Technology for Reconciling Human Security and Environmental Protection”
  — P.C. KESAVAN

DAY 2 | APRIL 8, 2006
Foundation For the Future, Bellevue, WA
• Participants Break into Two Preassigned Groups
  – Discuss Priorities for Planet Earth
• Summary Presentations of Groups to Plenary
  – Questions & Answers
• Identification of Three Most Significant Topics/Questions/Issues Pertaining to the Future of Planet Earth
• Fishbowl 1: First Group Dialogue, Others listen
• Fishbowl 2: Second Group Dialogue, Others listen
• Individual Concluding Statements
• Closing
  — WALTER KISTLER
• Seminar Adjournment
• Group Dinner
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P.C. Kesavan 201
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David Wasdell 211
William H. Calvin, Ph.D.

William H. Calvin, Ph.D., is a professor emeritus at the University of Washington School of Medicine in Seattle. He is also affiliated with Emory University’s great apes project and on the Board of Advisors of the Foundation For the Future.

Calvin has written 14 books for general readers. His 2008 book is Global Fever: How to Treat Climate Change. While covering the “What’s Up” aspects of other global-warming books, he also examines why a double-duration El Niño is so threatening, addresses our closing window of opportunity to halt the warming and then restore our climate to conditions surrounding the Earth before the fossil-fuel surge after 1950, and then spends five chapters on “What to do about it.”

His 1998 cover story for The Atlantic Monthly, “The Great Climate Flip-flop,” was the first major magazine article on the now-familiar subject; the article grew out of a long-standing interest in abrupt climate change and how it influenced the evolution of a chimpanzee-like brain into a more human one. He expanded on these topics in A Brain for All Seasons: Human Evolution and Abrupt Climate Change, which won the 2002 Phi Beta Kappa Book Award for Science and the 2006 Walter P. Kistler Book Award.

A Brief History of the Mind: From Apes to Intellect and Beyond (2004) addresses what led up to the “Mind’s Big Bang” about 50,000 years ago, a creative explosion compared to the very conservative trends in tool-making over the previous 2.5 million years. That span featured two million-year-long periods without much progress – despite the growth in brain size.

Calvin’s neurobiology research interests primarily concern the neocortical circuits used for detailed planning and for improving the quality of the plan seen as humans “get set,” presumably utilizing a milliseconds-to-minutes version of the same Darwinian process (copying competitions biased by natural selection) seen in the immune response and species evolution on longer time scales. His research monograph, The Cerebral Code: Thinking a Thought in the Mosaics of the Mind (1996), concerns Darwinian processes in neural circuitry that can operate on the time scale of thought and action to resolve ambiguity and shape novel courses of action. He also collaborated with the linguist Derek Bickerton to write Lingua ex Machina: Reconciling Darwin and Chomsky with the Human Brain (2000), which addresses the evolution of syntax.

Following studies in physics at Northwestern University, Calvin branched out into neurophysiology via studies at MIT, Harvard Medical School, and the University of Washington (Ph.D., physiology and biophysics, 1966). For twenty years, he talked shop every day with the neurosurgeons, then moved on to explore applicable topics with biologists, psychologists, anthropologists, and psychiatrists. Presently he is concentrating on climate scientists.

Recent, Relevant Publications


W. Wayt Gibbs

W. Wayt Gibbs is Senior Writer at Scientific American magazine. He studied English and physics at Cornell University, where he also worked as a computer programmer and as a technical writer for the university’s national supercomputer center. Gibbs moved to London in 1992 to write for The Economist on the science desk, and joined the editorial board of Scientific American shortly thereafter as a news writer, primarily covering biotechnology and information technology. In 1998 he was promoted to Senior Writer and launched the magazine’s “Expeditions” series, which he edited for three years.

In recent years, Gibbs has covered a wide array of subjects, ranging from biodiversity loss to gravitational wave observatories, from the demise of rare languages to new thinking about the origins of cancer. Gibbs’s work has been honored by the AAAS Evert Clark/Seth Payne Award for Young Science Journalists (1995 and 1998), the Wistar Science Journalism Award (2004), and the AAAS Science Journalism Award (2005).

In his 13 years at Scientific American, Gibbs’s byline has appeared on some 230 articles; he has edited another three dozen. He was awarded a Knight Science Journalism Fellowship at the Massachusetts Institute of Technology and spent the 1999–2000 academic year studying nanofabrication, computational molecular biology, biostatistics, and other fun subjects. He completed the Stanford Professional Publishing Course in 1998 and a mini-fellowship in brain science at MIT in 2004.

Recent, Relevant Publications


“Preparing for a Pandemic,” Scientific American (November 2005). One day a highly contagious and lethal strain of influenza will sweep across all humanity, claiming millions of lives. It may arrive in months or perhaps not for years, but the next pandemic is inevitable. Are we ready?

“How Should We Set Priorities?” Scientific American (September 2005). The world faces no shortage of problems, or of good ideas to solve them. Which should we tackle next? Even as leaders converge on some answers, new markets are being set up to preempt politics.

“Nanobodies,” Scientific American (August 2005). Antibodies, often described as magic bullets, are actually more like tanks: big, complicated, and expensive. Tinier “nanobodies,” derived from camels and llamas, may be able to infiltrate a wider range of diseases at lower cost. That is the hope, at least, of one small start-up in Belgium.

“Cosmic CAT Scan,” Scientific American (August 2005). Picture being able to observe the early universe – with 10,000 TV antennas.

“Obesity: An Overblown Epidemic?” Scientific American (June 2005). A growing number of dissenting researchers accuse government and medical authorities – as well as the media – of misleading the public about the health consequences of rising body weights.

“Considerate Computing,” Scientific American (January 2005). Digital gadgets demand ever more of our attention with their rude and thoughtless interruptions. Engineers are now testing computers, phones, and cars that sense when you’re busy and spare you from distraction.

“A Split at the Core,” Scientific American (November 2004). Physics is forcing the microchip industry to redesign its most lucrative products. That is bad news for software companies.

“Computing at the Speed of Light,” Scientific American (November 2004). Emerging ways to make photonic connections to electronic microchips may dramatically change the shape of computers in the decade ahead.
“Crossroads for Planet Earth” Seminar Proceedings
Natarajan Ishwaran, Ph.D.

Dr. Natarajan Ishwaran is Director, Division of Ecological and Earth Sciences, UNESCO, Paris. The Division of Ecological and Earth Sciences is the focal point for all UNESCO relations on biodiversity. It oversees two of the many intergovernmental scientific programmes of UNESCO directly related to sustainable development, namely the Man and the Biosphere (MAB) and the International Geological Sciences (IGCP) Programmes. The Division promotes ecosystem, biodiversity and Earth sciences, and remote sensing applications for sustainable development. A major emphasis is capacity building in less developed countries, particularly strengthening ecological and Earth sciences applications in sustainable use of biodiversity in Africa. The Division also advocates and supports the use of biosphere reserves designated under the MAB Programme, as well as other UNESCO designated places like World Heritage areas, as laboratories and learning sites for sustainable development. In addition, the Division serves as the UNESCO focal point for biodiversity and the UNEP-UNESCO Great Apes Survival Project (GRASP), a project of the United Nations Environment Programme (UNEP).

Dr. Ishwaran has worked in UNESCO since 1986 on programs and activities linked to ecological sciences and biodiversity conservation in cooperation with intergovernmental forums, national and international NGOs, funds and foundations, and private sector institutions. He has work experience and achievements in negotiating significant technical and financial benefits, particularly in less developed countries, for biodiversity conservation, protected area management, ecological sciences research, and capacity building.

His educational background includes a B.Sc. in zoology earned in Sri Lanka; M.Sc. in ecology from the University of Peradeniya, Sri Lanka; and Ph.D. in wildlife biology and management from Michigan State University, USA. He has 30 years of experience in teaching, research, wildlife-protected areas planning and management, multi-lateral environmental and biodiversity treaties, and coordination and management of international cooperation in environment and development. He has authored more than 25 publications in refereed journals and co-authored two edited volumes on ecology, biodiversity conservation, and protected area management themes.

Recent, Relevant Publications


Dr. P.C. Kesavan is currently Homi Bhabha Professor and Distinguished Fellow at the Department of Atomic Energy, M.S. Swaminathan Research Foundation (MSSRF), Chennai, India. His previous positions include Director, Biomedical Group of Bhabha Atomic Research Centre (BARC), Mumbai, from 1993 to 1998; Professor and Dean, School of Life Sciences, Jawaharlal Nehru University (JNU), New Delhi, from 1970 to 1993; and Executive Director, M.S. Swaminathan Research Foundation (MSSRF), Chennai. He has also been a Visiting Professor/Fellow at University of Manchester, UK; at the University of Texas at Austin, USA; at Justus – Leibig Universitat, Giessen, Germany; and at Strahlenzentrum of University of Leiden, The Netherlands. Dr. Kesavan is a geneticist and a radiobiologist, known internationally for his work on the modification of radiobiological effects by caffeine. He represented India at the United Nations Scientific Committee on Effects of Atomic Radiations (UNSCEAR), IAEA, Vienna (1995–1998).

Dr. Kesavan is currently very closely following the footsteps of Prof. M.S. Swaminathan, UNESCO Chair for Ecotechnology and Chairman, MSSRF, in harnessing science and technology for human welfare, particularly in the realm of sustainable management of natural resources for rural development and livelihood security of the coastal poor. He is greatly cherishing his close interaction with social scientists and gender specialists to accelerate the process of strengthening the social contract of science. He is also deeply interested in all aspects of human and environmental security. Issues such as extreme natural hazards, climate change, and their impacts on Planet Earth and humanity are currently engaging his attention. He is working on ways and means to integrate disaster management with sustainable development in order to enhance the resilience and coping capacity of the resource-poor farming and fishing families in the coastal regions, which are particularly vulnerable to water- and weather-related natural hazards.

Professor Kesavan has published over 160 original research papers in national and international journals, and has supervised the doctoral (Ph.D.) research of 42 scholars. He is a member of the Editorial Board of the International Journal of Radiation Biology, published in Canada, and J. Radiological Protection, published in the UK. He is a Fellow of the Indian National Academy of Sciences, and Past President of the Environmental Mutagen Society of India and the Indian Society for Radiation Biology. He is a life member of the Indian Nuclear Society, Indian Association of Radiation Protection, and Indian Association for Radiation and Photochemical Sciences.
Professor David R. Montgomery is internationally recognized as a leader in the study of geomorphology, the evolution of landscapes. He is the Director of the Quaternary Research Center and a Professor in the Department of Earth and Space Sciences at the University of Washington in Seattle, Washington USA.

Montgomery’s research interests range from the co-evolution of the Pacific salmon and the topography of the Pacific Northwest to the environmental history of Puget Sound rivers, sediment transfer from the Andes to the Amazon, giant glacial floods in eastern Tibet, and the formation of Martian outflow channels. In addition to his recent environmental history of salmon (*King of Fish: The Thousand-Year Run of Salmon*), he has published over 150 publications in scientific literature.

**Recent, Relevant Publications**


George Musser

George Musser is a Staff Editor for Scientific American magazine, where his primary focus remains space science, although he continually finds himself drawn to a subject far more challenging than astrophysics: human society. A number of articles he solicited and edited have appeared in The Best American Science Writing and The Best American Science & Nature Writing anthologies. Musser was the originator and one of the lead editors for the single-topic issue “A Matter of Time” (Sept. 2002), which won a National Magazine Award for editorial excellence. He also coordinated the single-topic issue “Crossroads for Planet Earth” (Sept. 2005), which won a Global Media Award from the Population Institute.

Musser did his undergraduate studies in electrical engineering and mathematics at Brown University and his graduate studies in planetary science at Cornell University, where he was a National Science Foundation Graduate Fellow. His thesis work, done with Steven Squyres, modeled mantle convection on Venus in order to explain broad plateaus known as coronae, mapped by the Magellan orbiter (on which, coincidentally, he had worked during an undergraduate summer internship at the Jet Propulsion Laboratory).

From 1994 to 1998, Musser served as Editor of Mercury magazine and of The Universe in the classroom tutorial series at the Astronomical Society of the Pacific, a science and science-education nonprofit organization based in San Francisco. During his tenure, he expanded and revamped both publications; the San Francisco Examiner called Mercury “the most exciting and thought-provoking astronomy magazine for several light-years around.”

Recent, Relevant Publications


“Was Einstein Right?” Scientific American (September 2004).

Paul Polak, M.D.

Paul Polak, M.D., a psychiatrist and an entrepreneur, is founder and President of International Development Enterprises (IDE), an organization that has ended the poverty of more than 12 million rural poor throughout the world.

IDE applies proven techniques to enable the poor to participate in markets, enabling them to work their way out of poverty. The uniqueness of IDE’s approach comes from its strengthening of suppliers and purchasers, design of low-cost technologies and training to improve farmer income, and sustainability of benefit. The IDE method has been proven in areas such as high-value cash crops, aquaculture, pork production, animal-feed production, fertilizer production, water purification, and sanitation. Targeted poor families typically increase their income by more than $500 a year, and often double it again for succeeding years.

Polak was a boy when his father relocated the family from Czechoslovakia to Canada in 1939 to escape the Nazi regime. In Canada he helped his father build from scratch a new life for the family and thus gained his entrepreneurial attitude to the problem of poverty. Practicing psychiatry as a young man, he saw links between mental illness and impoverished conditions.

Dr. Polak and IDE’s work have been recognized by the Scientific American Top Fifty award for agriculture policy (2003), the Ernst and Young Entrepreneur of the Year Award (2004), and the Tech Museum Award for the design of IDE’s low-cost drip-irrigation system (2004). Articles about IDE and Polak have appeared in National Geographic, Harpers, Forbes, and Scientific American.

Recent, Relevant Publications


Michael A. Treder

Michael A. (Mike) Treder, Executive Director of the Center for Responsible Nanotechnology (CRN), is a professional writer, speaker, and policy advocate with a background in technology and communications company management. In 2002, he co-founded CRN, a non-profit research and advocacy organization that promotes public awareness and education, and works to craft effective policy to reduce the dangers of the use of advanced nanotechnology and maximize the benefits of the wise, comprehensive, and balanced plans for responsible worldwide use of this transformative technology.

In addition to his work with CRN, Treder is a consultant to the Millennium Project of the American Council for the United Nations University, serves on the Scientific Advisory Board for the Lifeboat Foundation, is a Research Fellow with the Institute for Ethics and Emerging Technologies, is on the Nanotech Briefs Editorial Advisory Board, is a consultant to the Future Technologies Advisory Group, and is a member of the World Future Society.

Treder has published more than a dozen articles and papers, and has been interviewed numerous times by the media. As an accomplished presenter on the societal implications of emerging technologies, he has addressed conferences and groups in the United States, Canada, Great Britain, Spain, Germany, Italy, Switzerland, and Brazil.

Recent, Relevant Publications


“Ethical Use of Advanced Nanotechnology,” Presentation at the University of Alcala, Madrid, Spain (March 2006).

“Technology: Are We Watching It or Is It Watching Us?” Presentation at Upper Canada College, Toronto (February 2006).

“From Heaven to Doomsday: Seven Future Scenarios,” Future Brief (February 2006).

“Productive Nanosystems,” Presentation at the “Risk Governance for Nanotechnology” Workshop, Zurich, Switzerland (January 2006).


David Wasdell

Born in 1942, David Wasdell has spent most of his working life in the multicultured and rapidly changing environment of the East End of London. He married Evelyn, his long-term working partner, in 1995 and has two grown children from his previous marriage. Wasdell’s interests include hill-walking, photography, music, house restoration, gardening, and keeping fit. He has a lifelong commitment to education, personal development, professional training, and gaining IT and presentation skills.

With degrees in mathematics, physics, and theology, Wasdell consistently adopts a multi-disciplinary approach in his professional research, which has focused on the psychodynamics of complex human systems.

Wasdell is the founder and Director of the Unit for Research into Changing Institutions (URCHIN), a registered UK charitable trust founded in 1981, and since 1987 has been the International Coordinator of the Meridian Programme, which promotes human integration at every level of the world system in order to ensure species survival and to optimise the quality of life within the sustainable limits of the Earth, our holding environment.

Wasdell has designed and directed Group Relations events in Finland, Germany, Switzerland, Israel, South Africa, Philippines, Australia, and the USA, as well as at various venues in the UK. He specialises in consultancy-research with a wide range of institutions and organisations undergoing rapid change in conditions of low resource and high stress, as well as acting as mentor and trainer to organisational consultants, managers, and psychotherapists. In addition to his organisational/institutional role, he also has a private psychotherapeutic/human potential development practice. Prior to the founding of URCHIN, Wasdell was the founder and Director of the Urban Church Project, which conducted operational and psychodynamic research with religious organisations in the UK, sponsored by the Church of England.

A prolific author, Wasdell has some 90 articles and papers available in print and via www.meridian.org.uk. He has also presented most of these articles and papers at major conferences around the world.

Recent, Relevant Publications


“The Feedback Crisis in Climate Change.” [www.meridian.org.uk/Resources/Global%20Dynamics/Feedback%20Crisis/index.htm] (November 2005). This Meridian Report highlights the all-too-real possibility of runaway climate change, driven by the naturally occurring positive feedback loops of the biosphere. It raises issues of the most fundamental and urgent nature for the world community and calls in question the effectiveness of current strategic responses to global warming.


“Working in the Shadow of the Future: The Psychodynamics of the World Health Organisation.” Presentation to the International Society for the Psychoanalytic Study of Organisations 2004 Symposium (Coesfeld, Germany). This presentation draws on new theoretical understanding of the roots of the common unconscious, which helps to illuminate the extreme phenomena of regression, fragmentation, passivity, and impotence. Included are outlines and reviews of possible strategies of psychodynamic intervention that could be effectively deployed in macro-systems.

“Towards a New Paradigm of Psychosocial Analysis.” [www.meridian.org.uk/Resources/PsychoSocial_Analysis/Boston/index.htm] (September 2003). Exploring the implications of relevant insights from the last three decades of groundbreaking psychoanalytic, group-dynamic, and medical research, this presentation introduces a paradigm-shift in psychosocial analysis that is fundamental to the conceptual framework of the Meridian Programme.


“The Psychodynamics of War and Religion.” [www.meridian.org.uk/Resources/PsychoSocial_Analysis/WandR2/index.htm] (2002). This paper argues that both religion and war have common roots in the pre- and perinatal experience of the species, and that the social defences are laid down in response to the universal trauma of birth. First presented in Heidelberg at the Conference of the Association for Pre- and Perinatal Psychology (June 1991).


“Crossroads for Planet Earth” plenary sessions and small-group discussions included face-to-face dialogues among seminar participants as well as occasional comments by the following observers and staff:

OBSERVER 1
Richard T. Henry
President
UnifiedField Associates
Bellevue, WA USA

OBSERVER 2
Michael Li
Affiliate Professor, Electrical Engineering
University of Washington
Seattle, WA USA

OBSERVER 3
Paula Fraser
Teacher
PRISM Program
Bellevue School District
Bellevue, WA USA

CAMERAMAN
Jeff Holdsworth
Creative Director and IT Manager
Foundation For the Future
Bellevue, WA USA
To set the stage for the April 2006 “Crossroads for Planet Earth” seminar, Foundation For the Future Co-founder and Executive Director Bob Citron presented two PowerPoint presentations for consideration by seminar participants. Content shared in these presentations was based on preliminary findings of The Genographic Project, a global venture tracing the migratory history of the human species. The Foundation For the Future provided a planning grant for the project in 2005.

The first presentation was “The Human Journey on Planet Earth,” which includes a series of National Geographic Society slides illustrating the departures of groups of *Homo sapiens*, initially from their place of origin in Africa 160,000 years ago, to journey to other locations, ultimately settling throughout the Earth. The Genographic Project, an international program of geneticist Spencer Wells, the National Geographic Society, IBM, and the Waitt Family Foundation, is a five-year program using genes to chart this human migration. Each chronological period depicted in the slides shows the full extent of human life on Planet Earth at that time.

The second presentation was “The Human Impact on Planet Earth,” which uses space photography from the 1970s and current images from satellites to show changes in the Earth as a result of our species’ activities over the last 35 to 40 years.
The Human Journey on Planet Earth
200,000 Years Ago to the Present

The National Geographic - IBM Genographic Project
Recent Global DNA Analysis

Bob Citron
Foundation For the Future
Humanity 3000
“Crossroads for Planet Earth” Seminar
Bellevue, Washington, April 6, 2006
African origins

Over 160,000 years ago, modern humans - Homo sapiens - lived in Africa. The earliest known archaeological evidence of our mtDNA and Y chromosome ancestors is found in East Africa.

160,000 - 135,000

Four groups travelled as hunter-gatherers south to the Cape of Good Hope, south-west to the Congo Basin and west to the Ivory Coast, carrying the first generation of mtDNA gene type 'E1'.

135,000 - 115,000

A group travelled across a green Sahara 125,000 years ago, through the open northern gates, up the Nile to the Levant.

1st EXIT
115,000 - 90,000

The beach that reached the Levant died out by 90,000 years ago. A global freeze-up turned this area and north Africa into extreme desert. This region was later recolonised by Neanderthal Man.

90,000 - 85,000

85,000 years ago a group crossed the mouth of the Red Sea, the Gate of Grief, prior to travelling as beachcombers along the southern coast of the Arabian Peninsula toward India. All non-African people are descended from this group.

85,000 - 75,000

From Sri Lanka they continued along the Indian Ocean coast to western Indonesia, then a landmass attached to Asia. Still following the coast they moved around Sumatra to South China.
74,000 Mt Toba
Super-eruption of Mt Toba, Sumatra, causing a 6 year nuclear winter and instant 10000 year ice-age with a dramatic population crash, to less than 10,000 adults. Volcanic ash from the eruption up to 6m deep covered India & Pakistan.

74,000 - 65,000
Following the devastation of the Indian sub-continent, repopulation took place. Groups crossed by boat from Timor into Australia and also from Borneo into New Guinea. There was intense cold in the Lower Pleistocene in the north.

65,000 - 52,000
Dramatic warming of the climate 52,000 years ago meant groups were finally able to move north up the Fertile Crescent returning to the Levant. From there they moved into Europe via the Iberian peninsula from 50,000 years ago.
53,000 - 45,000
Mini Ice Age. Aurignacian Upper Palaeolithic culture moved from Turkey into Bulgaria, Europe. The new style of stone tools moved up the Danube into Hungary then Austria.

45,000 - 40,000
Groups from the east Asian coast moved west through the central Asian steppes towards Northeast Asia. From Pakistan they moved into Central Asia, and from Inner China (through Tibet) into the Qing-hai Plateau.

40,000 - 25,000
Central Asians moved west towards eastern Europe, north into the arctic Circle and joined East Asians to start the spread into north-east Eurasia. This period saw the birth of spectacular works of art, as in the Chauvet cave in France.
25,000 - 22,000
Ancient humans who crossed the Bering Land Bridge connecting Siberia to Alaska, passed through the ice corridor reaching Meadowlark before the Land Bridge melted.

22,000 - 19,000
During the last Ice Age, Northern Europe, Asia, and North America were depopulated with isolated surviving groups locked in refuges in North America, the ice corridor closed and the coastal route froze.

19,000 - 15,000
The Last Glacial Maximum [LGM] 18,000 years ago. In North America, west of the ice groups continued to develop diversity in languages, cultures, and genes as they crossed into South America. Australian rock art. Brodhead Paintings.
15,000 - 12,500

Continued amelioration of the global climate. Coastal route recommended. Monte Verde. Chile - human habitation; radio-carbon dating from 11,790 to 13,565 years ago. Simple stone tools such as flakes and cobbles were excavated.

12,500 - 10,000

Reoccupation of North America 12,500 years ago from south of the ice going north. In the sub-Antarctic 11,500 years ago people moved out from the Beringian refuge to become the Eskimo, Aleuts and Na-Dene speakers.

10,000 - 8,000

The final collapse of the Ice Age heralded the dawn of agriculture. The Sub-Saharan grassland, as implied by the life-size giraffe petroglyphs in Nijer, recolonisation of Britain and Scandinavia. Agriculture.
People and the Earth
Human Impact on the Planet

Satellite Imagery:
Showing changes on planet Earth in just 30 years

Bob Citron
Foundation For the Future
Humanity 3000
“Crossroads for Planet Earth” Seminar
Bellevue, Washington, April 6, 2006
Global Population Change from AD 1 to 2000

Earth's Shrinking Biosphere
AD 1900-2000

Land Area: hectare per/capita

Earth's Shrinking Biosphere
AD 1-2000

Body text

Earth's Shrinking Biosphere
AD 1900-2000

Global Population Change from AD 1 to 2020

Foundation For the Future
Bellevue, Washington USA

Foundation For the Future
Bellevue, Washington USA

Foundation For the Future
Bellevue, Washington USA

Foundation For the Future
Bellevue, Washington USA
Evidence from satellites of thinning of the ozone layer led to the Montreal Protocol for reducing CFCs.

Almost one-fifth of the Amazon rainforest has been cleared.

1986 - "Fishbone" patterns on the landscape show agriculture fields.

Deforestation: Rondonia, Brazil

Evidence from satellites of thinning of the ozone layer led to the Montreal Protocol for reducing CFCs.

Almost one-fifth of the Amazon rainforest has been cleared.

1986 - "Fishbone" patterns on the landscape show agriculture fields.

Deforestation: Rondonia, Brazil
High-Impact Human Changes

Wildfires in Africa

Las Vegas, Nevada

Transforming Desert to Cities

Drought: Western United States

Las Vegas, Nevada - Growth in 27 Years

The explosive growth of development-world cities such as Santiago
In 1973, signs of deforestation are evident, but the forest cover is extensive throughout the region. By 2000, the protected national park is sharply defined in the dark green enclave to the right of the images.

In 1975, Bolivian lowlands suitable for agriculture

1977 to 2000, Dhaka grew from a city of 2.5 million to more than 10 million.

From 1977 to 2000, Dhaka grew from a city of 2.5 million to more than 10 million.
Lake Hamoun, Iran/Afghanistan

Changes in water levels between 1976 and 2001 in Lake Hamoun

Al Isawiyah, Saudi Arabia

The Huang He (Yellow River) is the muddiest river on Earth and is China’s second longest river, running 5,475 km (3,395 miles) from eastern Tibet to the Bohai Sea. The Huang He’s yellow color is caused by its tremendous load of sediment, composed primarily of mica, quartz, and feldspar particles. The sediment enters the water as the river carves its way through the highly erodable loess plateau in north-central China. (Geosial soil is called huang tu, or “yellow earth,” in Chinese.) Centuries of sediment deposition and dike building along the river’s course have caused it to flow above the surrounding farmland in some places, making flooding a critically dangerous problem. Where the Huang He flows into the ocean, sediments are continuously deposited in the river delta, where they gradually build up over time. Between 1979 and 2000—as these satellite images show—the delta of the Huang He expanded dramatically. Several hundred square kilometers of newly formed land were added to China’s coast during this period.
For decades, heavy demands have been placed on the land-locked Dead Sea to meet the needs of growing populations in the countries that border it. Both Israel and Jordan draw water from rivers that flow into the Dead Sea, reducing the amount of water that would naturally replenish it. The amount of area devoted to evaporation ponds for producing salt has greatly expanded over the past three decades. The creation of salt works tends to accelerate evaporation, further contributing to the reduction in water level. Currently, it is estimated that the water level of the Dead Sea is dropping at a rate of about one meter (3 feet) per year. These images reveal dramatic changes in the Dead Sea over a period of about 30 years. Declining water levels, coupled with impoundments and land-reclamation projects, have greatly increased the amount of exposed arid land along the coastline. The near-complete closing off of the southern part of the Sea by dry land (2001 image) reveals the severity of water-level decline.

Honduras is second only to Ecuador in the production and export of cultured shrimp from Latin America. Vast areas of the delta have been converted into farms for the cultivation of shrimp. The rapid growth of shrimp aquaculture in Honduras has caused both environmental and social problems. Shrimp farmers are depriving fishers, farmers, and others of access to mangroves, estuaries, and seasonal lagoons; destroying mangrove ecosystems, altering the hydrology of the region, destroying the habitats of other flora and fauna, and precipitating declines in biodiversity; contributing to degraded water quality; and exacerbating the decline in Gulf fisheries through the indiscriminate capture of other species caught with the shrimp larval stage used to stock ponds. These two images provide a visual comparison of the increase in coverage by shrimp farms in the Gulf of Fonseca over time. It is evident from the images that between 1987 and 2004, a period of about 17 years, the total area under shrimp farming has increased dramatically.

This pair of satellite images shows the impact of massive and rapid agricultural development in Almeria Province along Spain’s southern coast. In the earlier image, the landscape reflects rather typical rural agricultural land use. In the 2004 image, much of the same region — an area covering roughly 20,000 hectares (49,421 acres) — has been converted to intensive greenhouse agriculture for the mass production of market produce. In order to address increasingly complex water needs throughout Spain, the government adopted the Spanish National Hydrological Plan (SNHP) in 2001. Initially, this water-redistribution plan involved the construction of 118 dams and 22 water-transfer projects that would move water from parts of the country where it was relatively abundant to more arid regions. In 2004, the Spanish government announced that it would begin exploring more environmentally friendly water-saving technologies, such as wastewater recycling and seawater desalination.