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Balancing the biocomplexity of the planet's living systems: a 21st century task for science

Good evening. I am delighted to be here. There is an old saying about how the best audiences are intelligent, well informed, and a little drunk. Since the reception is after the speeches, we're batting two for three. Not bad, right?

Although we are all members of a large and proud community of researchers in the life sciences, I welcome you today in a new capacity. As the still "wet-behind-the-ears" director-designate of the National Science Foundation, I am acutely aware that Neal Lane (the outgoing director) leaves a legacy of vision and excellence.

These opening remarks are in part greeting and welcoming, but my intent is also to challenge all of us in the larger science community with a formidable task. I will cut to the chase. For the 21st century, our goal must be to understand, and learn to keep in balance, the "biocomplexity" of all of Earth's ecosystems.

"Biocomplexity": what do I mean by that? It may not be in our lexicon right now, but it is where we need to go in our quest to understand the Earth's biosphere.

Let me start with a bit of historical perspective. With the exception of the life sciences community, this is the first time in human history that global inhabitants are collectively beginning to recognize that the environment needs protection from humankind. For 6000 years, the pattern has been humans needing protection from nature.

Of course, we are still vulnerable. Recent tornadoes, tidal waves, and earthquakes remind us of that. Nevertheless, the planet has become vulnerable to our human power to inflict irreversible damage.

For hundreds of years people have, with abandon, depleted forests and mineral resources, polluted the air, and contaminated waterways. This trend has intensified with a burgeoning world population, coupled with the power of technology. It has escalated and accelerated alteration of the environment in ways never before possible.

The special emphasis of this meeting of AIBS is on the Chesapeake Bay ecosystem, which has a very personal meaning for me since my husband and I are racing sailors who have spent the last twenty-five years sailing on the Bay. Jack and I just returned from meetings in England, which we combined with a visit to the Lake District, where the poet Samuel Taylor Coleridge lived.

I am reminded of Coleridge's lines from his long poem, "The Rime of the Ancient Mariner", those lines that we all had to memorize in high school: *Water, water everywhere,/ And all the boards did shrink;/ Water, water, everywhere/ Nor any drop to drink.../ The very deep did rot.*

To Coleridge, in his altered state of the fantastical, this dire fate came about to avenge the death of the albatross. One nevertheless has to wonder at the insight and the imagination of Coleridge writing at the end of the eighteenth century.

Here we are at the end of the 20th century, roughly 200 years later. And our "water, water everywhere" has the potential to become barren, useless, and even poisonous to aquatic life and inhabitants of the land. Like the ancient mariner and his crew, we would not be innocent victims, but rather societal participants.

Much like the Chinese definition of "crisis", there is both opportunity and responsibility for the science community. This is where biocomplexity takes shape as a research direction, as well as a key to social understanding. To my mind, biocomplexity reaches beyond biodiversity. When we speak of sustaining biodiversity, we mean primarily maintaining the plant and animal diversity of the planet, a very important goal.

On the other hand, the phrase "understanding biocomplexity" speaks of a deeper concept. It is not enough to explore and chronicle the enormous diversity of the world's ecosystems. We must do that—but also reach beyond, to discover the complex chemical, biological, and social interactions in our planet's systems. From these subtle but very sophisticated interactions and interrelationships, we can tease out the principles of sustainability.

I recognize that to many of you, this must sound like a "coals to Newcastle" speech, a preaching to the choir. Nevertheless, there is a purpose. This message is one that we have to take to the larger science community and ultimately to the public.

On President Clinton's recent trip to China he urged the Chinese government and the Chinese people not to make the same mistakes that other developing nations have visited on themselves. He reminded them that economic growth and environmental preservation are not mutually exclusive. As all of you know, this is a lesson we are still struggling to appreciate in America.

In my new job as NSF Director, I am learning new things about biology from very unlikely sources. Congressman George Brown

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of the House Science Committee, and a long-time friend of science, made an astute observation in the commencement address he delivered at UCLA in 1994. He said to the graduates: "Not unlike the way diverse cells in multicellular biological organisms signal their activity and thus coordinate their behavior with unlike cells to ensure the survival of the organism, we as citizens need to do the same. We can learn our place and function in the larger community only by signaling—by explaining ourselves."

For the science community, this signaling is more than just biochemical—it means reaching across disciplines. It will take biologists, ecologists, physical scientists, computer scientists, engineers, and surely those in the behavioral sciences to understand the signals for survivability.

The new challenges of understanding biocomplexity will draw us together across diverse disciplines. As we collaborate in an array of disciplines, our work will connect and overlap. It will gain strength and insight from that blending.

This means that as scientists we must get better at signaling to each other. Only by doing this can we develop a universal language that allows all of us to communicate and develop an understanding of the biocomplexity that defines life on this planet.

As scientists, we must also become more comfortable with dialogue —that is our signaling—to the larger public about the value and contributions of science to society. That signaling requires astute listening as well.

As biologists and ecologists, we are especially aware that each species and organism has distinct characteristics and capabilities. So too with the human species. Perhaps our most distinct capability is to be able to plan and construct a sustainable future for the benefit of all species and ecosystems.

Despite this capability, just learning to decipher the delicate interactions and balances of a complex ecosystem like the Chesapeake Bay is a significant challenge—at least as difficult as learning how to understand, influence, and educate our own species. Survival, let alone the capability to flourish, depends on our ability to achieve what is a truly interdisciplinary task.

We should aspire to move from remediation to increasingly predictive and more powerfully preventive capabilities. The challenge is, at the same time, to be more focused, yet more integrated in our research. No problems exist in isolation, whether they are scientific, social, or technical. More often, they are all three at once.

My own research on the ancient scourge, cholera, which is still very much with us today, can provide an example. It is now possible to utilize remote sensing and computer processing to integrate ecological, epidemiological, and remotely sensed spatial data to produce predictive models of cholera outbreaks.

We can now predict conditions conducive to pandemics of cholera in those parts of the world where the public health infrastructure is inadequate or even lacking. Populations can then be instructed on preventive public health measures. This is a major step forward from the old pattern of remedial action, that is, reacting to major, devastating epidemics.

In the long run, our individual research knowledge and understanding will not be sufficient for the larger-scale research programs. Our cooperative attitude—and our comprehensive vision—will also be needed to devise and implement strategies at the interdisciplinary level.

This sets a goal for all of us. Our new knowledge, and our approach to solving problems, must be collaborative. This will move us toward sustaining all living systems, ourselves included. We already have considerable evidence to suggest that the human species often works in opposition to its own long-term best interest.

The late social philosopher, Lewis Mumford, wrote: "Western society has accepted as unquestionable a technological imperative that is quite... arbitrary... Not merely the duty ...to create technological novelties, but equally the duty to surrender to these novelties unconditionally... without respect to their human consequences."

Mumford does not devalue science and technology here. Instead, he is critical of our lack of attention historically to our values and our vision as a society. He is telling us something worthy of our serious consideration. His words should not only make us attentive to what we are able to do but also make us ask ourselves if those things we can do take us to where we need to go as a society and a civilization. Marshall McLuhan said more simply, "First we shape our tools and then our tools shape us."

Today, we have sophisticated research methods and tools, thanks to the work and the creativity of many of you here. This capability, and our growing awareness of the effect of human exploration and settlement on the planet, will drive our new agenda for the 21st century.

The Chinese have an oft-quoted expression that is both cautionary and opportunistic: "May you live in interesting times." We surely are living in those times. The expanding knowledge of our research base holds the key. It will both caution us of the dangers and allow us to take advantage of the opportunities for positive change.

As I said earlier, we in the life sciences have been aware of the issues and problems of Earth's biosphere for decades now. But it is not enough for us to just be aware of the problems: We need to play an active part in the solutions.

The solutions are not only scientific, but social and political. They will require your active participation. In the end, our task for science in the 21st century will be to acknowledge that Coleridge was a good poet but not a good prophet in his devastating scenario. I am convinced we will meet the challenge.

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