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Remarks on industrial ecology

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Today the term industrial ecology is both evocative and enigmatic. Your task will be to make it commonplace and creditable. I am pleased to have the opportunity to join with you as you begin to define this concept and to plan a new and constructive direction for the future progress of American business and industrial practice. I want to commend both the National Academy of Sciences and AT&T Bell Laboratories for organizing and sponsoring this 2-day colloquium. The participants comprise a gathering of expertise that clearly represents some of the nation's most insightful thinking on issues of environmental survival and industrial excellence.

John Atcheson of the Environmental Protection Agency's Office of Pollution Prevention unwittingly framed the context for our task today when he wrote in a recent paper, “There are three realities that will make the next twenty years fundamentally different from the last twenty years. First, we are learning that the biophysical systems we depend on to support and sustain us are extraordinarily fragile and exquisitely complex. Second, we are beginning to understand and accept that man has become a global force, as influential on the biosphere as any of the other forces of nature. Third, the pace of change dictated by man, the planetary force, is unprecedented in natural history.”

Within this context, we must set out to solve the two fundamental issues of survival. (i) How can we support a growing global population through agriculture, commerce, and industry? (ii) How can we care for and preserve the planetary home that sustains all the activities of human existence? There is a subset of this latter issue, which hopefully may be of declining significance—namely, how can we avoid the destruction of both human society and the global environment in a world-wide nuclear conflict?

It goes without saying that, in this convocation, these goals of supporting a growing global population and preserving our planetary home are not considered mutually exclusive. However, we have only recently discovered the global impact of environmental problems and, I might add, the consensus on this is not yet universal.

I hold two vigorous opinions here. It is my absolute belief that we must reverse the forces of environmental degradation at work across this nation and the world. It is my further conviction that this cannot be accomplished without the participation and the prosperity of American industry.

Let me take a moment to describe two scenarios. Each scenario is independent of the other; our task will be to make them work in synergy. (i) The first scenario concerns industry in America today. America's industrial sector is at a formidable crossroads. We are losing or have lost major market share in many industries where we were not only successful but also preeminent.

In critical technology areas, those technical territories that will enable us to develop the new products, processes, and industries of tomorrow, we are weak or far behind our competitors in everything from structural ceramics to memory chips. A series of responsible analyses over the past several years has documented this fact and the fact that our decline continues.

At this juncture, American industry is faced with the need for a fundamental restructuring, not only for success but, in some cases, for survival. Most of today's progressive trends in manufacturing have been set by our competitors. Our choice is to follow or to continue to falter. These trends are toward shorter production runs and shorter product cycles. The trends place increased emphasis on quality, dictate greater variety of products with increased customization, and include an abbreviated time-to-market for new products. Accomplishing this restructuring will require integrated manufacturing and easily arranged incremental improvements both in the product and in the manufacturing process.

In addition, over the last decade we have seen a global trend for industry to move toward science-based technologies, dependency on an information-based infrastructure, and manufacturing that is increasingly independent of raw material sources. These are dramatic changes.

(ii) Now, the second scenario, which concerns environmental evidence and thinking. First, the evidence—the recently revised Montreal Protocol, which aims to eliminate chlorofluorocarbon production in developed countries by the year 2000, has further dramatized the ozone-depletion problem in global consciousness. Ozone-devouring chlorofluorocarbons have existed for only 60 years. It is astonishing that a chemical with a production history of just six decades has been able to alter fundamentally our atmosphere's natural condition in a period too brief to measure as a moment in the earth's existence. This is a chilling revelation.

Then there are the graphic recollections: the odyssey of the Long Island garbage barge that carried cargo refused at every port and just recently the railroad train of toxic dirt. No further elaboration is needed. There are thousands of examples of environmentally destructive patterns that are ossified in our routine lives. Many we know about; of some, assuredly, we are still unaware.

The Clean Air Act and the Clean Water Act of the early 70s were milestones of awareness for a nation that had heretofore been completely negligent of the despoliation and deterioration of its very cradle. The Resource Conservation and Recovery Act of the mid 70s was a major national effort to deal with solid and hazardous waste. Other successes include the recent passage of the Clean Air Act Amendments, which culminate a decade-long struggle toward further improvement. The Pollution Prevention Act of 1990 is an important departure from the school of environmental-remediation philosophy; so, too, are current legislative proposals that would mandate preservation of the nation's biological diversity.

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However, much of that 20-yr period also should have been spent trying to change attitudes, which are always the most intractable part of any problem. At this moment, America's environmental policies and practices are at a crossroads not entirely dissimilar from the one faced by American industry. In environmental thinking, we are at a point where we must seriously reconsider and reorient our approach to the solutions, and we must then accelerate the pace at which we implement them.

We need to go beyond the naive and fragmented solutions that divert pollutants from disposal in one environmental medium only to eventually release those pollutants in another form into a different medium. We cannot continue to lurch from one environmental brush-fire to another, as if these incidents and excesses were isolated and independent problems. We cannot continue to treat environmental problems with remedial solutions such as "end-of-the-pipe" treatment that do not address the source of the problem but only treat the symptom.

We have come face-to-face with the fantasy that the environment is inexhaustible and indestructible, and we now recognize that fantasy for the myth it is. We must now carry the albatross of massive environmental cleanup as retribution for our previously cavalier behavior. However, we also have the opportunity to avoid this same prospect as a future scenario.

To realize a better future, we need to perceive our whole economic process at the level of family, enterprise, and nation as a continuous cycle that affects and is affected by the environment. We need to abandon the economic paradigm in which the environment is expendable and cost-free, sometimes called the tragedy of the Commons. This change will enable us to design a prevention process—a pattern that is integrated into lifestyle, industry, and commerce—that will eventually become elemental in our societal pattern.

Here then are the sites of two scenarios—one for industry and one for the environment—both involving pervasive problems in our national life. Each scenario is at a moment of major transition, each is at a point of restructuring and redesign, and each is at a watershed that provides the nation with a singular opportunity to integrate the two reformations.

Enter the concept of industrial ecology and this 2-day colloquium. The mere act of connecting the words industrial and ecology brings together two psychologies of existence that have, in the past, been framed in opposition. These points of view are traditionally represented by separate and sometimes hostile communities defending their distinct differences.

Thus, the concept of industrial ecology becomes a common meeting ground. The goals of each group remain the same, simple and stridently focused. Industry must become increasingly competitive. Environmental degradation must be prevented, not just repaired. However, with the "ecosystem design" of industrial ecology, we have the opportunity to change the way we reach these goals. We have the possibility of creating a sphere of synthesis.

There must be trade-offs to achieve this gain. (i) We must abandon the strongly ingrained bipolar portrayal of industry as the abuser of the global environment and of environmentalists as the antigrowth, antiprosperty neo-Luddites of today. (ii) We must be willing to reject the myth that environmental initiatives, by necessity, retard economic development.

A recent article by Marc Ross and Robert Socolow in the journal *Issues in Science and Technology* sheds some light on this problem. They write, "... U.S. business managers tend not to take the lead in formulating environmental goals and regulations; instead, they often pursue an adversarial approach. This is unfortunate because they are often in the best

position to know what can be achieved with new technology and where the pitfalls lie.

"... Environmentalists are sometimes uncomfortable with new technology, which, after all, has been the source of many environmental problems. Moreover, some environmentalists are wary of advocating a public policy aimed at new technology for fear that it will delay achievement of environmental goals. They believe that environmental problems are social in nature and can be solved with present technology."

It will not be easy for either group to abandon the position and persona that define its professional place in the culture. You who believe in the benefit of breaking these traditional molds will have to carry the burden of proving the new values.

Fortunately, the evidence is beginning to accumulate. We can actually document profitability from the use of environmental-enhancing technologies. The 3M Company estimates a savings of \$482 million since 1975 from its Pollution Prevention Pays program. In the process, they have eliminated >500,000 tons of waste and pollutants and also have saved another \$650 million by conserving energy.

Nevertheless, we need much more data on the economic basis for an "ecosystem approach" to industrialization. In addition, companies not only need to understand that the potential benefits exist but also need to know where to go for advice and expertise. And all American companies must develop a planning horizon that has longer term expectations than an annual earnings report.

Part of the push for creating this momentum will require environmental policymaking that rewards, rather than inhibits, environmentally superior practices and innovation. Regulations that mandate remedial, or end-of-the-pipe, solutions will stifle innovative pollution-prevention techniques. On the other hand, properly constructed regulatory standards, which dictate outcomes and not methods, will both allow and encourage companies to redesign their technologies and management strategies.

The Office of Technology Assessment currently is conducting a study on integrating environmental goals with industrial product design. The study was requested jointly by the Science, Space, and Technology and the Energy and Commerce Committees of the House of Representatives. This study will examine trends in materials use and product design in four major product areas.

I assume that you have heard more about this study from Greg Eyring, the project's Director, who was a discussion leader for the Materials in Industrial Processes group earlier in the day. Suffice it for me to say that the study will explore how technologies for disposal or reclamation of wastes could be comprehensively coupled to the initial design process.

By making environmentally benign choices for front-end materials, by extrapolating the best energy efficiencies, and by recycling and transforming waste into salable new products, we can restructure the behavioral process of our economic existence.

Currently, America's costs just for waste management and disposal are staggering for industry and, through government spending, for the individual taxpayer. As a nation, we generate ≈570 million tons of hazardous waste and >11 billion tons of nonhazardous waste annually. The estimated cost of managing these pollutants is close to \$100 billion each year, two-thirds of which is spent by industry. This cost is clearly money spent on the nonproductive end of the cycle, both by industry and by the public.

What we are trying to do in this meeting is to define a process by which industry anticipates the pollutant-producing, waste-generating components of production. Then industry designs minimization of these burdens into the forward point of production, while planning for the reuse of

the remaining waste product. In this way, industry's resources will be spent on the productive front end of the cycle, where costs can influence savings instead of creating drain.

The pace at which we are able to perform the needed research and technology development for the application of industrial ecology precepts is crucial. American industry—company by company, sector by sector—will be forced by competitive survival to restructure. The window of opportunity exists for that restructuring to incorporate broad use of the principles of industrial ecology. This is an aperture of particular advantage, one in which we can make an informed reordering.

How then do we move beyond discussion toward implementation?

First, I believe that industry must take the lead. This meeting is a strong sign of its willingness to do so. The momentum developed here from cross-cultural discussions can begin the process of building a community of expertise. I would highly recommend that the industry participants consider founding a permanent Industrial Ecology Roundtable with a rotating location. Its objective should be to elucidate and expand the application of industrial ecology.

The Roundtable should be composed of the strongest advocates of industrial ecology from diverse orientations—(i) from the industrial sector in a cross-cutting scope that provides the specific experience of vastly different industries; (ii) from the scientific community, in disciplines as

varied as ecology, chemistry, and materials, but not exclusive to those; (iii) from the engineering community to encompass a breadth from engineering research to manufacturing engineering; (iv) from the economics community to include ecological economists, who at this point are a rare breed, as well as conventional economists. This diversity may appear unwieldy, but the bonding criterion, advocacy of industrial ecology, will be a strong directive.

Under the auspices of the Roundtable, companies that have succeeded with their own programs should offer stewardship programs that foster open exchange of information and know-how. Industry and universities should cosponsor industrial ecology science and engineering fellowships to expand the knowledge base and broad application of the concept. Let me suggest only that any discipline can too quickly become frozen by too narrow a definition. The success of industrial ecology will depend on its flexibility and fresh outlook. Indeed, as the concept succeeds, it will necessarily change its emphasis.

If I have exceeded the boundaries of my invitation to make some comments here tonight, I have done so only out of enthusiasm for your ideas and encouragement for your initiative. Let me conclude with the wisdom of Ralph Waldo Emerson, who said, "Society is always taken by surprise at any new example of common sense."

So, too, will it be with industrial ecology.