PRESIDENTIAL ADDRESS

# Science, Sustainability, and the Human Prospect

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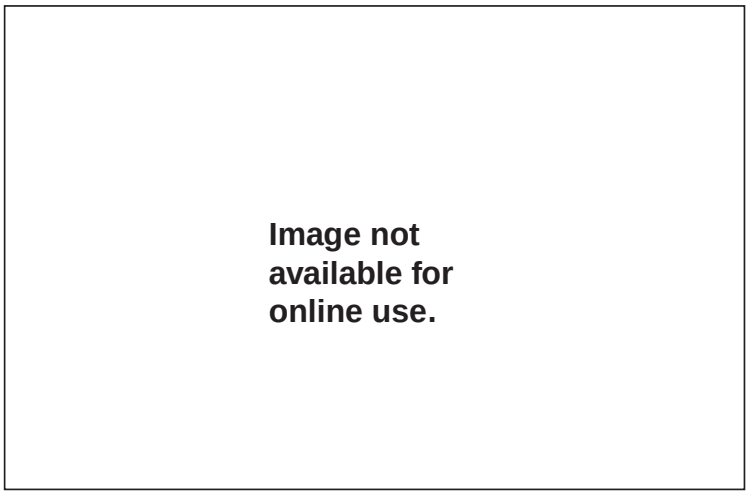
When we set out the theme for the 2002 American Association for the Advancement of Science (AAAS) Meeting, "Science in a Connected World," we thought of the ways in which the fates of nations were intertwined as never before and of the role of science in shaping communication. I was mindful of the enormous challenges that faced a world that had grown so rapidly in population, individual consumption levels, and changing technologies. In the months that followed, the shock delivered by the September 11th events brought home with unimagined force the ways in which our collective neglect of these relationships had helped to bring about the dangerous and unstable state of the world in which we find ourselves. The problems we face seem cruelly compounded, but their root causes remain unchanged.

The challenges that we face are enormous and deeply rooted in relationships neglected for far too long. We must find new ways to provide for a human society that presently has outstripped the limits of global sustainability. New ways of thinking—an integrated multidimensional approach to the problems of global sustainability—have long been needed, and it is now up to us to decide whether the especially difficult challenges that we are facing today will jolt us into finding and accepting them.



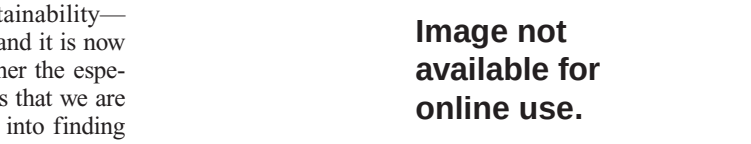

## The State of the World

Over 400 generations (10,000 years), our human population has grown from several million people to approximately 6.1 billion. During this time, villages, towns, cities, and nations formed and became the homes of poets, philosophers, lawyers, builders, religious leaders, and tool makers. We continue to depend on a series of ancient, genetically and socially determined habits and attitudes, many of which seem to have been more suitable for our hunter-gatherer ancestors. We must adopt new ways of thinking that will serve our descendants well in a world that is crowded beyond imagining, a world in which we shall always be the major ecological force; unless, of course, we destroy ourselves.

During the 1790s, the global population amounted to about 800 million people. Despite the Reverend Thomas Malthus' dire prediction that population growth would outstrip food production, we did limit the extent of starvation during the 19th and 20th centuries, in large part because of the steam engine and its successors. We manufactured increasingly toxic pesticides with which we now douse our agricultural lands at the rate of 3 million metric tons per year, worldwide. We are fixing nitrogen with an output that exceeds natural processes. Cultivated lands have grown to comprise an area about the size of South America. Rangelands occupying about a fifth of the world's land surface support 3.3 billion cattle, sheep, and goats. Two-thirds of the world's fisheries are being harvested beyond sustainability.

Over the past half century, we have lost a fifth of the world's topsoil, a fifth of its agricultural land, and a third of its forests. Grain production has fallen short of consumption for two consecutive years, reducing the surplus to the lowest level in two decades (*1*). We have changed the composition of the atmosphere profoundly, driving global temperatures upward and depleting stratospheric ozone. Habitats throughout the world have been decimated by intentionally and accidentally introduced plants and animals.

Most troublesome is the irreversible loss of biodiversity. For the past 65 million years, the rate of species extinction has remained at about one species per million per year. It has now risen by approximately three orders of magnitude, to perhaps 1000 species per million per year (perhaps 0.1% of all species per year), and it continues to rise as habitats throughout the world are destroyed. Species-area relationships, taken worldwide in relation to habitat destruction, lead to projections of the loss of fully two-thirds of all species on Earth by the end of this century (*2*). And these projections do not include the inevitably negative effects of climate change, widespread pollution, and the destruction caused by alien species worldwide, among other factors. In addition, the ecosystem services on which all life on Earth, including our own, depends are being disrupted locally and regionally in such a way as to deprive future generations of many of the benefits that we enjoy now

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(*3*).

Considering the ways in which plants and animals enrich our lives, it is incredible that we continue to destroy them so carelessly (*4*). The actions that we carry out over the next few decades will decide the fate of millions of species of plants, animals, fungi, and microorganisms, the greater number of them completely unknown at present and likely to have remained so at the time of their permanent disappearance from our planet.

Thus, the world has been converted in an instant of time from a wild natural one to one in which humans, one of an estimated 10 million or more species, are consuming, wasting, or diverting an estimated 45% of the total net biological productivity on land and using more than half of the renewable fresh water. The scale of changes in Earth's systems, well documented from the primary literature by Pimm (*5*) is so different from before that we cannot predict the future, much less chart a course of action, on the basis of what has happened in the past (*6*).

Against this background, it is not surprising that false prophets and charlatans have arisen who, neglecting the scientific context that must underlie all wise decisions, pretend to deliver "good news" about the environment. They win fame by telling people what they want to hear. Warmed by the applause that their misstatements generate, such individuals can simply deliver falsehoods or the products of wishful thinking.

The most recent example is the work of Danish economist Bjørn Lomborg, who reprises many of the earlier misleading, if not outright delusional, conclusions offered earlier by Julian Simon and Gregg Easterbrook (*7*), among others. Lomborg's book, *The Skeptical Environmentalist: Measuring the Real State of the World* (*8*) has, remarkably, been published by the generally respected Cambridge University Press, but evidently without critical review. Although he appropriately questions some of the hyperbolic statements that environmentalists have made over the years, Lomborg largely ignores the peer-reviewed literature and frequently misrepresents the views of many of the scientists who have analyzed these areas. He blithely attacks a series of straw men that he resurrects from the past literature or simply constructs, and then repeatedly exposes his ignorance of facts and critical analyses.

Lomborg's popular success demonstrates the vulnerability of the deliberative and hypothesis-driven scientific process to misrepresentation and distortion. It is difficult to understand why a respected journal like *The Economist* would rush to his defense. Although there have been multiple excesses on both sides of this debate, at its root it is a matter of science and factual analysis, and that is the point that seems to have been lost in all the controversy that followed the book's publication. All of the world's environmental scientists cannot reasonably be classified as "dedicated greens" and their views dismissed.

The consequences of our environmental problems are severe. About a quarter of humanity survives on less than $1 per day. Depending on the criteria used, one-eighth to one-half of the world's people are malnourished. Some 14 million babies and young children under the age of four starve to death each year. In the world's poorest societies, women and children are uneducated and spend their time foraging for firewood or water. Such relationships are inevitable in a world in which 20% of us control 80% of the resources, and 80% of us have to make do with the rest.

Among the nations of the world, the role of the United States has become particularly dominant. Although we contain just 4.5% of the world's people, we control 25% of the world's wealth and produce 25 to 30% of its pollution. We are dependent on the stability and productivity of nations all over the world to maintain our level of affluence. It is remarkable, therefore, that the richest nation is the lowest per capita donor of international development assistance of any industrialized country. Only in public health do we support even the rudiments of an adequate global system.

Since publication of the report of the World Commission on Environment and Development (*9*), we have become accustomed to thinking of the world as a place in which everyone could eventually become rich. This may be so, but it cannot happen using the technologies we possess now and building to industrialized-world levels of consumption. Many years ago, when asked whether then–nearly independent India would follow the British pattern of development, Gandhi replied "It took Britain half the resources of the planet to achieve this prosperity. How many planets will a country like India require?" More recently, Wackernagel and Rees (*10*) have estimated that it would take two additional planets to support the world at the living standard of the industrialized countries, three if the population doubled, and 12 if standards of living doubled.

## The Central Role of Science and Technology

It is generally accepted that advances in science and technology power the world's economy and economic progress. In America, leading economists and government policymakers uniformly agree that the nation's extraordinary capabilities in science, technology, and health are among its strongest assets. U.S. investment in basic scientific, engineering, and medical research produces a rate of return of between 20 to 50% per year.

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What are the specific contributions that science and engineering can make to the development of a sustainable society? Contemporary efforts to build the science of sustainability as an accessible, integrating discipline are well summarized in the National Research Council study *Our Common Journey. A Transition Toward Sustainability* (*11*). Noting that many trends and conditions undermine efforts to achieve sustainability, the report concludes that an overall transition could be attained in the next two generations without the development of miraculous technologies or drastic transformations of human societies. The report stressed, however, that significant advances in basic knowledge, in the social capacity and technologi-

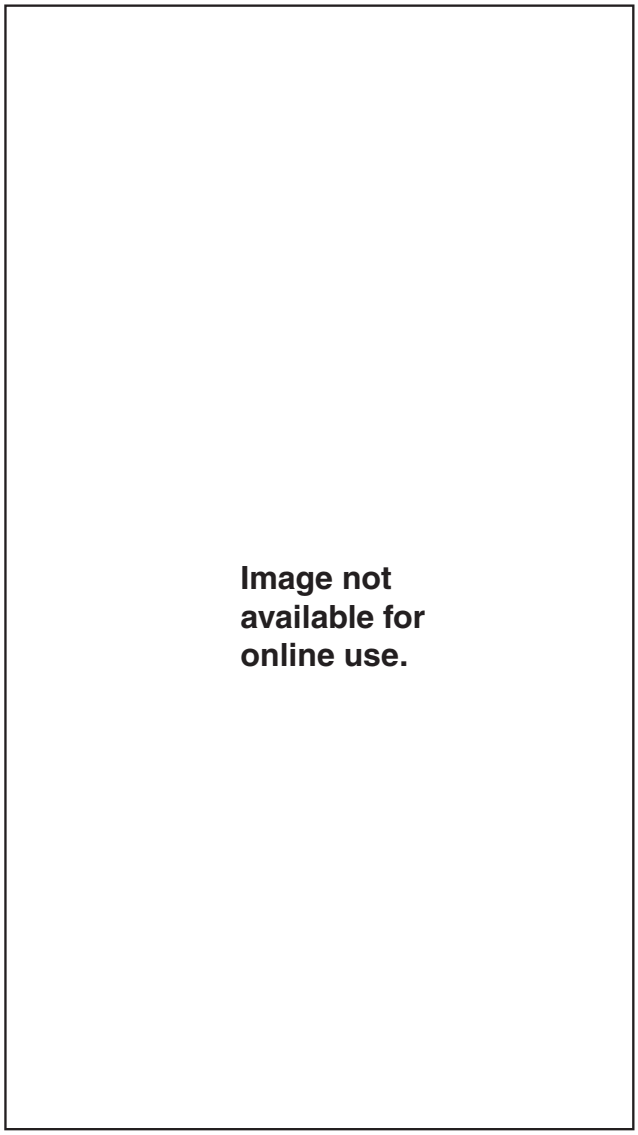
cal ability to use it, and in the political will to turn this knowledge into action will be necessary to achieve this transition.

Those who find comfort in the soothing words of Lomborg might wish to read what a panel of distinguished environmental scientists (people actually working in the area and knowledgeable about it) concluded from 3 years of study of the pertinent facts and have presented in this report, before they completely relax their focus on the world as it really is.

Energy is particularly important for global sustainability. The potential savings from energy conservation and from the development and adoption of alternative sources of energy are well understood and massive. As to alternative sources of energy, Lester Brown cogently points out in his new book *Eco-Economy* (*1*) that a combination of wind turbines, solar cells, hydrogen generators, and fuel cell engines offers both energy independence and an alternative to the fossil fuels that are driving global warming. Worldwide and over the past decade, the use of wind power grew by 25% a year, solar cells at 20% a year, and geothermal energy at 4% a year. During the same period, oil consumption grew by 1% a year, while coal consumption declined by a similar amount. Natural gas grew by 2% annually.

Unfortunately for the United States, most of the growth in alternative energy use has taken place abroad. In 2001, the United States consumed an average of 19.6 million barrels of oil per day. Our total oil imports were 11.6 million barrels per day, or 59% of consumption. Of the imported oil, 2.73 million barrels per day (or 23.5% of total imports) came from the Persian Gulf. According to the Cato Institute (*12*), America spends at least $30 billion to $60 billion per year and deploys thousands of military personnel in securing Persian Gulf oil, for which we pay approximately $21.4 billion (*13*). Against this background, it seems astonishing that we would consider drilling for oil in the Arctic National Wildlife Refuge, which at peak production would provide barely 5% of our national needs. At the same time, we do not sufficiently encourage inventiveness in developing and marketing sustainable energy sources.

The challenges of the 21st century, owing principally to the combined impacts of the globalization of markets and technology-driven knowledge as well as the information explosion, demand increased attention to the development of educational systems both for the United States and for the world at large. Scientific understanding is no longer only a desirable good but clearly an imperative for building truly representative democracies. The involvement of scientists in an effective information network leading to an improvement of the educational system and in promoting public understanding of science would help greatly in building strong sustainable societies (*14*). Such efforts will help informed citizens to make better decisions and will ultimately lead to increasing the financial support for the scientific enterprise. The AAAS has been a leader in increasing public understanding of science and in formal science education, and we continue to stress these fundamentally significant fields in the future.

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### Achieving a Sustainable World

In light of all this, one is compelled to wonder whether the current model for international institutions, established in the wake of World War II, is adequate for building a sustainable world. It is telling that the organizers of the Rio Summit failed to persuade the United States, Japan, or any other country to provide the funds necessary to redress the global imbalances.

Scientist-to-scientist cooperation between those in industrialized nations and their colleagues in developing countries is important for achieving effective global communication and, ultimately, sustainability. Or, as the late Congressman George Brown said to the National Academy of Sciences in 1993: "This work must begin first by viewing developing nations as partners instead of as step-children . . . Of all the many ways in which we can cooperate for the common good, the case for science and technology cooperation with science-poorer nations is perhaps the most compelling. To do so, we must abandon the instinct to judge others by their past accomplishments, or to judge our own accomplishments as the proper path for others."

The problem of transferring technologies to and building capacities in countries throughout the world in such a way that they can contribute adequately to sustainable development is a difficult one, but one that we must confront fully (*15*). Ismail Serageldin (*16*) has presented an argument for the cooperative development of science throughout the world that is both moving and compelling, stressing also the role of the scientific attitude in bringing people together on a rational basis.

Many of us look forward with trepidation to the World Summit on Sustainable Development in Johannesburg, South Africa, to be held this September, because the continued deterioration of the environment over the past 10 years has been so obvious and the signs of progress so limited. Nonetheless, there have been some outstanding efforts to refocus and renew commitments there (*17*). There also is growing evidence that corporations are increasingly realizing that understanding and working with the conditions of sustainable development are necessary prerequisites for success in the corporate world of the future (*18*). John Browne, chief executive officer of BP-Amoco, for example, set his company on a course that will embrace alternative energy sources and energy conservation, reasoning that in the face of global warming, they must do this if they are to continue to be a prof-

itable energy company in the future.

The kinds of grassroots activities that are promoting sustainability on a local scale have become a powerful force throughout the world. Perhaps they are, fundamentally, only a reemphasis of what has been traditional. Whether establishing local clinics and sustainable industries in the Biligiri Rangan Hills of southern India, building people-based ecotourism centers on native lands in Kenya, rebuilding a broken landscape at the Bookmark Biosphere Reserve in South Australia, learning how to ranch sustainably on the vast grasslands of the Malpai Borderlands of New Mexico and Arizona, or simply rooting out alien plants on Albany Hill in the San Francisco Bay Area, the people who are pursuing sustainability in a direct and personal way will hugely affect the shape of the world in the future.

Within a few years, a majority of the world's people will, for the first time, be living in cities (*19*). In order to build a sustainable world for the future, it will be necessary first to develop better models for cities, taking into account the multidimensional contributions of science and engineering, politics and social sciences, and many other fields for designing the improved cities of the future. On the other hand, it will be necessary to pay increasing attention to the rights and needs of rural dwellers throughout the world and to find ways to give them access to the information that they so obviously require. Activities such as those of the M. S. Swaminathan Research Institute in Chennai, India, in bringing health and agricultural information at low cost to the villages around Pondicherry will need to be multiplied many times over for success.

### A Vision for the Future

On 6 January 1941, President Franklin Delano Roosevelt, addressing Congress on behalf of a nation that was moving inexorably toward full participation in World War II, said, ". . . we look forward to a world founded upon four essential human freedoms. The first is freedom of speech and expression—everywhere in the world. The second is freedom of every person to worship God in his own way—everywhere in the world. The third is freedom from want, which, translated into world terms, means economic understandings which will secure to every nation a healthy peacetime life for its inhabitants—everywhere in the world. The fourth is freedom from fear, which, translated into world terms, means a world-wide reduction of armaments to such a point and in such a thorough fashion that no nation will be in a position to commit an act of physical aggression against any neighbor—anywhere in the world. That is no vision of a distant millennium, it is a definite basis for a world attainable in our own time and generation . . . Freedom means the supremacy of human rights everywhere."

When the end of the war was in sight, farsighted people took the first steps in the construction of the institutions that they thought would help to build the kind of world that Roosevelt had envisioned. They believed that global institutions such as the United Nations, the World Bank, and the International Monetary Fund would serve the world well, as indeed they have. None of our national leaders could have imagined withholding support from these institutions because of a perceived lack of control over their activities. Instead, the nations of the world recognized themselves as a community in which all people should ultimately be able to enjoy the kinds of specific rights embodied in Roosevelt's Four Freedoms. Where have these dreams gone?

For reasons that are starkly obvious, we are now focusing our attention on terrorism and the problems associated with it. As the months go by, the real challenge facing us, however, will be whether we will come to regard the events of September 11 as specific and short-term or will analyze their underlying causes and learn how to deal with those causes. We must learn to deal justly with people around the world if our own hopes and aspirations are to be realized. Despite the Lomborgs, *Economist*s, and *Wall Street Journal*s of the world, simply appropriating as much as possible of the world's goods and processing them as efficiently as possible can never be a recipe for long-term success.

The United States is a small part of a very large, poor, and rapidly changing world, and we, along with everyone else, must do a much better job. Sustainability science has a good deal to say about how we can logically approach the challenges that await us, but the social dimensions of our relationships are also of fundamental importance. Globalization appears to have become an irresistible force, but we must make it participatory and humane to alleviate the suffering of the world's poorest people and the effective disenfranchisement of many of its nations. As many have stated in the context of the current world situation, the best defense against terrorism is an educated people. Education, which promises to each individual the opportunity to express their individual talents fully, is fundamental to building a peaceful world.

**We looked forward to a world founded upon four essential freedoms.**

**Where have those dreams gone?**

In reality, the only way to build a secure world is to change both that world and our way of thinking about it. Obviously, there are many steps that we can and should take now, such as better surveillance, better detective methods, hardened infrastructure, improved methods for protecting data, a better understanding of people living in different situations, and more secure ways of dealing with nuclear materials. But we also must address the need for constant supplies of renewable energy and reduce our dependence on both foreign and domestic sources of oil, coal, and natural gas, putting high priorities on both energy conservation and alternative sources of energy. The technology to accomplish this is available, and the economic and security advantages that would accrue to the nation are enormous.

### Some General Principles

We have the extraordinary privilege in the United States of living in a democracy, a system developed over the more than two centuries of our history and based on individual expression and participation. But effective participation involves access to an appropriate level of education, as well as widespread active involvement in the political process.

In a democracy, governmental processes must be transparent to all, participatory, and subject to review and improvement. People must have confidence in their government. The mishandling of the epidemic of mad cow disease in the United Kingdom provides a vivid example of what happens to that confidence when inappropriate advice is given by governmental agencies.

Civil liberties are fundamental, precious, and not to be sacrificed, however briefly, for any but the most urgent reasons. Pressures on civil liberties will increase as the world population swells and demands for enhanced consumption grow. In the face of these pressures, we need to be vigilant to protect what we consider the most important.

Accepting, even embracing, diversity must become a cornerstone of society. It is against our common interests that hundreds of millions of women and children, living in extreme poverty, are unable make the best use of

their abilities. Such discrimination, whether we focus on it or not, is morally abhorrent.

Clearly, a small minority of Earth's residents cannot continue to consume such a large majority of its productivity. As Ismail Serageldin (*16*) has put it, ". . . a world divided cannot stand; humanity cannot survive partly rich and mostly poor." Population, overconsumption (*20*), and the use of appropriate technology must all be brought into the equation to achieve a sustainable world. Nothing less than a new industrial revolution (*21*) and a new agriculture (*22*) are required to make that world possible. The task is daunting, but it is one we must undertake. The basic conditions for change must come from within us: We need new ways of thinking about our place in the world and the ways in which we relate to natural systems in order to be able to develop a sustainable word for our children and grandchildren (*22*).

**The conditions for change must come from within us.**

Think about our relationship with Afghanistan and Pakistan. Once the Russians left Afghanistan, we left. It was a clear demonstration of our lack of fundamental interest in the people of the region, and we all know the consequences. Although the events that followed have certainly not all been clear examples of cause and effect, there is a relationship. In the context of this global reality, how many collaborate with a scientist working in an Islamic country, and how many are making the effort to nurture science there? We need to work together to overcome the malign effects of the September 11 events, which have put on hold efforts by scientists in Islamic nations to strengthen ties among themselves and with the West, and we should reserve resources to make sure that that effort succeeds (*23*). We also must see the estimated 6 million Muslim U.S. residents, with their unique contributions to our society, as a bridge to the vast Islamic world that we understand so poorly.

Think about India and the state of science and technology in that vast country. What do we really know about India, and how are we working to improve our relationships with the world's largest democracy? One-sixth of the world's people live in India, constituting a major economic and environmental force. But what does the average American really know about India? How much does he or she really appreciate what India has to offer, or try to understand its people in a psychological sense; socially; politically; in terms of its art, its writers, its history, its scientists, and all of the other components that make up that great nation? Would it not be in our common interest to engage much more fully, to understand, to work to build communication? Can we, in fact, hope to build a sustainable world without such engagement?

Then think about Africa. We know that many of its people are dying of AIDS; we know that many of them are starving; we have heard of merciless dictators, of bloody civil wars, of the slaughter of magnificent large animals. Many of us have learned to appreciate 19th-century African art, but do we know what Africans are thinking about now? About their dreams and hopes; their literary, musical, and artistic traditions; their efforts to achieve democracy throughout the continent? Are we working with African scientists to help them develop advanced scientific and technical skills that they could use to improve their lot, the sustainability of their lands, and their contribution to global sustainability?

Many of the world's life-support systems are deteriorating rapidly and visibly, and it is clear that in the future our planet will be less diverse, less resilient, and less interesting than it is now. In the face of these trends, the most important truth is that the actual dimensions of that world will depend on what we do with our many institutions and with the spiritual dimensions of our own dedication. In the words of Gandhi, "The world provides enough to satisfy everyman's need, but not enough for everyman's greed."

At the AAAS, we must be dedicated to expanding our global leadership role on behalf of science and society. In our connected world, both the associations between the disciplines that are symbolized by our fellowship and the global connections are of extraordinary significance.

If the United States can become more international, if we can all learn to deal with the conditions of the world as they really are, much more closely than we have done before, we can begin to think about the contours of the sort of world that we want to build for the future. To the extent that we do that, the operations of our individual institutions will be successful, and we will be making a worthy contribution to the kind of a world where our grandchildren would like to live. Being optimistic about the future by wearing rose-colored glasses and engaging in wishful thinking in a moral vacuum constitutes a crime against our posterity; being optimistic because of a determination on the part of each to contribute what he or she can to make the world a better place is, in the words of Kai Lee (*24*), engaging in a "search for a life good enough to warrant our comforts." As scientists, we should understand this, and we must contribute what we can to improve the world and to learn to respect one another. I am confident that we will do this and determined that the AAAS will help in important ways in achieving this all-important goal.

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