4. Future S&T Directions in the United States

In a speech at the annual meeting of the AAAS, on February 15th 2002 in Boston, the Science Advisor to the President, Dr. John Marburger, gave some excellent insight as to future science directions in the United States. The speech is considered so important that the significant parts are quoted or summarized below.

After about a 20 minute introduction covering current science policy issues, Dr. Marburger made points about the frontiers of science and complexity. He started: *"As a scientist, I believe science policy should reflect what I referred to as the 'intrinsic imperative of science'. .... During the centuries since that dawn of modem science, the frontiers of discovery have been defined by the limits of technology. ..... that exploration at the frontier entails advances in technology ... Today the frontiers of the large and the small -- of astronomy and particle physics -- remain unconquered. But they have receded so far from the world of human action that the details of their phenomena are no longer very relevant to practical affairs. Not by accident, the instrumentation required to explore them has become expensive. Because we can no longer expect that society will benefit materially from the phenomena we discover in these remote hinterlands, the justification for funding these fields rests entirely on the usefulness of the technology needed for the quest..."*

Dr. Marburger continued: *"But the greatest opportunities in science today are not to be found at these remote frontiers. .... It seems to me ... that we are in the early stage of a revolution in science nearly as profound as the one that occurred early in the last century with the birth of quantum mechanics. The quantum technologies of the chemistry and physics of atoms, molecules, and materials, developed rapidly through several generations .... By 1991, when the Soviet Union finally dissolved, scientists were beginning to wield instruments that permitted the visualization of relatively large scale functional structures in terms of their constituent atoms. The importance of this development cannot be overstated. The atom-by-atom understanding of functional matter requires not only exquisite instrumentation, but also the capacity to capture, store, and manipulate vast amounts of data. The result is an unprecedented ability to design and construct new materials with properties that are not found in nature. .... We can actually see how the machinery of life functions, atom-by-atom. We can actually build atomic scale structures that interact with biological or inorganic systems and alter their functions. We can design new tiny objects 'from scratch' that have unprecedented optical, mechanical, electrical, chemical, or biological properties that address needs of human society. Their images are ubiquitous in newspapers and magazines, and the application of our knowledge of them appear not only in technical journals, but also in the Wall Street journal."*

After describing the tools used in this revolution, Dr. Marburger then returned to the realm of science policy: *"The picture of science I have portrayed -- and I am aware that it is only part of science, but an important part -- has immediate implications and challenges for science policy.* ***First,*** *there is the need to fund the enabling machinery for exploring the frontier of complexity. Some of this machinery is expensive, such as the great x-ray sources operated by the Department of Energy, or the Spallation Neutron Source. Even the computing power required at the frontier is expensive and not yet widely available to investigators. ... information technology ... is also of fundamental importance for the extraordinary new control of matter at the atomic level. The reason, of course, is that any physical or biological system large enough to perform a function of human interest is going to be made of a colossal number of atoms. The computing power is needed to keep track of all the types and positions of the atoms, estimate how they will*