Beyond Sputnik

U.S. Science Policy in the 21st Century

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Brief Description

Beyond Sputnik offers one of the first comprehensive surveys of national science policy looking at how policies for science are made, the government entities that make these policies, and the impact federal policies have on the conduct of science. The book also provides a detailed description of the role played by universities, federal laboratories, industry, state governments, and the public in partnering with the federal government to carry out scientific research in the United States.

Beyond Sputnik is a must read for lawmakers, scientists, journalists, and advocates interested in understanding federal policies for science. It can also serve as an excellent introductory text for courses in science policy.

Authors and experts Homer Neal, Tobin Smith, and Jennifer McCormick address a range of topics from science education to stem cell research and cloning, to big science projects such as the Super Conducting Super Collider and the Human Genome Project, to homeland and national security research—and offer readers the opportunity to study real instances of policymaking at work. *Beyond Sputnik* also discusses major policy challenges facing both policymakers and the scientific community and offers some ideas concerning sound public policies to address these challenges.

Review of Chapters

Overview

Beyond Sputnik is organized into four distinct sections, of five chapters each. The first section is intended to give the reader a general overview of what science policy is, how U.S. science policy originates, the processes and players involved in its formation, the rational for U.S. science policy, how science is funded in the United States, and the means used by the government to evaluate the effectiveness of its scientific programs. Complementing this overview, the second section identifies the partners that work with the government to conduct science and therefore who have a major stake in the development of policy for science. These include universities, federal laboratories, industry, the states, and the general public. In particular, this section is intended to address the respective roles of these various interests, explaining their unique roles in both the conduct of science and in the formation of science policy. The third section examines some of the major science policy issues that have been a part of the fabric of science policy, that still face the nation today, and that will continue to be of importance as we move forward. Finally, the fourth section looks toward the future and attempts to highlight some of the issues that seem particularly relevant in an era of increasing globalization. The chapters in the second half of the book point to areas in which the book's authors believe the nation's scientists and policymakers must be engaged to insure the continued advancement of scientific research.

In each chapter, the reader will find at least one policy discussion box. The point of these is to not only provide information on a particular issue in science policy, but to also raise questions and stimulate discussions. Policy is often debated and implemented

around differences in opinion; conflicting views and the questions raised by each side are often grounded in the values and perspectives they bring to the table for discussion. More details about the individual chapters are provided below.

Section I Overview of U.S. Science Policy

Chapter -1 – Science Policy Defined

Chapter 1 of *Beyond Sputnik* attempts to define what exactly "science policy" is and what drives its formation. In this chapter, science policy is compared to other forms of public policy and the difference between "science for policy" and "policy for science" is explained. Terms such as basic research, applied research, and development are explained as well as various models that have been used to explain the path through which basic scientific knowledge is transformed into technologies that benefit society. In this vein, this chapter raises questions as to whether the traditional linear model is still adequate to explain the relationship that exists between basic research, applied research, and technological development. The chapter concludes by talking about the importance of national science policy and discussing the positive and negative potential of science itself.

Chapter 2 – U.S. Science Policy Before and After Sputnik:

Chapter 2 provides some historical insight into the development of the American system of science and science policy. It looks back as far as the Constitution to better understand the foundation upon which our current science policy is built in the United States. It further examines the need for the development of a more formal U.S. science

policy during World War II and Vannevar Bush's seminal report, *Science – The Endless Frontier*, which, despite being over 50 years old, is still recognized by many as the basis for current day science policy. The chapter continues by briefly tracking the evolution of science policy through the Post World War II era, the Cold War, and the Post Cold War world. The defining role of Sputnik in establishing modern-day science policies is highlighted, and other points in contemporary history that have influenced policies governing science in the United States are also discusses. Chapter 2 concludes by briefly outlining some of the new science policy challenges facing both policymakers and the scientific community and how science might both influence, and be influenced by, public policy in the post -September 11 world.

Chapter 3 – The Players in Science Policy

Chapter 3 discusses how the U.S. government is organized to create and implement federal research policies. This includes the role of the executive, legislative, judicial branches in the formulation, implementation, and interpretation of science policy. This chapter also discusses some historical aspects of the various entities involved in science policy and considers the roles of various federal departments and independent agencies in funding scientific research. The chapter highlights the plurality of the U.S. system for supporting science and the complex interplay that occurs between subsets of government entities as new policies are developed, or old ones are challenged.

Chapter 4 – The Process of Making Science Policy

Chapter 4 follows with an examination of how science policy is made. It examines how different federal players interact to formulate policy and presents various models used by political scientists to help explain how federal policies are formulated. It discusses the levels at which key science policy decisions are made and the various mechanisms used to formulate science policy. Chapter 4 also examines the role of Congress and key congressional committees in both the development of national science policy and in the budget and appropriation processes. Finally, the chapter attempts to knit the complex federal system together to provide insight into how the various branches of government interact with the scientific community and other non-governmental organizations to formulate science policy.

Chapter 5 – Federal Funding for Research: Rationale, Impact, and Trends

Chapter 5 discusses federal research funding in the broader budgetary context and examines research funding trends. It provides a discussion on different studies that have been conducted to determine what the "returns" on investment in scientific research are and examines the challenges in actually accurately determining the value of such investments. Moreover, it also discusses the difficulties in evaluating science programs to determine their effectiveness and in measuring their success. The chapter concludes by examining various R&D funding trends over time. For example, what is the mix of federal funding for R&D by federal agency, by scientific discipline, and how does this compare to other sources such as industry? The chapter also briefly examines the implications that these funding trends have for both science and science policy.

Section II Federal Partners in the Conduct of Science

Chapter 6 – Universities

Universities play a very critical role in research. At the same time, they rely heavily on federal funding to conduct research. Chapter 6 discusses the research environment at our nation's universities, the roles they play in the conducting research, development, outreach, and technology transfer, as well as their critical mission in preparing future scientists, mathematicians, and engineers. Chapter 6 also examines the state of the Federal-University partnership and the issues which have both enhanced and strained this partnership in recent years, such as recovery of indirect research costs, merit review, and academic earmarking.

Chapter 7 – Federal Laboratories

Chapter 7 examines the critical role played by federal laboratories in carrying out U.S. scientific research. The chapter attempts to describe different categories of federal laboratories. It devotes a significant amount of attention specifically to the Department of Energy's National Laboratories which grew out of World War II and have played key roles in the overall security of the nation since their formation. These laboratories have also served as special sites for research facilities, or large scale or long term projects that could not be practically located at other sites such as a university campus or within industry. They have served the nation well in these capacities and will likely be an important component in the nation's overall R&D effort for decades to come. Since the

end of the Cold War, however, the mission of the laboratories has become increasingly unclear, causing some to call into question the need for their continued existence. This has created new challenges for the labs in redefining both their roles and their missions. Chapter 7 attempts to identify and describe these challenges.

Chapter 8 – Industry

A growing proportion of R&D conducted in the United States is performed in industry. However, unlike in the past, when industry supported its own industrial research laboratories, today much of the R&D conducted by industry is focused on development as opposed to basic and applied research. Chapter 8 examines various industrial sectors that depend on, and which invest heavily in, R&D. It also looks at some of the major science policy issues facing industry and examines policies and programs that attempt to bridge the divide that exists between where government sponsored R&D ends and where industrial R&D begins.

Chapter 9 – States

As the role of research and development in advancing innovation and economic growth has become better recognized, more and more States have been increasing their investments in R&D. Working closely with their state universities and industry, numerous States have made investments in R&D that will help them to achieve economic gains such as those enjoyed by California from Silicon Valley, Massachusetts from the Route 128 Corridor, and North Carolina from the Research Triangle. Chapter 9 examines the increasing interest that States are taking in making R&D a priority and how these

efforts have increasingly placed State governments in positions of influencing science policy.

Chapter 10 –The Public

The public, too, has a role in the formulation of the nation's science policy. Chapter 10 discusses how the public can influence science policies, why the public cares about policy governing science, and the interplay between the public, policymakers, and scientists. The chapter also looks at the role the media have in communicating science and technology to the public as well as non-profit organizations and public interest groups. In addition, the chapter examines links between the public's understanding of science and if it, in turn, impacts their support of science.

Section III Science Policy Issues

Chapter 11 –Science for National Defense

Chapter 11 examines what defense research is and the kinds of research conducted by the U.S. Department of Defense. The chapter specifically discusses funding for defense R&D and specifically examines the question of how much of the overall national defense budget should be devoted to defense research. The DOD receives input from independent advisory boards and chapter 11 provides a brief look at these. The chapter also attempts to put defense research into historical context and reminds the reader of the numerous civilian products that have in actuality resulted from defense research.

Chapter 12 –Big Science

'Big science' refers to science projects that require a large investment and special infrastructure, often involving many scientists and large facilities. Chapter 12 provides a definition of 'big science' and describes several 'big science' projects, including the Superconducting Super Collider (SSC), the International Space Station (ISS), the International Thermonuclear Experimental Reactor (ITER), and the Human Genome Project (HGP). It discusses some of the differences and similarities between the different projects and looks at the 'big science' projects anticipated for the future. In addition, the chapter discusses the dilemma that arises when considering funding one 'big science' project vs. many smaller science projects as well as some of the challenges for 'big science' e.g. project management, adequate recognition for young scientists, and how disciplines organize around 'big science' projects.

Chapter 13 – Scientific Infrastructure

The conduct of modern research requires an increasingly complex set of instruments, laboratories, technical support, and administrative structures. Collectively, these components are referred to as scientific infrastructure. Chapter 13 reviews the various infrastructure components required to successfully support the nation's research efforts and the various programs that have been put into place to support the development and maintenance of the scientific infrastructure. Chapter 13 also examines various science policy issues that pertain to scientific infrastructure.

Chapter 14 – Scientific Ethics and Integrity

In chapter 14 the general subject of scientific ethics and integrity is addressed. Public confidence in science, and thus the public's willingness to support science, as well as the vigor of science itself depend on research being conducted at the highest ethical standards. Chapter 14 discusses various efforts underway to achieve this goal. It examines issues such plagiarism, data falsification, and conflict of interest. It also goes further looking beyond mere matters of scientific integrity to areas where science bumps up against moral and ethical issues in areas such as using human subjects and human embryonic stem cells in research, and cloning.

Chapter 15 – Science, Technology, Engineering, and Mathematics Education

Chapter 15 addresses issues in science, technology, engineering, and math -- or STEM -- education. With the limited supply of qualified native U.S. born scientists and engineers and no clear guarantee that this supply will increase, science and engineering education becomes one of the most challenging science policy issues facing the country. This chapter examines the different levels of STEM education and the various venues where this education is provided, both formal and informal. The chapter discusses concerns that exist regarding how US children rank globally in terms of science and math knowledge. The different players in STEM education policy are also discussed along with some of the more recent national policies the guide efforts to improve STEM education. Some of the current issues in STEM education are examined, including science and religion, women and minorities, and policies that may be implemented at the

undergraduate and graduate levels to entice more students to pursue careers in science and engineering.

Section IV Beyond Sputnik: Science Policy in an Era of Increased Globalization

Chapter 16 – Science and Engineering Workforce

Chapter 16 reviews the human resources available for the conduct of R&D in the United States. Specifically, it discusses if there is a sufficient supply of technically skilled individuals to meet the S&T workforce needs of both the Federal government and industry and the ongoing debate on whether there is or is not a shortage of scientific and engineering talent in the United States. The chapter takes note of the changing makeup of the U.S. science and engineering workforce in terms of ethnicity, gender, and country of origin. Several areas of concern with regards to workforce composition are discussed in the chapter, including ensuring that women and minorities are better represented in the S&T workforce. Finally, the chapter discusses several policy options for addressing issues relating to the S&T workforce.

Chapter 17 – Globalization and Science Policy

This chapter attempts to tackle issues relating to the science and globalization. It discusses the increasing importance of international scientific cooperation and U.S. participation in international projects to the conduct of science. Many of the major scientific undertakings today are collaborations by teams of scientists from numerous countries. While internationalization of science may have several positive benefits for the

scientific community and even for the world as scientists work across borders to solve world-wide problems, it may have some not-as-positive economic consequences for the United States. Chapter 17 discusses some of these globalization issues as they relate to economic competitiveness and the science and technology workforce. All of these issues present major challenges and real trade-offs that must be considered in the formulation of science policy.

Chapter 18 – Science and Homeland Security

Chapter 18 explores many of the issues associated with encouraging, supporting and advancing open scientific research in an era where homeland security concerns are pre-eminent. On the one hand, science has tremendous potential to advance our ability to prevent and respond to the new homeland security threats we face, whether they be detecting and fighting against a chemical, biological, nuclear, or convention terrorist attack or through the advancement of knowledge that helps us better understand the motivations and predict the actions of those most likely to engage in terrorist acts. On the other hand, the events of 9/11 and the subsequent anthrax attacks have had the potential to adversely impact the conduct of science in many ways, from new regulations limiting access to biological agents, to potential restrictions on publication of research results, and new limitations placed upon foreign scientific visitors and cooperative ventures. The historical similarities and differences concerning our homeland security concerns of today and the national security concerns that emerged out of World War II are examined. Questions such as how science policy might change in the post 9/11 world and what

opportunities and challenges will arise out of growing homeland security concerns are also addressed.

Chapter 19 – Grand Challenges for Science and Society

Chapter 19 discusses the role of science in meeting grand challenge for both science and society and highlights some current grand challenges in both areas. Some of the grand new challenges include the next generation of the Human Genome Project, novel transportation and energy initiatives, greenhouse gas reduction, continuing advancements in information technology, nanotechnology, waste disposal, cures for major diseases, and anti-terrorism efforts. In pushing the frontiers of science yet further to address these major scientific and societal challenges, new and more complex science policy issues will arise, that will need to be resolved and addressed through increased interagency collaborations and new multidisciplinary science initiatives supported by the federal government.

Chapter 20 – Science, Science Policy, and the Future

Chapter 20 is devoted to the "Future." In this final chapter, the authors conjecture about what lies ahead in terms of science policy. Just as the events over the past several decades were impossible to predict in the mid-1900s, it is daunting to imagine the decades ahead. This final chapter examines issues such as: the future of the government/university partnership; the increasing tensions between science and religion; the growing politicization of science; the increasing role of the courts in science policy;

and the blurring roles of which entities – universities, federal laboratories or industry -- perform what types of research on behalf of the federal government.

Having an educated public that understands that major advances in one period are likely the results of careful basic research in prior periods may be critical to the continued progress in science, especially in an environment where the public is increasingly eager for immediate results. The future holds the prospect of extraordinary advances for society, and the extent to which these prospects materialize may very well depend on science and the policies that regulate its pursuit.