A Theoretical Justification for Government Funding of Basic Physics Research

An honors thesis for the Program in Peace and Justice Studies

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Tufts University, 2015

Acknowledgements

This thesis was made possible with the input and aid of many people. Thoughts, criticisms, and perspectives from others made this thesis better than I ever could have imagined, though I certainly have much more work to do. I would like to thank my committee chairperson, Professor Lionel McPherson, who pushed me to think about my thesis with historical and philosophical perspective that I would have lacked without him. The theory and scope of my thesis was made with stronger foundations due to his input, and I am thankful to him for pushing me to think with greater care about the topic at hand. Professor Timothy Atherton, my second reader, also added invaluable insight. Without a physicist on my committee, I surely would have lacked the knowledge of the inner-workings about many parts of this thesis. I thank Professor Atherton for working outside of his field, and putting such time and effort forward with his insightful comments.

I would also like to thank Dale Bryan and Bruce Hitchner, for allowing me to stretch the limits of what a Peace and Justice Studies thesis can be. I approached the topic using my background from the field, yet I appreciate their willingness to allow me such flexibility to pursue the topic at hand. My housemates, Joe Philipson and Jonah Harris, were irreplaceable. They endured this year of academic exploration with me and provided emotional and academic support. Michael Schneider, who edited my thesis multiple times and pushed me to write wisely, cannot be thanked enough. Lastly, I would like to thank Hannah Seigel for her help throughout the year. From pushing me to craft a better thesis proposal in August, editing, and being incredibly supportive, she has been a valuable part of this process. Of the people named above, I would like to thank them all for their willingness to hear me struggle for hours with the ideas contained in the following pages. This thesis would have been vastly different without them.

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Introduction

What do Google and the Higgs Boson have in common? Both are part of our culture because of research done at CERN,[1] a physics laboratory in Geneva. In fact, many of the technological advances that occurred during the 19th and 20th centuries can be attributed to incidental advances due to research in fields of non-applied research. While this is exciting, and one could argue that the world is better off due to these advances, it does not seem obvious as to why this is an argument for the government to fund basic research. Scientists and philosophers alike understand that something happening occasionally does not indicate that it will continue to happen. Just because unapplied research has been crucial for advancing incidental advances in technology and modern society does not mean that it will continue to play such a critical role. While the next global economic revolution might come from an accidental or incidental discovery due to investment in unapplied research, it might not. And yet, scientists and laypeople alike continue to talk about unapplied science as if it is “a fruit tree: you shake the tree, and new products and technology come showering down.”[2]

This non-applied research is often called basic research, or pure research.[3] Though some would claim that the distinction between basic and applied research is not practical or useful,[4] the distinction is used widely today. The National Science Foundation defines basic and applied research as follows:

> **Basic research** is defined as systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific

1. The European Organization for Nuclear Research.

2. R. L. Sproull, “Federal Support of Science and Technology,” in *Science and Society: A Symposium* (Rochester, New York: Xerox Corporation, 1965), 32–55.

3. I shall use those three terms interchangeably throughout.

4. Steven Shapin, “Science and the Modern World,” in *The Handbook of Science and Technology Studies*, ed. Edward J. Hackett et al. (Cambridge, Massachusetts: The MIT Press, 2008), 433–48.

> applications towards processes or products in mind.
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> **Applied research** is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.[5]

Working within the distinction of basic and applied research, who should be thanked for the belief that basic science must be pursued due to its nature to grant its funders economic and military successes? Questions regarding the purpose of science emerged as early as the ancient Greeks and were evolved by philosophers such as Francis Bacon. The modern, American incarnation of this viewpoint is due in large part to Vannevar Bush. In his 1945 report to President Harry Truman, *Science, The Endless Frontier*, Bush outlined steps for the advancement of science in the United States, suggesting policies such as creating a National Science Foundation, investing in basic research, and encouraging collaboration between universities and industry. In it, he writes:

> Basic research is performed without thought of practical ends… The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic research were long neglected.[6]

In the mind of Bush, basic research should be funded and pursued because it furthers applied research. Building upon the success of early particle physics — which resulted in the ability to harness the power of nuclear fission for energy and defense purposes — promises of applied benefits as a return on the investment in basic research became commonplace. As basic research has asked questions that probe deeper, the relevance of this science was increasingly questioned. Bush also warned that: "A nation which depends upon others for its new basic

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5. *Globalization of Science and Engineering Research* (National Science Board, 2010), http://www.nsf.gov/statistics/nsb1003/pdf/nsb1003.pdf.

6. Vannevar Bush, *Science, the Endless Frontier. A Report to the President* (Washington: U.S. Government printing office, 1945), 13.

scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill."[7] A push for science and scientists developed in the midst of the Cold War, under the belief that the United States needed to train scientists to outsmart and out-build the Soviets. This ushered in a new era for science, where scientists were funded predominantly by governments seeking practical outcomes for basic science. The Federal government helped academia and industry to fund basic science, and also created National Laboratories and Federally Funded Research and Development Centers in order to advance scientific goals.

However, the argument for government support of research proclaimed that though the science was basic in character, there might be some application down the line. One never could have expected that research in particle physics could have led to the television, and yet, the earliest monitors were cathode ray tubes. A 1949 article by Alan T. Waterman, the Chief Scientist at the Office of Naval Research argued:

> Although assistance in this direction [of basic research] could not be counted on to produce immediate practical benefits, the by-products would in many cases lead to important applications. From straight content alone, the outcome would merely add to our store of scientific knowledge. But ideas beget ideas and we should thereby greatly enhance the likelihood of turning up untold treasures, still in the rough.[8]

However, there are weaknesses to this argument, and those weaknesses have often been exposed. In the 1970s and 80s, there was a noticeable shift from basic to applied research, due to "growing disenchantment within Congress about the return the government was getting on its

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7. Ibid, 13-14.

8. Alan T. Waterman, "Government Support of Research," *Science*, New Series, 110, no. 2870 (December 30, 1949), 702.

investment in science."[9]

Though there is a chance of great treasures being found due to innovation in basic research, a great number of projects produce nothing more than what they hypothesized, and a great many more produce nothing of import at all. However, given that each project *could* produce the next technological innovation, scientists happily advertised that their science should be supported not because of what it was, but because of what it might produce: technological, military, industrial, or medical advances to benefit the country.[10]

Another problem that faced scientists during the past century was that science became *big* science. By the mid-20th century, many scientific innovations required huge pieces of technology, — The Hubble Space Telescope, The Tevatron, and the Human Genome Project, for example — teams of hundreds or thousands of scientists working in concert, and budgets on a gargantuan scale. Not all science was becoming expensive: Theoretical research and many subfields of physics, chemistry, and biology can sustain research at a much smaller scale. Yet as science became more expensive, and the government began funding substantial components of big science, scientists themselves faced a problem. The types of projects that received massive funding from the government were decided by what would advance the "public good" rather than what necessarily interested science. Scientific choice was becoming "harder and harder to achieve without lying, or without bootlegging within the trappings of a system that is engineered to provide 'accountability.'"[11] Many scientists who wanted to pursue pure science had to convince the government that their massively expensive projects would, in fact, be good for the defense of the nation or reap unforetold benefits.

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9. David Dickson, *The New Politics of Science* (New York: Pantheon Books, 1984), 30.

10. E. S., "The Redemptive Power of Science," *Minerva* 11, no. 1 (January 1, 1973), 5.

11. William D. Carey, "Science and Public Policy," *Science, Technology, & Human Values* 10, no. 1 (January 1, 1985), 13.

Science thus faced, and faces, a problem. Its projects have become bigger, the necessity for funding greater, and they have thus turned to the government for support. In order to secure that funding, many scientists chose to emphasize the geopolitical and economic reasons to fund science. The epistemic goal of science — to advance basic knowledge — was superseded in the public sphere by the practical goals of science — to solve problems with the newfound knowledge.[12]

For many years, I have found it strange that those scientists who prefer pure research would be content arguing for government support of research under the guise of the external benefits that their research might produce. While it is impossible to argue with the fact that science has resulted in great advances for individuals and society over the past hundred years,[13] science does not always produce those technological innovations. If scientists are to continue searching for research funds from the government, the government will continue to ask for accountability as to how they are advancing the public good, or the needs of the nation with regards to defense. What big, pure science needs is a different means for justification. To continue to advance arguments of external benefits will be to continue to disappoint the sources of funding, and thus to put future funding in peril.

The other means for justification for pure science is found not in applied science, but towards the opposite direction, in the arts and humanities. The government funds many non-applied endeavors, and perhaps by examining those justifications scientists can craft similar reasons for support. By aligning with the arts and humanities, scientists who pursue basic research have the opportunity to justify their work based not upon secondary benefits, but upon

12. David B. Resnik, *The Ethics of Science: An Introduction*, Philosophical Issues in Science (London ; New York: Routledge, 1998), 39.

13. Most Americans would err to the side of "a lot better off" when assessing this statement: "The world is better off, or worse off, because of science and technology."

the merit of the work itself. The arts and humanities do not claim to aid the defense of the nation, nor do they claim to be able to produce technological spinoffs. Perhaps there are justifications that they have used that would be applicable to the pure sciences. This support would not wax and wane with the necessity of government need for production of defense infrastructure, or intellectual competition with partner nations.

What therefore must be constructed is the foundation for government support that does not depend on benefits that are secondary to the success of science meeting its epistemic goals. In the following chapter, a theoretical framework for government support for non-applied endeavors is constructed. This framework is not limited to pure science. Rather, by aligning basic research with the arts and humanities, a holistic examination for government support of all unapplied endeavors is undertaken. This framework not only establishes what would be required for justifying government support for unapplied endeavors, it is also, to some degree, normative in its findings. That is, if unapplied endeavors can meet some justifications and cannot otherwise be secured in doing so, then the government ought to fund these endeavors.

In the second chapter, I examine two projects: the Hubble Space Telescope (HST) and the Superconducting Supercollider (SSC) that were unabashedly big, pure science. Both the HST and the SSC were proposed in the 1980s, yet only the HST's project was carried through to fruition. I detail the HST and the SSC, examining in-depth what it is that they would do for science, for the public, and for the government. In the third chapter, I examine those projects, and analyze whether they meet the justifications from the first chapter. I apply the framework established in the first chapter onto the case studies found in the second.

Some absences remain notable in this examination for the funding of basic research. Notably, I am unable to adequately analyze where unapplied endeavors fit within the priorities of the government. I assume that the government has discretionary funds, that it is not terribly indebted, and that it is generally meeting its obligations to its citizenry. However, I do not venture near the question about the other endeavors that the government could — and perhaps should — spend its money. For example, not everyone in the United States has healthcare, nor housing, nor equal educational opportunities. Problems of racial injustice remain. Perhaps the government would be better suited to spend its funding on bringing all of its citizens above the poverty line, helping the countries in which it has fought so many wars, and immediately working towards the cessation of coal-fired power plants. These *justice priorities* are all noble and important causes, and I have been unable to say why funding for museums or particle accelerators should remain whilst the government has so many issues to which it ought to attend.

Though some may argue to suspend government support for basic research until justice priorities are met, I find that idea unsatisfactory. Even if that is what *ought* to happen, so long as the current sociopolitical reality remains, we might as well attempt to improve the current system. The government *does* fund research and development, which has a tangible impact on the lives of many people. Funding unapplied endeavors both affects those who are direct recipients of the funds, but also those who are impacted by the funds and the endeavors themselves. Furthermore, if the government were able to see the value in the work of basic science than its dubious application, then perhaps we could see a shift from the military-industrial complex.

There are benefits to shifting the conversation towards the justification of basic research for what it is, rather than for what it may produce. Robert Wilson, the founding director of Fermi National Lab outside Chicago, was testifying to the Joint Committee on Atomic Energy in Congress in 1969. He was asking Congress to authorize funding for the creation of a new particle accelerator, one with more power than ever before. During his testimony, a Member of Congress grilled him on whether the accelerator would have military or defense application. Senator John Pastore was unable to see the value in the accelerator beyond its possible applied implications.[14]

By crafting an argument in support of basic research, a shift can be made from applied defense technologies to unapplied endeavors for their own value. This could have myriad benefits. For example, modern, big, science has often been hailed at being able to cross borders and cultures in a unique way. Though defense technologies are an applied science, they are often classified and proprietary information of the governments that fund it. Basic research, on the other hand, is often seen as serving the entirety of humanity. Ludwig Audrieth, when writing about science and international affairs, observed:

> [H]ere is a magnificent idealism which motivates the scientist in his espousal of science as a "common enterprise of man." Scientists have traditionally advanced the premise that science recognizes no boundaries with respect to race and language... And in this respect the scientist, like the write, the composer, the artist, and the musician, can play an important international role. [15]

By focusing not upon what science *can do down the road* and rather upon what science can do as it is there is an opportunity to shift funding from the applied and military to the unapplied and international. Perhaps there is a certain naïveté in this hope. Nonetheless, if I am unable to answer why science should be pursued while there exists justice priorities that perhaps should take immediate priority, I must look to see how this shift from the applied to the pure could, in some manner, still advance those justice priorities.

Basic research scientists must look beyond the secondary applications of their work for

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14. Robert Wilson, *Authorizing Legislation, Fiscal Year 1970. Hearings, Ninety-First Congress, First Session* (Washington, U.S. Govt. Print. Off., 1969), http://collections.stanford.edu/atomicenergy/bin/detail?fileID=569870540.

15. Ludwig F. Audrieth, "Science and International Affairs," in *Science and Contemporary Society*, ed. Frederick James Crosson (Notre Dame: University of Notre Dame Press, 1967), 175–91.

its justification. It imperils their future —they are not often able to guarantee true returns on the investment. Furthermore, it diminishes the work itself, making it only instrumentally valuable. By doing so, they limit the value of their work, and ignore the implications — greater funding for military technology, lack of value for basic science, and an inability to pursue the research about which they care honestly and freely. For it is the "general public which, indirectly or directly, pays the piper, and which, through its elected representatives, ever more frequently wishes to call the tune."[16] Only if there is a shift in analyzing basic research can scientists continue to pursue the research as they truly intend, rather than attempt to promise unforeseen future benefits that may never materialize.

16. Jerome R. Ravetz, *Scientific Knowledge and Its Social Problems* (Oxford: Clarendon Press, 1971), 14.

Chapter One: A Theoretical Justification of Government Spending on Non-Applied Endeavors

As part of the federal budget, the United States Government spends an incredible amount of money every year. Equally so, the government must exercise an incredible amount of discretion to operate within a budget limited by both debt and tax-revenues. That is to say, they must prioritize their spending. Prioritizing is not merely a practical question; at its foundations are a host of ethical concerns. In particular, this chapter concerns the implicit ethical dilemmas of a government choosing to secure funding for the humanities, the arts, or basic research, which (as a practical reality) deprives other programs of those allotted funds. While politicians and the general populous may not require strenuous ethical justifications to grant funds, we may still hope that such ethical justifications can strengthen the case for government spending even when popular support is lacking. These arguments could manifest either positively or negatively — encouraging spending where it seems the activity is ethically just or discouraging spending where it seems unethical (even when the public strongly supports such an effort). What justifications could exist that could, in the context of programs that seem to fall outside the proper domain of the government's mission, ground decisions to fund such programs independent of (or even contrary to) popular instinct?

The question itself presupposes numerous ideas and encompasses many topics, thus requiring that I first narrow the scope, framed in part by the practical realities surrounding the investigation. First, I presume in this essay that there exists a governing body (in particular, one that resembles the federal government of the United States) that is justified in collecting and allocated tax money. Furthermore, the ability of the government to peacefully extract such money (and to then redistribute it) is not fundamentally threatened by any seeming arbitrariness of the government's actions. It is also presumed that the government may — when revenues fall short of its desired spending — spend a deficit and enter into debt, receiving loans either through the issue of government bonds or with the help from other such governments. In such a context, this essay considers how those funds should be distributed. I assume that this government's primary tasks are to provide for the security, welfare, and infrastructure of its citizenry. This government, I imagine it, typically has the resources to spend on its basic needs, sufficiently so that it may spend excess revenue — this spending will be referred to as "discretionary" spending.

These presumptions being detailed, the question is then where should that funding be directed, and can funding programs that have no practical applications be justified? One implication of the aforementioned presumptions is that there is no question of whether the government should fund an art museum *or* repair a damaged bridge. Though that question — and the arguments that follow — is common in popular political debate, it is a fictitious question. Comparisons of that sort suggest that those are comparable, and somehow linked.[17] One may inquire as to why I am not overly concerned with why applied research, education, mass art, or other programs should be funded. Others have sought justification spending on applied research,[18,19] and it is often found under the banner of national security or welfare.[20]

Direct support of the arts (i.e. funding artists or opera houses), indirect support of the arts (e.g. funding museums), humanities research, and basic (or pure) science research do not appear to fall within the presumed scope of the federal government. Yet there is demand that the

17. Noël Carroll, "Can Government Funding of the Arts Be Justified Theoretically?," *Journal of Aesthetic Education* 21, no. 1 (April 1, 1987), 24, doi:10.2307/3332811.

18. Bush, *Science, The Endless Frontier*.

19. Sproull, "Federal Support of Science and Technology."

20. Just because something is applied, does not automatically mean that it is beneficial, or worthy of government support. Some applied programs fall outside of the realm immediate government support (i.e. defense, social welfare, and infrastructure).

government fund these programs, and equally loud calls for the cessation of any funding[21]. Why fund these activities, and by what justification? This question carries important consequences: it is not clear why the government can spend the money on unapplied projects, nor is it clear why it should — perhaps the discretionary spending can be better spend on applied research, or mass art. Secondly, there may even be a moral imperative to do so, thus obliging the government to spend its discretionary funds on these programs. Once possible justifications are provided, the question of whether these unapplied programs could ever meet those necessary qualifications can be tackled. It must also be considered whether the justification is strong enough to supersede other government spending.

Justifications for State Spending on Non-practical Projects

There may be many reasons for the government to fund non-practical endeavors. Governmental spending does not disappear into non-practical endeavors; this funding benefits *some* recipients. I will consider whom this spending may benefit, and whether that would justify the government in funding those programs. In addition to clear benefits, I will consider whether these non-practical programs provide some basic need that would be unmet otherwise. Lastly, I will consider whether the government would be justified in funding these programs if they are intrinsically valuable. Let us begin to examine these possible justifications, to see what might be required for governmental support, and if any such non-practical programs meet those requirements.

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21. The debate regarding the proper role of government has no shortage of opinions, and it seems that whether someone feels comfortable with the government spending such funds depends greatly on the view of the proper role of the government. For example, there is a strong correlation between political leanings (liberal or conservative in colloquial parlance) and desire for increased or decreased spending on the arts. Generally, the more one identifies as "conservative," the more he or she wants the government to spend less or the same on funding of the arts. This data was collected from: Smith, Tom W., Michael Hout, and Peter V. Marsden. *General Social Survey, 1972-2012 [Cumulative File]: Version 1*, September 11, 2013. http://www.icpsr.umich.edu/ICPSR/studies/34802/version/1.

Whom could the government funding benefit?

The use of the word *benefit* here is used broadly. Economic and material benefits are considered, though emotional, societal, and other benefits are considered as well. When the government spends money there are clearly recipients and beneficiaries. Who are those beneficiaries? The primary material and emotional beneficiaries are those who receive the actual funding: the artists and researchers who perhaps would not have been able to work if it were not for the government subsidy.

This funding has myriad benefits to those artists and researchers. They are able to do the work that they would not otherwise be able to do. This work may be of emotional benefit to the scientist or artist, since government funding would allow him or her to do the work that they desire. Yet it is clear that this is not a justification for government funding of the arts or basic research. While not receiving the grant may harm the artist's or the scientist's psyche, it does not seem to fall within the government's responsibility to help a few select individuals to receive the funds that would enable them to pursue the work that each one desires.

The government subsidy would also benefit them economically, insofar as it would prevent economic harm or increase economic prosperity. If it were not for the money from the government, they perhaps would be unemployed, seeking government welfare, and draining resources from others in need. Noël Carroll, when arguing for government funding of the arts, states that while "welfare is a legitimate arena of state activity," if the artist (or the scientist) would have their social welfare needs met by the government in the event that they were unemployed, "there is no reason to propose prospective arts funding as a further aspect of the state's welfare function."[22] The artist is not entitled to the benefits of direct funding vis-à-vis

22. Carroll, "Can Government Funding of the Arts Be Justified Theoretically?", 23-25.

their social welfare needs. The fact that without government funding the artist may be unemployed does not then compel the government to fund the artist or scientist, since the welfare function of the state would then protect him or her.

However, economic benefits may be more widespread. Those artists and researchers would be engaged in the local economy, enriching those around them. Farrington Daniels, writing in *Science and Contemporary Society,* remarked that "[a] considerable portion of these research funds has been granted to institutions on the east and west coasts of the United States. Around these laboratories have sprung up many new wealth-producing industries".[23] In many cases, universities or private institutions house researchers, especially researchers of the humanities, or of basic science.[24] Linking the arts and sciences, economist William Baumol notes that often, the external benefits of funding science is often the creation of cultural centers, for which the secondary benefits are more widespread:

> For example, it is noted that when a firm which needs engineers and physicists for successful operation opens for business in some area, the presence of cultural activity will facilitate the hiring of the educated personnel they require. Similarly, it is often noted that theaters and museums attract visitors and thereby offer business to hotels, restaurants and taxicabs, among other lines of activity.[25]

The challenge of justifying government spending using the argument of widespread economic benefit is twofold. Firstly, the government does not have a responsibility to provide economic benefits beyond those generated by its typical endeavors. Secondly, even if the government did have the responsibility to provide economic benefits, if those benefits could be

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23. Farrington Daniels, "Science and Human Welfare," in *Science and Contemporary Society*, ed. Frederick James Crosson (Notre Dame: University of Notre Dame Press, 1967), 202.

24. United States., Office of scientific research and development., and Vannevar Bush, *Science, the Endless Frontier. A Report to the President* (Washington: U.S. Govt. print. off., 1945), 26-27.

25. William J Baumol. "IV. Panel Discussion: Public Support for the Arts," *Columbia-VLA Art and the Law* 9 (1985 1984), 223.

generated by innumerable sources, what would direct the government towards funding non-practical endeavors, rather than their applied counterparts which may fall more clearly within the realm of responsibility of the government? Essentially, why should economic benefits be a source of justification for *any* spending, especially non-practical spending?

It seems that the best for which the arts and basic sciences can hope is that being able to prove economic benefit aids the search for justification. The government is not a calculating machine: it need not fund only the most beneficial and the most efficient sources of beneficence. The arts and basic sciences need only demonstrate that their existence would be broadly economic beneficial, even if applied projects could offer similar benefits. What has been shown is that broad economic benefit alone does not justify spending, yet it is certainly a component to the decision for the government to fund any project that does not clearly fall within the confines of its responsibilities.

Artists, scientists, and the surrounding communities do not receive only economic benefits from government support. If the government funds the production or exhibition of art and science, then those who consume science and art would also be beneficiaries. Artists create art, and museums house art. Those who *view* that art would be considered secondary beneficiaries. Similarly, researchers *do* research, and those who learn from that research are beneficiaries. In this way, the government — by providing funding — would have helped *create* something that otherwise would not be created. These benefits would have to be demonstrated by a project seeking funding under the auspices that it benefits the public.

What does it mean to be *benefitted* by art or research? Beyond the aforementioned economic benefits, there may be emotional benefits, social benefits, etc. It has often been claimed that art provided a sense of morality; i.e. that there were moralizing benefits of viewing art and being “cultured.”[26]

It seems intuitive that to be beneficial to those other than the artist and the researcher, “the public” should view the product of subsidy and labor. If the government subsidy benefits not just the few artists or researchers, but *many* citizens, then the subsidy would have a stronger case for it to be the proper concern of government (the problem of reduced funding for *other* beneficial programs notwithstanding). It seems that public consumption and appreciation is of vital importance to the idea that the benefits help more than just the direct recipients of the funds. If government spending on the arts and unapplied research should be justified under the premise of the benefit of the masses, then the project *must* be viewed, absorbed, and understood in some way by many. If an artist receives a direct subsidy, the artwork may not sit in some basement and be beneficial; research must be published and accessible; museums must be open for long hours, not only on occasion.

Even this may be unattainable, for research “is typically so esoteric as to be accessible to not more than a hand-full of specialists working in a particular area,”[27] and art exhibitions can only reach and attract so many visitors. Furthermore, the art may not appeal to many, or the research may not be of import to those outside of the field. How can one say the art is beneficial if everyone finds it ugly? Art that is repulsive would not seem to be beneficial to those who are viewing it. At worst, it could be harmful. What is the benefit of research about which nobody cares or that nobody understands?

It may be possible that one can be benefitted by art and science even when he or she does not know about it, and is not seemingly affected by it in any way directly. For example, all

26. Carroll, “Can Government Funding of the Arts Be Justified Theoretically?”:31.

27. Robert J. Baum, “Can Governmental Support of Philosophy of Science Research Be Justified?,” *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1976 (January 1, 1976), 298.

citizens are benefitted when there exists a strong system of public education — even when they do not have children, or their children do not attend public schools themselves. While this may be true, it still does not preclude the necessity that *some* people be direct and secondary beneficiaries. Indirect benefit is derived from *some* direct benefit being propagated through society. Thus, although I may not need to be benefitted by a project for it to be beneficial, someone must have benefitted. Therefore, it seems apparent that moderate to widespread benefits must be received by a project for it to be justified under the idea of beneficence.

There arises difference between the broad justification of government funding of the fields of art and basic research, and government funding of specific questions. As a matter of broad justification, if it is conceivable that there is basic research that has broad appeal or that there are museum subsidies that benefit many, then as entire fields arts and basic research could use this argument to theoretically justify government support. Specific projects would have to demonstrate their benefits, but this section is concerned with general justification, rather than specific inquiries.

This is to say that, if projects can demonstrate their broad benefits, this might be a justification for government support. Insofar as the government is permitted to spend discretionary funds in the ways that it sees fit, funding a project that benefits many people is preferable to a project that has limited benefits. The government does not have an obligation to support individuals or small groups in preference to others. Nonetheless, the government would be justified spending on a project if it were to benefit many people. It would be advantageous to the fields of art and science to demonstrate unique benefits, in order to prioritize spending on the arts and basic research as opposed to other projects. However, even lacking unique benefits, non-practical endeavors — if they could show efficient use of government funds resulting in widespread economic, societal, or emotional benefits — would be able to demonstrate a justification for government support.

We have built a “benefit” argument for the support arts and basic research. Arts and basic research may provide broad benefits — economic, social, moral, emotional, etc. — to the public, thus justifying government support of these projects. If a project was proposed and its outcomes were the benefit of the public, that benefit would seem to be sufficient justification for government funding. A liberal republic or democracy as part of its mission to provide for defense and common welfare does not also have an obligation to provide superfluous benefits. However, insofar as this money falls within the right of the government to spend its discretionary funds as it sees fit, providing a benefit would be within the right of the government. While this would not oblige the government to support the arts and basic science (it does not have an obligation to fund things that provide benefits) the government is justified in doing so.

Could these projects satisfy basic needs?

If the creation of art or housing of art or the carrying out of basic research met some basic need, perhaps there would be a justification for government spending. For this argument to hold, two qualities must be satisfied: 1) the government, at minimum, must be justified in providing basic needs and 2) these unapplied endeavors satisfy this basic need that the government may provide.

In the previous discussion of how the government may spend its discretionary funds, I stated that the government had a clear responsibility and right to promote social welfare, build infrastructure, and provide for defense. The “benefit” argument fell upon the right of the government to spend its discretionary funds as it saw fit, since beneficence is not found within the right to protect welfare, infrastructure, of the nation. Nonetheless, if providing basic needs is also a legitimate state activity, and the arts or basic research can provide such basic needs, then the government would certainly be justified in funding those endeavors. Furthermore, if it could be found that those endeavors are the only way to secure such basic needs, then the government may even be *obliged* to support such programs.

I propose that the government can and should provide basic needs to its citizenry. While pursuing a theoretical justification of government funding of the arts, Noël Carroll focuses heavily on the idea of needs, and whether the government has a responsibility to provide those needs.[28] While he admits that we lack a full theory of needs, he speculates that we can conceptualize needs in a variety of manners. Perhaps needs are those things that if someone lacks, "she will suffer injury, sickness, madness, hunger, or avoidable death". Carroll suggests we consider needs as "the amount of goods and services sufficient to raise an individual from his present state to somewhere above the poverty line". Regardless of the lack of full conception of needs, it seems clear that if someone needs something, it would be bad if he or she were unable to secure it. If people are unable to secure it, and their lacking it is bad, then the government — under its responsibility to protect the welfare of its citizenry — could rightly be justified in seeking measures to secure that need. What is necessary, then, is to demonstrate that the product of arts or basic science research secures a basic need that cannot be met without government funding.

While the purpose of this section is only to consider *how* one might justify government spending on the arts or basic research, I would be remiss to simply state that if the arts or basic research met a basic need, then the spending would be justified. It is surely necessary to — at minimum — provide some conceptualization of what those needs are, even if I do not decide

28. Carroll, "Can Government Funding of the Arts Be Justified Theoretically?"

whether those needs are worthy of government support at this current juncture.

In Carroll's paper, he provides two examples of *needs* that the arts may supply. Defenders of government funding for the arts often claim that humans have an "aesthetic need." Here he says:

> [J]ust as the government has an obligation to forestall the deterioration of the ecosystem, so there is an obligation to reverse the deterioration of the aesthetic environment… Miles of gas stations, fast-food restaurants, used-car lots, body shops—the string phenomenon—present an impoverished aesthetic habitat that has unsettling psychic consequences… An aesthetic need… would be a need for experiences of the beautiful, the sublime, or for the experience of objects and environments with… warmth, friendliness, or joyfulness.[29]

The above argument finds its strength in the idea that without the government funding art, the commercialization of our world would be harmful to the average citizen. It would be deleterious, and the government must step in to protect our well-being and enjoyment of art as a "countermeasure" to the vast ugliness of our current aesthetic environment. This would be an examination of the *product* of viewing art.

Alternatively, one may argue that there is a "need for art."[30] Humans must make and consume art. Without this, we would be harmed. This argument falls upon the idea of the intrinsic need for art, regardless of type of art. Whether there exists such an aesthetic need or a need for art — and whether the government must provide this need — is not a discussion for this section.

On the other end of the spectrum, what *needs* might basic research fulfill? Research

29. Ibid, 27-28.

30. Ibid, 29.

"produces a wealth of knowledge."[31] It may be conceptualized as a search for knowing about the universe, or a search for ultimate truth. While science has historically been considered a useful tool, there is a conception today that science produces the "only true form of knowledge," in a way that is superior to other types of knowledge.[32] Perhaps there is a *need to know* or a *need to seek understanding* that science can satiate. If this were indeed the case, then without funding of the basic research, our ability to know and understand — to secure this need — would be hampered, thus harming us. Whether this need exists and is something that government funding can provide is better left for another part of this paper.

The idea of large consumption of the product is clearly necessary here as it was for the benefit argument. These government-funded projects could not meet the basic needs only to the recipients of the funds. Rather, the projects that the government funds must meet the basic needs of *many* citizens. Though the idea that research and arts may meet basic needs such that the government is right (and perhaps obliged) to fund these projects is compelling, this argument (what we could refer to as the "basic needs argument) would be limiting. It is clear that not all art would meet an aesthetic need, and not all research would fulfill the human need to seek understanding. Furthermore, just because the artwork or research meets those needs, those who seek that funding would have to demonstrate that the work would meet the basic needs of *many* others, more efficiently, and that those basic needs *would not be met sans government support*. It may be a tall order, yet it has been demonstrated that the government would be justified in spending money for arts and pure research if those projects were to meet basic needs, as that funding would be justified insofar as the government has the right to protect the wellbeing of its

31. David B. Resnik, *The Ethics of Science: An Introduction*, Philosophical Issues in Science (London ; New York: Routledge, 1998), 168.

32. Robert F. Rich, "Knowledge in Society," in *The Knowledge Cycle*, ed. Robert F. Rich, Sage Focus Editions (Beverly Hills: Sage Publications, 1981), 18.

citizenry.

Are these non-practical endeavors intrinsically valuable?

When assigning value to an object or an endeavor, one must inquire about the type of value that it holds. Speaking colloquially, one may say that something is valuable because it allows actions to happen with greater ease. The *value* of a coffee grinder is that it allows coffee to be ground more easily; from there, it is attributed monetary value. However, not all things are instrumentally valuable. Some things are valuable in-spite-of, or perhaps due to, their lack of instrumental value. To say that things are non-instrumentally valuable is to assign them *intrinsic* value. In the event that this is the case, would an endeavor's intrinsic value be a justification for government subsidies?

Thomas Nagel, during a panel discussion for public funding of the arts, argued that sometimes, even if things are beneficial to some, their value may be greater than the benefits they provide. "Some things are wonderful and important in a measure quite beyond the value of the experiences or other benefits of those who encounter them," he writes. He believes that we all know these sorts of things: "difficult, rare, creative achievements that realize the highest human possibilities."[33] *Everyone* need not think that the thing is valuable, yet it is certainly apparent that there are things that many people conceive of as valuable. There may even be things that *many* in society find to be valuable — even if they do not benefit from it. There are works of art, pieces of knowledge, ideas, events, etc., that have value not because of the benefits they produce but because of their very existence. This is the basis of the idea for things that are "intrinsically valuable" — they are those objects that are valuable for their existence.

Joel Feinberg, is his paper about government funding on the arts, explored the conception

33. Nagel, Thomas. "IV. Panel Discussion." 237.

of benefit-less values as a means for justifying government spending on the arts.[34] He is more reticent than Nagel to accept that there may be intrinsically valuable things.[35] Those things that are intrinsically valuable are objects or ideas that have properties that are considered valuable (by humans) not for what they do but simply for *being*. Their own "characteristics and properties" are what makes these things valuable, not their instrumental purposes.[36] That is not to say that they would be good or valuable if humanity — as it is — were nonexistent. Things are intrinsically valuable because of the value that humans *find in them*. This is distinguished from those that are *instrumentally* valuable. The benefits of arts and research that was the focus at the beginning of this chapter saw value in the arts not because one appreciates the arts, but because of the external benefits — employment, economic stimulation, meeting of needs — as valuable. While I appreciate the caution with which Feinberg approaches the subject of whether things can have value beyond their instrumental value.

It is better that there are valuable things created than invaluable things. If there were a theoretical choice between the government supporting two distinct projects that were equal except one created greater value, the government should choose the project that creates more value. Things that are valued or valuable are desirable things; we, as humans, want value, and would not want to miss the opportunity to create value if given the chance. However, the government does not have the responsibility to bring valuable things into the world, so no supporter of the arts and sciences could argue that the government has the *obligation* to protect valuable things simply on the value of their merit alone. Value creation extends beyond the role

34. Joel Feinberg, "Not with My Tax Money the Problem of Justifying Government Subsidies for the Arts," *Public Affairs Quarterly* 8, no. 2 (April 1, 1994), 101–23.

35. Feinberg also seeks to distinguish things that are intrinsically valuable from things that are inherently valuable (he rejects that the latter —value regardless of human appraisal — exists.) While this distinction may indeed be important, I do not find it necessary to explore here.

36. Ibid, 108.

of the government to provide basic welfare, defense, and infrastructure. The government may have the leniency, of course, to secure the funding for that which is valuable under the idea that it has the power to spend its discretionary funding in a way that it sees fit.

If citizens find a particular endeavor valuable, a democratic government would be justified in supporting its existence through funding. Perhaps art is intrinsically valuable. Perhaps the outcomes of research can be considered intrinsically valuable. If many citizens see the value in the existence of "the arts" (in general) or basic research, then the government could use their general support as the motivation for supporting the funding of these projects. A democratic government should be responsive to the needs of the people, and if the general population in whose interests the government acts views the creation of these projects as valuable, then the government — even without explicit call for funding — would be justified in funding these projects.

The government need not require that taxpayers ask for funding if they admit to supporting its existence or creation. Nagel suggests that we persuade the tax-base to support projects that are valuable.[37] Feinberg, too, echoes his suggestion, and states that "even the egoistic philistine taxpayer, I should think would have to admit that the possession in high degree of intrinsic value is not a gross irrelevancy," to whether a project should receive protection or support.[38] However, it is possible to formulate a stronger claim. I believe that if a taxpayer admits that something is valuable, then the government can act to provide the funding even if the taxpayer does not *call for* the government to provide such support. People are hesitant to spend money, and the government is charged with the protection of their interests. If they believe

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37. Nagel, "IV. Panel Discussion."

38. Feinberg, "Not with My Tax Money the Problem of Justifying Government Subsidies for the Arts.", 120.

something to be valuable, then it is in their interest that its value continues to exist (or is brought into existence). Just because they do not *want* to foot the bill does not mean they are relieved of this responsibility.

The argument that the government can be justified in funding projects that are intrinsically valuable is distinct from the previous arguments insofar as it appears to rely on an appeal to the public for value-appraisal. Polls will need to be conducted to find out if the people find value in support for the arts, basic research, humanities research, etc. What if the public does not like a specific project, or does not want to fund something specific, though admits that projects of its kind are valuable? One vein of thinking is that those uneducated in the field would have to relinquish their decision about what constitutes specific value. If it is agreed upon in the abstract that basic research in physics, chemistry, or mathematics is valuable, then we should leave the decision of which specific projects are valuable to physicists, chemists, and mathematicians.[39] The democratic United States government would therefore be justified in funding the National Endowment for the Arts and the National Science Foundation if a majority of the citizenry agrees that *art* and *science* are valuable, and the artists and scientists would get to decide which art or science *is* valuable.

The question then arises: what happens if only few people see the value in an endeavor. Of course, they could appeal to the National Endowment for the Arts and the National Science Foundation for support, and perhaps they would find more supporters there. The government need not protect the interests and values of each concerned citizen. However, there is also good to public appeal. Just because the public may not benefit from a specific project does not mean that they may not be interested in protecting its value. Let's take the example of a select group of

39. Ibid., 119.

people perhaps find value in some obscure piece of memorabilia. Even if they do not appeal to the public, if they need government support to protect the piece of memorabilia, they must argue that the memorabilia is intrinsically valuable in a manner that is broadly supported by the public. If this is indeed the case, then they may be able to appeal to the government that — even though few people *currently* see the value in such a piece, in general, it is a type of value endorsed more broadly.

An advantage to the use of intrinsic value as a justification is that — if the government is justified in funding things on the basis of their intrinsic value — the *uniqueness* of that value need not be proven. In order to justify the previous arguments relating to benefits and the meeting of needs, one needed to show that the arts and basic research were *efficient* in providing their benefits and meeting certain needs. In the case of intrinsic value, to view something as valuable would not require that value as unique. Value is — in and of itself — the desired justification, and if this can be shown, then there is no need to seek value elsewhere. This source of justification is also distinct from that of basic needs. Basic needs must be defined, and then a project must be found to either meet those basic needs or not. Whether a project meets a basic need is not at the discretion of the population. Furthermore, basic needs are those needs that must be met for the wellbeing of society. Non-instrumental value-creation, on the other hand, is based upon appraisal from the population, and also transcends needs. Value-creation is not necessary, yet it is still justification for government support.

Therefore, if there were non-practical endeavors that are intrinsically valuable — or produce things that are intrinsically valuable — then the government would be justified in funding these endeavors if its citizens endorsed support of these valuable objects. While the would be no need for public opinion for *each and every project* — this would be left up to peer review — it would be necessary to ensure that people see value in the arts, or basic research, or humanities research. If that value is indeed affirmed, then it has been shown that the government would be justified in funding projects to create or protect that value, even if no person requests that their tax money is spent to do so.

The Distinction Between Intrinsic Value and Meeting Basic Needs

There may be some ambiguity as to whether it is possible to value something and have it not meet a basic need, or vice-versa. I think an example is most illustrative as to why it is possible for this to be the case. The following is adapted from Joel Feinberg's analysis of intrinsic value as a means for justifying government funding of the arts.[40]

There seems to be a value placed on the preservation of the sites of previous American battles. Let us say that someone says he or she values the preservation of the Battlefield of Gettysburg. The material benefits derived from the tourism associated with people visiting Gettysburg is not worth the government's subsidy for its preservation. Nor are the benefits associated with historical education, the moralizing effect of learning about great casualties in war, or the entertaining aspects of Civil War Reenactments.

Nonetheless, this person believes that there is value to preserving the battlefield. The value of standing where men and women lost their lives for the preservation of Union — and slavery — carries emotional weight that implies value. We search as to weather it may meet a basic need. Preserving the battlefield at Gettysburg does not seem to meet any such basic need. Though there is no clear construction of what basic needs exist, most people would not suffer from the disappearance or development of the battlefield. After all, most people will never visit Gettysburg. However, there seems to be value in knowing that this battlefield is preserved. This

40. Ibid.

is not the theoretical benefit in the fact that one day this person *could* visit Gettysburg, but rather in the mere fact that it is good to preserve and remember the place where many lost their lives. It stems not from benefit, nor from meeting the basic need. Hence, there must be something distinct in intrinsic value from the conception of meeting basic needs or production of benefits.

This example has demonstrated that some things have value without meeting basic needs. This conception also flows naturally from our definition of intrinsic value. If the intrinsic value of a thing were to stem simply from its ability to meet a basic need, that value would be based in its instrumental ability to meet our basic needs, rather than its non-instrumental ability to simply be of value to us. This distinction will be important for later analysis.

Are There Other Justifications?

This list, it seems, is rather short. To be justified, the programs of an unapplied nature would need to benefit a large group of citizenry, would need to efficiently satisfy unmet basic needs, or would need to be or to produce something that is intrinsically valuable. All of these arguments — in the abstract — have been shown to be justifications for the government to spend discretionary funds on unapplied endeavors. In fact, it has even been shown that the government is justified in supplying basic needs as part of its role in protecting the welfare of its citizens. There have been other arguments suggested by philosophers, economists, and politicians, and though I do not feel as if they are necessary to explore in-depth here, they should certainly be mentioned as alternatives.

Some proponents of the funding of arts decry the decay of culture that would occur without government funding of the arts.[41] The basis of this argument seems to be that the arts are a cornerstone of our culture — existing in Neolithic caves and across all societies in one form or

41. Ibid, 33.

another — and that they are necessary. Without government funding, the argument goes, the arts would crumble and culture would go with it. While this is an emotional argument, I believe it can be usurped by both the idea that there is a need for art — if humanity has always and everyone done art, one could argue that we find it necessary — and the idea that art is valuable — many people find value in art, from all cultures and all times in history. Similarly, one could argue that we live in a "knowledge based society," and that, in order to pay homage to this society — and to continue to build our society — we must secure funding for basic research in science and the humanities. Again, this argument can be appropriated by the arguments of basic need and intrinsic value. If we have come to live in a society that is "knowledge-based" then we must *value* knowledge, and this knowledge is valuable within our society.

A common justification for government spending for basic research is also that basic research *may have applied applications eventually*. This is true. The intent of the European Organization for Nuclear Research (CERN) was not to invent the World Wide Web, yet that was an outcome. Many of the greatest economic drivers from the 20th century did come from government investment in basic research. Yet this is not a satisfactory argument for why the government should spend money on basic research. There have also been many failures in government-funded basic research, even if the government has a "well diversified portfolio."[42] Yes, government funded research can lead to unprecedented economic and applied gains, yet that alone does not justify government subsidy. `Even if it did, other justifications would allow for government subsidy to continue even in the face of extended periods of failure to produce applied gains.

Some also justify government funding of the arts (and by extension here, basic research)

42. A concept that was used in "Risks and Benefits of Building the Superconducting Super Collider," *Congressional Budget Office*, October 1988, http://www.cbo.gov/publication/15728.

as a concept of rotational justice. The argument of rotational justice, in this case, is essentially an argument of fairness: if the government will concede to meeting the requests of some taxpayers in their discretionary spending (say, agreeing to pay for the construction of a stadium), then the government must also agree to fund other requests from taxpayers (say, building an art museum).[43] However, this avoids the question altogether as to whether the government should be spending *either* on sports or arts altogether. Furthermore, it places all discretionary spending projects on the same plane, rather than claiming that some endeavors may be *more* justified for government spending then others. Perhaps spending on stadiums can be justified while spending on arts is not. Fairness is not a requirement of government spending, and hence rotational justice is an inadequate source of justification.

A final argument in favor of funding pure research lies similarly to the concept of rotational justice. The basis of the argument lies in the fact that we live in a "knowledge-based society," with much funding for applied research. Insofar as that research is part of a "culture of science," the government — if it was defense and other applied research — must also fund basic research. This argument of *quid pro quo* would compel the government to fund basic research, yet still ties it to government spending on defense. Though it would achieve the ends, the means limit the ability to guarantee funding, for the government could reject the need to sustain this "culture," calling only on the development of basic research when it would further the ends of the applied research.

While there may be more ideas to justify the government funding of arts and research, it seems that, for now, there is a foundation of justification upon which more can be built if the argument is altogether unsatisfactory with more examination. Until that point, we shall proceed

43. Feinberg, "Not with My Tax Money the Problem of Justifying Government Subsidies for the Arts.", 104-105.

solely with the basis of three justifications set forth thus far.

Can unapplied programs meet the justifications?

It has been shown that the government is justified in spending money on programs when those programs benefit large segments of the population, when they satisfy basic needs, or when they are or create things that are valuable. The second question that must be answered is whether these unapplied programs can meet any of these requirements. There is a difficulty in the grouping used thus far when making this analysis: arts, research, and other unapplied programs most likely satisfy the aforementioned requirements in different manners.

It seems that this would require three papers to prove that these distinct manifestations of "unapplied endeavors" could meet justification for government support. However, if we must take the most extreme example of government funding, and consider whether *that* could be justified, then we would be able to answer the question of whether the government is justified supporting unapplied endeavors *at all*.[44] If government spending on such a program is justified, then programs that are similar and more applied could easily follow in the footsteps of this argument. Furthermore, demonstrating that the most extreme examples of costly, unapplied endeavors are justified for government funding may allow for other programs to seek justification under the idea of rotational justice, or under similar appeals for value, benefits, or needs.

I posit that government funding of experimental basic research is the most extreme example of unapplied programs. Experimental basic research is costly, on an order much greater than that of the arts, theoretical research, or humanities research. While it would be logically incorrect to say: if the government is justified in spending billions of dollars on basic research,

44. While we could also investigate the *least* extreme example of an unapplied endeavor and answer the question, there is benefit to choosing the most extreme case. To prove the most extreme case is to lay the groundwork for easier cases, especially in similar fields.

then it would be justified in spending thousands on arts," it is worth taking note the scale. Rather, it *is* logical to believe that if the government could find justification based in the aforementioned principles compelling enough to spend billions of dollars, and if the arts were similarly able to meet the aforementioned principles, the government, too, would be able to justify spending on those programs. Furthermore, experimental physics research is unique insofar as it would be difficult to further without government funding. The arts, science, and literature have, throughout history, required a patron. What is unique with regards to basic research in general is that, given how much more expensive it is, there are no longer very many patrons available. The arts still have some very wealthy donors, but for all intents-and-purposes, the only patron of science still standing is the government, and in some limited cases, the university or a research foundation.[45]

Basic research also has a more limited direct audience. Directly funding an artist or a museum can impact those who visit the museum or see the artist's work — a number in the thousands. In many ways the idea of public funding of the arts is directly linked to impacting culture. Basic researchers typically do not have a requirement to publicize their work beyond publishing their work. The published articles are often found in journals requiring a vastly expensive annual subscription to access the content. Art interacts with society through its very existence in a museum or gallery, while researchers must make it part of their intention to expose their research to a wider audience. With these two distinctions between basic research and the arts, it is clear that basic research is an extreme case of government funding of projects that have no practical outcomes. Basic research projects are more expensive and less engaging than other programs with which we have grouped them thus far.

Among basic research programs, there must surely be an extreme case as well. Basic

45. Alan T. Waterman, "Government Support of Research," *Science*, New Series, 110, no. 2870 (December 30, 1949), 701.

research can take many forms: there is basic research done in all of the sciences, yet basic research in physics is arguably the least applicable of all. Though it is often physicists who make this claim, this does indeed appear to be the case. To quote particle physicist Steven Weinberg, "Start anywhere in science and, like an unpleasant child, keep asking 'Why?' You will eventually get down to the level,"[46] that is investigated by high-energy particle physicists. Research into subatomic particles or far away galaxies are intellectual pursuits to understand the universe that have no clear practical applications and no clear path to practicality. Though researchers who apply for grants are often forced to claim applicability, the steps between discovery and applicability are few and far between and are often unforeseen if they exist at all. That is not to say that there are no forms of basic research in physics that can be closer to applied research, condensed matter physics can be useful for modern technology. However, of the physical sciences, physics houses the most fundamental, and most basic research. For example, basic research in biology — another field where unapplied research can often be found — is still more applicable than basic research in physics; furthermore, molecular biology is aided by quantum chemistry, which derives from physics' quantum mechanics. Whether basic research in physics can meet these justifications will be an inquiry tackled in the next chapter.

How Should These Programs Be Prioritized?

If unapplied projects in the arts, basic research, humanities, etc. can meet the aforementioned justifications, then the government is justified in funding the projects. However, the problem remains insofar as it is unclear *when* the government should spend the money, even if it would be justified in doing so. Justification is not synonymous with obligation, and — given that the government has myriad things that it may be justified in funding — the question as to

46. Steven Weinberg, *Facing Up: Science and Its Cultural Adversaries* (Cambridge, Massachusetts: Harvard University Press, 2001), 18.

when it spends on unapplied projects (rather than other projects for which it is also justified in spending) must be answered. Because the government does not have limitless resources, the dilemma of what to fund — and when and why to fund it — must be resolved. Even if the government is justified in funding unapplied projects, it must make the decision to spend on these projects rather than other endeavors, and that decision must be justified.

An appealing and compelling reason for funding is that of necessity for reliable funding — even though this argument is based solely on practical grounds. If the government is justified in funding a field, and decides to fund it when times are good (and conflicts are few), then the government cannot simply rescind the funding when budgets become more limited. Museums, researchers, artists, and the communities that rely on their benefits (values, etc.) need reliability. If the government has funding that fluctuates greatly from year to year then these projects would be in peril with frequency. These fluctuations in funding would have disastrous effects, for projects could never decide to proceed but cautiously and without risk.[47] Given that reality, if the *minimum* funding could ever reach zero, then the only logical source of funding for these endeavors would be foundations and organizations other than the government. This is not to say, of course, that the government — once giving funding — would be obliged to only increase funding. Rather, it is to say that the government must be reasonable in increasing and decreasing funding annually, for the recipients of funds are reasonably entitled to reliability.

Though it has been shown that the government could perhaps be justified in its funding of non-applied endeavors, it has not been shown that the government *should* fund these projects, even if it has the power and right to do so. The government has numerous responsibilities. In addition to the need to provide for defense, infrastructure, and social welfare, there are numerous

47. If they were going to expand and contract annually with large fluctuations in funding, it would result in expansion and contraction of employment, an inability to finance multi-year projects, and the impossibility of taking on debt of deficits

other justice priorities that the government could undertake. One could argue that the United States government needs to pay reparations to Native Americans, African Americans, and numerous countries throughout the world. The justice system, the "War on Drugs," and the broad failures of the public education system are all examples of systems perpetuated by the United States government that have compelling cases that need to be fixed. Why should the government focus its funding on high art or basic research, given these justice priorities?

Firstly, these justice priorities are not being met now, and even if the government were to cut all funding from non-practical endeavors, it is not clear that those funds would be diverted to justice priorities. Scientists who are not pursuing a life of social activism have the reasonable expectation to be able to pursue their livelihood, and if that requires asking the government for support, so be it. The government *ought* to fund justice priorities, yet unless that direct decision is posed, it does not seem to indicate that scientists and the arts should abstain from seeking support. Secondly, if the government can be convinced to fund non-applied programs using the justifications presented here, then there is no reason that justice priorities could not also seek funding in addition to the non-practical programs being funded.

If the government is justified in funding unapplied endeavors, demonstrating that it *should* is tantamount to demonstrating that it ought to choose funding these projects over other endeavors, such as fixing its justice priorities. It is likely that in a direct comparison between justice priorities and an unapplied art program, the latter would not be funded. Hence, this comparison is not useful for deciding whether the government should fund unapplied endeavors. Rather, what must be shown is that it would be reasonable for the government to incur a deficit in order to secure the funding for unapplied endeavors. We cannot show that the government should choose one project over another if the other project is unknown — or if the other project would surely take precedent. Rather, we can merely show that the government can find it worthwhile to invest in such unapplied projects to such an extent that it could incur a deficit.

This may seem like a disappointing and unfortunate conclusion. Perhaps I am incorrect. However, it is difficult to fathom a way to demonstrate that *no matter* the alternative project, unapplied programs should still receive funding. Instead, all programs must demonstrate that they are worthy of a deficit. Do unapplied projects provide such outcomes that it is better to undertake a burden than to eliminate the program due to lack of available funds?

One may point out that this creates a scenario of a bottomless well. If a project need only demonstrate that it meets the justifications provided in order to receive government funding, then the government could be forced to fund an infinite number of projects. By saying that projects need only demonstrate that they meet these criteria, thus requiring the government to incur a deficit to fund, then — given that the theoretical limitation to a government deficit is theoretically infinite — a limitless source of funds have just been found.

There are two reasons why this is not the case. Firstly, though the government currently has no preventative measure with regards to how large a deficit it can undertake, there are political reasons to prevent the incursion of a deficit. Hence, the government does not actually have infinite resources. Secondly, it would appear that a change in vernacular is all that is needed in order to avoid this problem. Rather than specific *programs* or *projects* finding themselves in the position to demonstrate to the government how they meet the aforementioned criteria, the *fields broadly* need to show how projects within that field can meet the criteria. Basic physics research must show that *some* basic physic research can meet the criteria; advocates of high arts must do the same. In this way, these respective fields will open themselves to receive government support. From that point, the fields themselves can decide how to allocate the funds.

Assessment is notoriously difficult. The methods of judging whether a project is of "high ethical quality" is dubious.[48] Whether a certain project may succeed or fail is difficult to tell at the time of request for funding. Art may be selected that is generally disliked, yet was found worthy of funding from the National Endowment of the Arts. What is needed then is norms for intracommunity allocations of funds. What has been provided here is an ability for respective communities to seek funding from the government when the role of the government in providing those funds is not immediately obvious.

It has been demonstrated that in order to be justified to receive government funds, a field of unapplied or non-practical endeavors must show that its constituent projects can provide certain benefits (direct, secondary, or indirect), meet basic needs, or have intrinsic valuable. Benefit production alone does not justify government funding. The government is not obligated to provide benefits, and so it is not obligated to incur additional costs in order to provide these benefits. However, it was shown that the government *is* obliged to provide basic needs if those needs cannot be met through alternative means. If a project meets basic needs, and those basic needs could not be met without government support, then the government would be justified in undertaking a deficit in order to continue to meet those basic needs. To end the program due to lack of available funds would be to cease meeting basic needs. While value-creation is also non-obligatory for the government to provide, its appeal to the broad public would allow it greater protections in case of conflict. If the public finds high value in the endeavors such that they would be willing to take on the collective burden of deficit, then the government would not be barred from continuing to provide that support.

Given how well defined the justification for government spending was, it was only

48. See: Stanley Parkinson, "Scientific or Ethical Quality?," *Psychological Science* 5, no. 3 (May 1, 1994), 137–38.

necessary to show the origins of those justifications in order to determine whether the government could take on a deficit in order to satisfy the requirements of funding a program of this nature. Given that a government is allowed to incur a deficit, it required no lengthy justification.

To conclude this chapter, I would like to briefly reiterate what was investigated and what was deduced. Originally, the question was what justifications could exist for the government to provide funding to non-applied endeavors such as the arts, basic research, humanities research, etc. It was found that if these programs provide unique benefits, then the government could be justified in spending discretionary funds on these programs. It was also argued that the government could fund unapplied endeavors that met basic needs, under the premise that the government may provide basic needs as part of its core mission. Finally, though the concept of intrinsic value was only nominally explored, a justification on the basis of public-appraisal of value concluded that the government could protect and create things that the public broadly conceptualizes as intrinsically valuable, even if the public does not want to pay for that protection or creation. Additionally, some other forms of justification, such as "rotational justice" and a "diversified research portfolio" were explored as possible — yet ultimately unsatisfactory — alternatives. Afterwards, it was discussed that given the differing benefits, needs, and values that coincide with different projects, it would be impossible to *answer* whether these projects would be justified in *practice* without specifying specific projects and ideas. An analysis led to the conclusion that experimental physics is the most extreme case of an unapplied, expensive endeavor and thus worthy of investigation more thoroughly. Finally, it was argued that the government must be willing to take on a deficit for these fields, and that only two of the three justifications (basic needs and value-creation) would be sufficient drivers for the government to do so. Project-specific analysis is necessary to demonstrate whether the fields themselves have projects that can meet the justifications. However, individual projects are decided upon within each individual field, perhaps also using the justifications provided here. In the next chapter, I will give two examples of experimental, pure physics research that will later be analyzed to determine whether they would sufficiently be justified for government spending.

Chapter Two: A Brief Examination of Two Expensive Basic Physics Projects

In order to most effectively move the theoretical justifications presented in the previous chapter into actionable recommendations for scientists and other researchers when they are preparing projects, two high-cost basic research projects in physics have been chosen as case studies. These projects are vastly different in purpose, scope, and outcomes. This chapter will be a brief overview of the Hubble Space Telescope and the Superconducting Supercollider. I will briefly describe the scientific mission of these projects, the cost and scope of the projects, the proposed benefits and values, and other pertinent information. In the case of Hubble, some outcomes will also be discussed. As the Superconducting Supercollider was canceled during its construction, the outcomes are limited. However, expected outcomes can nonetheless be included as part of the considerations.

The Hubble Space Telescope

The Hubble Space Telescope (Hubble or HST) is perhaps one of the best-known achievements of the National Aeronautics and Space Administration (NASA) since the end of the Apollo program. After years of delays, due in part to the crash of the Challenger Space Shuttle, Hubble successfully launched in April of 1990, and has been in continuous operation since that date. Originally, it was expected that Hubble would have an operational mission of at least fifteen years, though it would be in use until no longer feasible.[49] Hubble is still in use today, with no plan to end its mission. Over the course of its operational lifetime, astronauts have visited the HST five times in order to repair and improve the telescope.

The Scientific Purpose of the Hubble Space Telescope

The Hubble Space Telescope is an optical telescope system, meaning that it is sensitive

49. *Space Science: Status of the Hubble Space Telescope Program*, Government Report (United States General Accounting Office, May 2, 1988), http://www.gao.gov/products/NSIAD-88-118BR, 26.

to electromagnetic radiation in the ultraviolet, visible, and infrared light section of the electromagnetic spectrum. Its optical components are two large mirrors, which focus images onto the six instruments that are currently in use on the HST (though there have been other iterations of instruments aboard Hubble in the past.) Many research telescopes are optical telescopes, and commercially available telescopes are universally optical telescopes.

Hubble, orbiting 343 miles above earth, is free from the atmosphere, providing a significant advantage to similarly sized ground-based telescopes.[50] This is *the* compelling reason for Hubble over earth-based telescopes, and thus needs to be stressed. Light from galaxies, quasars, and distant stars travels millions of light-years[51] before it reaches our eyes or the sensors of a telescope. When this light reaches earth, it interacts with our atmosphere: ultraviolet light is mostly absorbed, visible and infrared light interact with particles in the atmosphere and are often distorted. Free from the earth's atmosphere, light reaches Hubble with less interference. This results in clearer, higher resolution images than are possible from earth-based telescopes.[52] Furthermore, it allows for the capture of light from sources that are fainter and farther away; it was predicted by NASA that images from Hubble could come from 14 billion light years away.[53] Though there have been great advances in technology since Hubble was launched in 1990,[54] the original optics and sensors resulted in galactic leaps for the fields of astronomy, physics and

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50. M. M. Waldrop, "Looking Forward to Hubble," *Science* 247, no. 4941 (January 26, 1990), 412–412, doi:10.1126/science.247.4941.412.

51. One light-year is roughly equivalent to 5,545,166,500,000 miles

52. Quantitatively, the original Hubble sensors had ten times higher resolution than the best ground-based telescopes, and had 600 times high resolution than the naked eye. Waldrop, "Looking Forward to Hubble."

53. *Space Science, 6*.

54. Johannes Koelman, "Hubble's 20th: A Taxpayer's Perspective," *Science 2.0*, April 23, 2010, http://www.science20.com/hammock_physicist/hubbles_20th_taxpayers_perspective.

cosmology.[55]

A Brief History of Hubble

The creation of a space-based telescope was one of the primary objectives of NASA, though no funding was provided for such an endeavor until 1978.[56] However, problems soon followed with the creation of what would eventually be called the Hubble Space Telescope:

> [T]he space telescope was scheduled to be launched in December 1983. In late 1982 serious technical and managerial problems associated with the program became apparent… NASA rescheduled the launch date to the first half of 1983. However, due to unanticipated technical problems with some of the HST components, the launch date was rescheduled again… The loss of the Challenger in January 1986 again delayed the launching of the HST, and it [was again rescheduled to] June 1989. [57]

Unfortunately for the HST, the problems did not stop there. Once it was launched, it was discovered that there was a near-fatal flaw in the mirror of Hubble. Images, which were expected to be crisp and clear, were blurry and unsuitable. A project that had ballooned from a budget of $435 million in 1978 to $1.6 billion in 1990 suddenly was unusable. The public, Members of Congress, and scientists all wondered how this error had gone undetected during the years of delays, and wanted to know how NASA would fix it.[58]

The HST was designed to have routine maintenance over the course of its lifetime. Five such missions occurred,[59] the first of which — in 1993 — delivered corrective optics to allow for the proper function of the HST. These missions ranged from the relatively affordable —

55. Hubble also required sophisticated advances in a number of areas. In order to transmit the data Hubble collected, for example, three geosynchronous telescopes were launched to relay the information back to earth.

56. *Space Science, 17*.

57. Ibid, 17.

58. Ann LoLordo, "Hubble Trip a Chance to Justify Huge Costs," *The Baltimore Sun*, November 28, 1993, http://articles.baltimoresun.com/1993-11-28/news/1993332073_1_hubble-space-telescope-nasa.

59. Though NASA parlance would have one believe that only four servicing missions took place

Servicing Mission 3A cost only $205 million[60] — to the lifesaving, yet expensive $1 billion price tag associated with Servicing Mission 4. These missions have not always been easy, yet they have greatly extended the life of the HST. The last Servicing Mission was delayed due to the Space Shuttle Columbia crash in 2003. Though the HST was originally planned for a lifetime of 15 years, current estimates expect that Hubble will continue to operate until at least 2018, at which time the next generation space telescope, the James Webb Space Telescope, is expected to launch.

The Scientific Impact of Hubble

With more than twenty years of active scientific use, Hubble's impact on the scientific community can be well established and argued. Over the course of its lifetime, Hubble has made more than 1,000,000 observations, a milestone it reached in 2011.[61] Those observations have resulted in upwards of 10,000 peer-reviewed scientific papers.[62]

These achievements are due in part to the relatively unique structure of observational requests and data storage for the HST. The fact that much of the observational time of the HST would be used by those in academia and research institutions, rather than NASA, is reflected in the body charged with maintaining the observational schedule and archival data of the HST. The Space Telescope Science Institute (STScI), housed at Johns Hopkins University, is the body charged with maintaining the science program of Hubble. Proposals for observations are directed to STScI, which also houses and disseminates all Hubble data to observers and the general

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60. *Hubble Space Telescope Servicing Mission 3A: COST TO TAXPAYERS* (National Aeronautics and Space Administration, October 1999), http://asd.gsfc.nasa.gov/archive/sm3a/downloads/sm3a_fact_sheets/cost-to-taxpayers.pdf.

61. "NASA's Hubble Makes One Millionth Science Observation," *HubbleSite*, July 5, 2011, http://hubblesite.org/newscenter/archive/releases/miscellaneous/2011/22/.

62. "Hubble Racks Up 10,000 Science Papers," *HubbleSite*, December 6, 2011, http://hubblesite.org/newscenter/archive/releases/miscellaneous/2011/40/.

public, in addition to maintaining ties with the scientific community writ large.

There are two further unique aspects to the Hubble Space Telescope scientific program. Firstly, data recorded on behalf of scientists and researchers did not remain their intellectual property indefinitely. Rather, NASA and STScI allowed for one year of private data — in order to make discoveries and write academic papers — at which time the data would be publically accessible through the archives at STScI. This has resulted in a great number of papers based upon not only new observations, but from researchers exploring the thousands of observations available through the STScI archives.[63] Secondly, NASA accepted proposals for observations from amateur astronomers (on a fairly limited basis) in addition to the hundreds of observations made annually on behalf of the broader academic research communities. These amateur astronomers did not need to be academics — accepted proposals came from teachers, electrical engineers, and plenty of others.[64] Their proposals were selected on the basis of feasibility and creativity.

One of the first major achievements of the HST was the study of the Hubble Deep Field. Hubble, high above the earth's atmosphere, is able to see images that are much fainter than any earth-based telescope. In 1995, Hubble spent over 100 hours observing a small segment of the sky. What resulted was a high-resolution image of over 3,000 diverse galaxies able to be studied by astronomers and cosmologists. These were some of the oldest and most irregular galaxies ever observed, and would not have been possible without a space-based telescope.[65]

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63. A. Boden et al., *Report of the Hubble Space Telescope Senior Review Panel* (National Aeronautics and Space Administration, March 28, 2014), http://science.nasa.gov/media/medialibrary/2014/05/15/Final_Report_HST2014_SeniorReview_Panel_.pdf, 6.

64. "Amateur Astronomers Will Use NASA's Hubble Space Telescope," *HubbleSite*, September 10, 1992, http://hubblesite.org/newscenter/archive/releases/1992/1992/23/.

65. "The Hubble Deep Fields," accessed February 9, 2015, http://www.spacetelescope.org/science/deep_fields/.

In fact, Hubble has made a great impact on the fields of cosmology, astrophysics, and astronomy. In a 2009 article titled "18 years of science with the Hubble Space Telescope," astronomer Julianne J. Dalcanton recounted many of the ways in which Hubble made an important impact on the scientific community:

> [T]he HST has dramatically changed our understanding of the Universe. These include tracing the structure and evolution of stars from their births through to their deaths, demonstrating the pervasiveness of black holes and their links to galaxy formation, tracking the evolution of galaxies over billions of years, and testing fundamental models of the expansion of the Universe.[66]

The HST helped determine the Hubble constant, the rate at which our universe is expanding, to a precision of 1%. It allowed scientists to analyze the composition of supernovae, and has even been used to analyze exoplanets for the possibility of life. Some might say even that "Few telescopes in history have had such a profound effect on astronomical research as the Hubble Space Telescope."[67]

Hubble's Impact on the Public

Hubble was very expensive, and as part of their mission to justify this cost, NASA made a conscientious effort to ensure that the impact of Hubble was known widely throughout the American population. Hubble produces beautiful (false colored) images, which have captivated the imaginations of millions of Americans. Photographs from Hubble have graced the front page of major newspapers, magazines, and websites over the past two decades. "Front page science," is both the education of the public and the demonstration that the scientific research conducted is newsworthy, and therefore, in the minds of many, worthy of being published.

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66. Julianne J. Dalcanton, "18 Years of Science with the Hubble Space Telescope," *Nature* 457, no. 7225 (January 1, 2009), 41–50, doi:10.1038/nature07621.

67. Mario Livio, "Hubble's Top10," *Scientific American* 295, no. 1 (July 1, 2006), 42–51, doi:10.1038/scientificamerican0706-42.

STScI has an "Office of Public Outreach,"[68] (OPO) which is charged with maintaining educational, outreach, and media resources. In addition, they maintain impressive metrics on the work that they do. According to the STScI OPO, NASA releases roughly 28 press releases every year, which result in a circulation of more than 140 million releases; the HST is also the subject of roughly 3,300 online articles a year, with a circulation of 3.8 billion. For context, a study in 2005 (conducted by scientists at STScI) found that roughly 5% of the world's science news originated from NASA, the majority of those stories regarding the HST.[69] In addition, a 2004 study found that the Hubble website received roughly 3 million viewers a year, many of whom spent significant time on webpages devoted to the Hubble Deep Field, photos of the "Pillars of Creation," among others.[70] Hubble has also engaged the public with science through action. There have been programs to help Hubble scientists identify galaxies, with public astronomers analyzing thousands of photographs from Hubble, helping them to contribute to the scientific effort.

However, that is not to say that the relationship between the public and Hubble has been without fault. Many scientists have criticized NASA for being overzealous in their press releases. In an effort to show the public the great science that Hubble produces, the nuance is lost. Many claim that the hype associated with the images are not bad for NASA, resulting in sensationalization, rather than public education about the actual impact of science.[71] Nonetheless,

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68. http://outreachoffice.stsci.edu/

69. Carol A. Christian and Greg Davidson, "The Science News Metrics," in *Organizations and Strategies in Astronomy Volume 6*, ed. André Heck, Astrophysics and Space Science Library 335 (Springer Netherlands, 2006), 145–56, http://link.springer.com/chapter/10.1007/1-4020-4056-3_11.

70. Carol A. Christian, "The Public Impact of the Hubble Space Telescope: A Case Study," in *Organizations and Strategies in Astronomy*, ed. André Heck, vol. 310 (Dordrecht: Springer Netherlands, 2004), 203–16, http://link.springer.com/10.1007/978-1-4020-2571-6_12.

71. Faye Flam, "NASA PR: Hype or Public Education?," *Science* 260, no. 5113 (June 4, 1993), 1416–18, doi:10.1126/science.260.5113.1416.

a trope among Hubble scientists is epitomized by Frank Summers:

> The greatest short-term public impact has been wonder and curiosity. The images we produce, and which are widely disseminated, provoke a sense of awe in all of us. Hubble has perhaps done more to expose the public to the magnificent celestial sights than any other telescope in history. And the more powerful impact is to awaken the innate human curiosity... Hubble's ability to reach the public and get them to wonder what, how, and why are a distinctly positive influence toward raising the level of discussion in the public sphere.[72]

With this brief investigation into the impact of Hubble on the scientific and public communities, as well as basic information such as form and cost, it should be possible to construct an argument as to the justification of the Hubble Space Telescope in the next chapter. Another case study, that of the Superconducting Supercollider, will provide another possibility for analysis.

The Superconducting Supercollider

The Superconducting Supercollider (SSC) was a planned particle accelerator to be built in northern Texas, a few miles south of Dallas. Proposed in 1983 and cancelled in 1993, the SSC would have been the largest particle accelerator ever built, producing collisions more than three times more powerful than the capabilities of the similar Large Hadron Collider (LHC) in Geneva. Many high-energy particle physicists expected the SSC to be the salvation of high-energy physics (HEP) in the United States, but competition for funding, runaway costs, and inadequate justification caused Congress to pull funding for the SSC in two highly contentious votes in mid and late 1993.

The Intended Scientific Purpose of the SSC

In the late 19th century and early 20th century, physicists were just beginning to

72. Frank Summers, "Hubble's Universe Unfiltered: How Do You Think the Hubble Space Telescope Affects the World Today?," *HubbleSite*, accessed February 11, 2015, http://hubblesite.org/explore_astronomy/hubbles_universe_unfiltered/blogs/qna-hst-affects-world-today-.

understand the structure and components of the atom. The concept of the atom had existed since the ancient Greeks, yet only in the 19th century had scientists devised experiments to better understand what composes the smallest unit of the basic elements. By the end of the 19th century, the consensus of the structure of the atom followed the so-called "plum-pudding model." It was thought that the atom was a small area in which even smaller positive and negative particles (protons and electrons, respectively), cohabitated relatively evenly throughout the space. However, in 1909, Ernest Rutherford designed an experiment in which tiny, positively charged α-particles were shot towards a sheet of gold foil. Upon discovering that the α-particles could be deflected by great angles, suggesting that the structure of the atom is not one of "plum pudding," but rather, a central nucleus of positive charge surrounded by a cloud of negatively charged electrons. This was the first major HEP experiment, and it represented the beginning of an era:

> Nuclear physics soon got bigger… To break into nuclei and learn what they are, physicists in the 1930s invented cyclotrons and other machines that would accelerate charged particles to higher energies… After World War II, new accelerators were built, but now with a different purpose. In observations of cosmic rays, physicists had found a few varieties of elementary particles different from any that exist in ordinary atoms… By the mid-1970s the work of experimentalists at these laboratories, and of theorists using the data that were gathered, had led us to a comprehensive… theory of particles and forces, called the Standard Model.[73]

The SSC was the next-generation of the particle accelerator, designed to exceed the energies available at the Tevatron accelerator at Fermi National Lab (Fermilab) by a factor of 20. This expansion, in the minds of the high-energy particle physicists, was necessary in order to continue to verify and expand the Standard Model. The Standard Model is the overarching theory unifying the electromagnetic, weak, and strong nuclear interactions. It was developed

73. Steven Weinberg, "The Crisis of Big Science," *The New York Review of Books*, May 10, 2012, http://www.nybooks.com/articles/archives/2012/may/10/crisis-big-science/.

through a combination of theoretical and experimental research, each building upon each other to continually reevaluate and improve the theory. By the early 1980s, the advances that were possible through the Tevatron had stalled, and a new particle accelerator was needed to continue to advance the field. Specifically, the top quark (which was later discovered at Fermilab), the Higgs boson, and proof of supersymmetry were all lacking.

The premise of particle colliders is that exciting atoms and their constituent particles through higher and higher-energy collisions will create new particles as the accelerated particles are transformed and changed due to the incredible energy. In order to find heavy particles such as the Higgs boson, or those particles that would indicate supersymmetry, extremely high-energy collisions were required, as predicted by theoretical evaluations. Therefore, the SSC was designed to provide an incredible amount of energy to beams of protons. Specifically, an elliptical tunnel 54-miles in circumference would accelerate beams of protons in opposite directions to 20 trillion electron volts (TeV),[74] therefore causing 40 TeV collisions. This energy was predicted to be sufficient for finding the Higgs Boson and any proof of supersymmetry. Additionally, many high-energy physicists hoped that the SSC would provide physicists with the opportunity to learn of further particles, helping to create a grand-unifying theory of fundamental theory of subatomic particles.

A Brief History of the SSC

High in the Rocky Mountains in Snowmass, Colorado in 1983, the proposal for the Superconducting Supercollider was born. Unable to continue to advance experimental tests of the standard model, and find new particles, high-energy physicists sought a new machine for

74. One electron volt (eV) is the amount of energy an electron gains moving across a potential difference of one volt. *e.g.* an electron would have gained (or lost) 9 eV if it moved from one end of a nine-volt battery to the other.

their research.[75] To the HEP community, the SSC was not just a new toy; it was a necessary next-step to save the field. Basic research in particle physics led to the creation of the nuclear bomb, and following WWII, the portion of basic research funding going towards HEP was huge. By 1970, HEP was consuming 11.9% of the federal basic research portfolio, yet by 1988 — even with science and technology-focused Ronald Reagan — HEP only had a 6.6% share of the federal basic research funds available.[76] In many ways, the SSC was viewed as a panacea for the field. It would reinvigorate both experimentalists and theorists, catalyze growth, and reestablish the United States as a center for HEP.[77]

As such, the Department of Energy submitted a proposal for the construction of the SSC, and Congress approved its construction in 1987. The original cost of construction of the SSC was placed at $5.3 billion in 1987, though by 1993, that cost had ballooned to over $11 billion.[78] Nonetheless, initial support for the SSC was quite strong. Congress voted strongly to construct the SSC, and even into the early 1990s, voted in favor of funding the SSC at very high levels.[79] However, support dwindled as site construction continued. A competition was held in order to select where the SSC would be built: Waxahachie, Texas was chosen as the site for the SSC. That announcement was made the day after George H.W. Bush was elected President of the United States. Texas had also promised to contribute $1 billion to the funding of the SSC,

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75. Jeffrey Mervis and Charles Seife, "Lots of Reasons, But Few Lessons," *Science* 302, no. 5642 (October 3, 2003), 38–40, doi:10.1126/science.302.5642.38.

76. "Risks and Benefits of Building the Superconducting Super Collider."

77. Faye Flam, "The SSC: Radical Therapy for Physics," *Science* 254, no. 5029 (October 11, 1991), 194–96, doi:10.1126/science.254.5029.194.

78. *Super Collider--National Security Benefits, Similar Projects, and Cost*, Government Report (United States General Accounting Office, May 1993), http://www.gao.gov/products/RCED-93-158, 13.

79. David P. Hamilton, "The SSC Takes On a Life of Its Own," *Science* 249, no. 4970 (August 17, 1990), 731–32, doi:10.1126/science.249.4970.731.

something that most likely helped guide the decision of the Department of Energy.[80] Nonetheless, the SSC advocates were politically savvy, and spread out the Research and Development budget throughout the United States — in 1990, 30 states received SSC funds.[81] However, as time went on, the support for the SSC dwindled, with the majority of support coming from Texas and Louisiana Congressional delegations.[82]

Furthermore, within the broad scientific community, the SSC faced criticism from many outside the HEP field. Critics were worried that it was costly and would usurp funding from other projects in basic research.[83] Calling high-energy physicists the unfortunate products of "big science syndrome," scientists from across physics called either for the delay or cancellation of the SSC. Furthermore, the European Organization for Nuclear Research (CERN) was concurrently planning the construction of the Large Hadron Collider. Though much smaller than the SSC, many outside of the HEP field were confounded as to why the United States needed to spend much greater sums to build the SSC when European scientists were already giving the field an upgrade.[84] In many ways, their fears of cost were well founded. By 1990, the SSC was one of the top-three most costly scientific endeavors in the United States (often found beside

80. Daniel Kevles, "Good-Bye to the SSC: On the Life and Death of the Superconducting Super Collider," *Engineering & Science* 58, no. 2 (1995), 19.

81. Hamilton, "The SSC Takes On a Life of Its Own."

82. Daniel Kevles, "Good-Bye to the SSC: On the Life and Death of the Superconducting Super Collider:" 23.

83. See, for example, T. H. Geballe and J. M. Rowell, "Funding the SSC," *Science* 259, no. 5099 (February 26, 1993), 1237–38, doi:10.1126/science.259.5099.1237. "Postpone the SSC Decision For Two Years | The Scientist Magazine®," *The Scientist*, accessed December 19, 2014, http://www.the-scientist.com/?articles.view/articleNo/8687/title/Postpone-the-SSC-Decision-For-Two-Years/.

Or Philip Anderson, "The Case Against the SSC | The Scientist Magazine®," *The Scientist*, June 1, 1987, http://www.the-scientist.com/?articles.view/articleNo/8688/title/The-Case-Against-the-SSC/.

84. *Super Collider--National Security Benefits, Similar Projects, and Cost*.

Hubble and the International Space Station).[85] Although newly-inaugurated President Clinton voiced support for the SSC in June 1993,[86] the SSC was ultimately cancelled in October of that same year.

The Intended Impact of the SSC on the Public

Although the SSC would never produce beautiful images similar to the Hubble Space Telescope, high-energy particle physicists still waxed-poetic about the impact and cultural importance of the SSC. Steven Weinberg, a Nobel prize-winning physicist and a major advocate of the SSC, often writes and speaks about the importance of high energy physics:

> The case for spending large sums of money on elementary particle physics has to be made in a different way. It has to be at least in part based on the idea that particle physics (and here, parenthetically, I should say that under "particle physics" I include quantum field theory, General Relativity and related areas of astrophysics and cosmology) is in *some* sense more fundamental than other areas of physics…[87]
>
> Now, these reflections don't in themselves settle the question of whether the SSC is worth $4.4 billion. In fact, this might be a difficult problem, if we were simply presented with a choice between $4.4 billion spent on the SSC and $4.4 billion spent on other areas of scientific research… All I have intended to argue here is that when the various scientists present their credentials for public support, credentials like practical values, spinoff, and so on, *there is one special credential of elementary particle physics that should be taken into account and treated with respect, and that is that it deals with nature on a level closer to the source of the arrows of explanation that other areas of physics.*[88]

Similarly, the founding director of Fermilab, when defending a similar accelerator in

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85 *Large Nondefense R&D Projects in the Budget: 1980-1996* (Congresional Budget Office, July 1991), http://www.cbo.gov/publication/16437.

86. William J. Clinton, "Letter to Representative William H. Natcher on the Superconducting Super Collider," June 16, 1993, William J. Clinton (1993, Book I), Page 864, Public Papers of the Presidents of the United States, http://www.gpo.gov/fdsys/pkg/PPP-1993-book1/pdf/PPP-1993-book1-doc-pg864.pdf.

87. Steven Weinberg, *Facing Up: Science and Its Cultural Adversaries* (Cambridge, Massachusetts: Harvard University Press, 2001), 12.

88. Ibid, 23. *Emphasis added*

1969 stated that the creation of a new accelerator:

> has to do with the respect with which we regard one another, the dignity of men, our love of culture. It has to do with those things… this new knowledge has all to do with honor and country but it has nothing to do directly with defending our country except to help make it worth defending.[89]

The argument put forth for the social impact of the SSC, then, was that it would capture the imagination of the public, and that, even if it did not, the public's commitment to build the SSC would be a demonstration of the importance of this *most fundamental* of basic sciences. One complication with the SSC would have been the fact that major discoveries would have been few and far between. For example, both the SSC and LHC were created with the specific goal of finding the Higgs Boson. The LHC was successful in reaching that milestone, nearly fifteen years after its construction began, and four years after it first became operational. Though the discovery of the Higgs galvanized a flurry of news and public interest (even generating 36,000 tweets-per-hour following the announcement[90]), the SSC certainly would have had a difficult time engaging the public on a regular basis.

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89. Wilson, *Authorizing Legislation, Fiscal Year 1970. Hearings, Ninety-First Congress, First Session*.

90. M. De Domenico et al., "The Anatomy of a Scientific Rumor," *Scientific Reports* 3 (October 18, 2013), doi:10.1038/srep02980.

Chapter Three: An Application of the Theoretical Framework to Actual Projects

What has been established thus far is a framework for evaluating unapplied endeavors and their respective fields. Additionally the previous chapter presented, descriptions of two examples that will be used to determine whether the field of experimental basic research in physics can meet the framework for justification. In this chapter, I will apply the framework of justifications from the first chapter onto the two examples found in the second chapter. While no number of anecdotes proves a theory, establishing that it is possible for some projects to meet the criteria granting the possibility of government support will demonstrate that the fields themselves would be justified in requesting government funding with confidence that projects in their field could meet those criteria. If Hubble or the SSC can meet the standards set forth in chapter one, then it is would be evidence that projects of basic research in physics can garner government support and thus the field can seek government funding as a field with the proper justification for that support.

Before delving into an analysis of whether the Hubble Space Telescope or the Superconducting Supercollider could meet the standards of justification set forth in the first chapter, it is first necessary to explore more deeply the meaning of *basic needs* and *intrinsic value* when dealing with the pure sciences. Though some examples were given in the first chapter, no detailed explanation as to what basic needs the sciences could meet was given. Furthermore, though intrinsic value was explored with some depth, no discussion was held about whether we (Western citizens) actually *do* value sciences and the arts. Without that discussion taking place, it would be impossible to analyze accurately whether the HST or SSC could be justified, let alone the entire fields of astronomy and high-energy particle physics.

Basic Needs and Intrinsic Value in the Sciences

The difficulty with assessing this inquiry is that, though examples of possible basic needs were given in the first chapter, we lack a comprehensive understanding of basic needs and how they might be met in myriad ways. There are conceptions of basic needs available to us. One could search the literature of psychology, biology, physiology, anthropology, or many other social and physical sciences for the answer. However, I am not an expert in any of those fields, and would be remiss if I were to report on those finding as evidence of the types of basic needs the arts or basic science may satisfy. I welcome research on this topic as a complement to what I write here, yet I cannot rely on it.[91]

Science and Basic Needs

As was discussed in the first chapter, Noël Carroll devoted significant space to discussing how art could satisfy basic needs. He writes that "on one reading, to say that someone needs X is to say that if she lacks it, she will suffer injury, sickness, madness, hunger, or avoidable death,"[92] and that if one wants to demonstrate an expanded conception of basic needs, then "research would have to be undertaken to show that we do indeed have… needs whose frustration results in some form of psychic discomfort."[93] Thus, while I am inclined to support an expanded conception of basic needs, there is a clear limitation to an argument that falls upon such a notion. In the event that this list of expanded basic needs could be disproven, then the whole argument falls apart.

Nonetheless, it is necessary to voice what needs— under an expanded conception of basic needs — pure science could hope to satisfy. One could believe that there is a basic, human need

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91. For those better-versed in developmental psychology and physiology, I will note here that Manfred Max-Neef, a contemporary economist, developed a "Human Needs and Human-Scale Development" model that includes understanding as one of the basic human needs. This could be contrasted with the popularly-known Abraham Maslow's hierarchy of needs, which does not mention understanding or knowing in any such way.

92. Carroll, "Can Government Funding of the Arts Be Justified Theoretically?", 24

93. Ibid, 27.

to seek understanding of the world around us. Since the beginning of ours lives, we are prompted to ask questions about the things around us. Children constantly badger those around them, asking "why" things are the way they are. We learn through experiment, formal and informal education, thought games, etc. We touch the hot stove, even when we are told not to, because we find it necessary to seek an explanation for how the world works. As we get older, the questions we ask become more complex. Not everyone in the world seeks answers to the questions that perplex philosophers and scientists: the meaning of life, the source of consciousness, or the origins of our existence. Some are content to find solace in religion, or in the certainty of the unknown. Though they may not ask what one might consider "big questions," there is still a need to seek understanding, and the euphoria that comes with that *eureka* moment. We seek understanding not only of the universe and how the *world* works, but how the mysteries of the universe work. Questions of the sort "why do bad things happen to good people," demonstrate our discontent with disorder and lack of understanding. The fact that questions about how everything works cut across disciplines — scientists, philosophers, theologians all attempt to explain how the world works — could demonstrate that we all have this *need* to understand the questions that arise when we think about how the world and its habitants work.

However, would there be psychic harm, physical pain, death, madness, etc. if our ability to meet this basic need were prevented? Seeming chaos and disorder — an inability to understand — does appear to upset many people. However, an inability to understand our everyday lives and an inability to understand the structure of the universe does not appear to be of comparable scale. While there may be a basic need to seek understanding, that basic need is probably already satiated by the typical use of heuristics to understand daily life. It seems unlikely that big science is a necessary component of satiating this need. Otherwise, it would seem to imply that humans have been suffering from the depravation of this basic need for thousands of years. Thus, though there may be a basic need to seek understanding, and though science may satiate that need, it seems as if that need is already satisfied to the point where the government would not need to subsidize science in order to secure our basic need to seek understanding.

The Intrinsic Value of Science

The intrinsic value of science must be analyzed through a variety of means. Firstly, value can be assigned to an object or idea for what it is and what it does. Secondly, value can be appreciated insofar as that idea or object furthers things that we already generally value. This intrinsic value is implicit in the ways that American cultures speaks, writes, and thinks about science. It can also be explicit through public opinion polling, and other avenues for public comment and engagement on this topic.

We are not content to say that we know all there is to know, that there is no more seeking that needs to be done. There is a craving, a desire, to continue to dig deeper and explore further. The extent to which the public has been captivated by programs such as NASA (the Apollo missions, but also images from Hubble, the International Space State, the Voyager missions) demonstrates the public's engagement with these issues. This desire to engage with science demonstrates our opinion of the intrinsic value of science. If the public in engaged with basic research findings, if they are excited by them and interested in them, then they must value them. It would be a strange sort of world to say that something was exciting and engaging yet of no value. Indeed, it seems clear that if the public engages with a field such as astronomy, then it follows that they value the field itself.

Scientists have not always been seen as providing any sort of value to the general public.

There have been great changes in how society accepts scientists and their answers about the universe:

> It is evident from this discussion that between the 5th and 19th centuries science changed its position in the social and political framework. Scholars/scientists began as heretics, outcasts from society (such as Galileo). By the end of the 19th century, scientists had become members of recognized professions, employed in academic teaching but engaged in and supported by research. Through learned societies and by contributions to "industrial progress," scientists acquired high social sand [and] were regarded as valuable servants of their respective countries…[94]

Archimedes' principle is taught in our public schools. Aristotle sought to make sense of the night skies, just as we do today. Though we now know that his theory of celestial orbs was incorrect, as a society, we are simply at the next iteration of his theory. The Aristotelian theory of the night sky was not disregarded until relatively recent times. Even Copernicus retained the circular orbits based upon this Aristotelian theory of astronomy. The teaching of historical theories coupled with the current explorations of science, and the comparisons between the two, demonstrate a historical value of science brought through to today. Science today is viewed as a profession of wonder and *gnosis.*[95]

In 1899, the President of the Physical Society of America, gave an impassioned speech on the *Highest Aim of the Physicist* in it he said:

> The aims of the physicist, however, are in part purely intellectual; *he strives to understand the Universe* on account of the intellectual pleasure derived from the pursuit, but he is upheld in it by the knowledge that the study of nature's secrets is the ordained method by which the greatest good and happiness shall finally come to the

94. Robert F. Rich, "Knowledge in Society," in The Knowledge Cycle, ed. Robert F. Rich, Sage Focus Editions (Beverly Hills: Sage Publications, 1981), 20.

95. Nicholas Rescher and Theodore Roszak, "The Monster and the Titan: Science, Knowledge, and Gnosis," in Introductory Readings in the Philosophy of Science, ed. E. D. Klemke, Robert Hollinger, and A. David Kline (Buffalo, N.Y: Prometheus Books, 1980), 238–53.

> human race.[96]

Physicists believe that their ultimate goal is to understand how the world works, and then to translate the knowledge that they gain to the general population. This continuation of our "intellectual heritage" is something that has been valued through the ages. Though there have been occasions when it was thought that everything about the universe was known,[97] it has generally believed that it is always possible — and often valuable — to continue to search for new knowledge. This new knowledge is absorbed into our culture, even if its initial impact is barely noticeable:

> Today's research at the boundaries of science explores environments of energy and time and distance far removed from those of everyday life and often can be described only in esoteric mathematical language. But in the long run, what we learn about why the world is the way it is will become part of everyone's intellectual heritage.[98]

This is viewed as a social contract between the producers of knowledge, the scientists, and society as a whole.[99] What has been shared here, however, is the point of view of physicists and their adherents. It is necessary to include the work of philosophers of science, so as to not present a completely romanticized view of science. There are great debates about the types and hierarchies of knowledge that exist. There are classifications of knowledge: industrial knowledge, intellectual knowledge, and spiritual knowledge.[100] Scientists and non-scientists alike do not agree as to whether basic research or applied research is "better," or superior. There

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96. Henry A. Rowland, "The Highest Aim of the Physicist," Science, New Series, 10, no. 258 (December 8, 1899), 832–33. Emphasis added

97. Lord Kelvin is often quoted as saying that all that was left of physics in the 20th century was "measurement"

98. Steven Weinberg, Facing Up: Science and Its Cultural Adversaries (Cambridge, Massachusetts: Harvard University Press, 2001), 82.

99. Rich, "Knowledge in Society", 23.

100. Ibid, 14.

are questions as to whether basic science is intrinsically *good*, while perhaps applied science is neutral or bad.[101] Nonetheless, one cannot simply deny the importance of science and the way that it has positively impacted our society:

> [F]or while the results of scientific inquiry are, in their statement, remote from specifically human concerns and values, the industrial applications of those results are transforming the material and social conditions of human life. A fully consistent 'humanist' critic must not merely point out the sterility (in his terms) of knowledge of the natural world but he must also deny the human value of modern scientific technology. The latter task can be done, but only by fabricating a legend of some bygone 'good old days' when men were poor but happy, or by denying the human importance of the majority of the human race.[102]

While the proposition by Jerome Ravetz above focuses on the interplay between science and its eventual technological impact on society, the same is true for basic science. Our collective understanding of the universe has changed drastically from the time when we thought the world was 5,000 years old. We have seen the births of stars, explored the inside of atoms, and are trying to dissect everything that we can about this universe. That is intrinsic value that has been added to our society.

The continual human confidence in science demonstrates the value we place on science as a society. While there seems to have been a shift in public opinion about the "professionals" since the confidence of the technocrats of the early and mid-twentieth century, the public nonetheless believes that there is value *knowing* scientifically. A 2010-2014 World Values Survey, found that a majority of adults believe that knowing about science is important in their daily lives.[103] A majority of Americans enjoy keeping up with science news "a lot," or "some,"

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101. Peter F. Drucker, The Age of Discontinuity; Guidelines to Our Changing Society, 1st ed. (New York: Harper & Row, 1969), 370.

102. Jerome R. Ravetz, Scientific Knowledge and Its Social Problems (Oxford: Clarendon Press, 1971), 24.

103. WORLD VALUES SURVEY Wave 6 2010-2014 OFFICIAL AGGREGATE v.20141107. World Values Survey Association (www.worldvaluessurvey.org). Aggregate File Producer: Asep/JDS, Madrid SPAIN.

and also believe that science has made life easier for most people. Projects such as the International Space Station receive broad public support.[104] It is quite clear that many Americans value science. However, as was found in the first chapter, what is not important is whether Americans *want* to fund science, or if they believe in the outcomes of science. What matters is whether they value science. It seems, from public opinion data, that they do.

What has been shown here is a brief overview as to how and why one may believe that there is a basic need to understand how the world works, and how science could be a means of satisfying that need. It has also been shown that the public values science, they enjoy science, and they support science. Given those realities, it is now easier to address whether the Hubble Space Telescope or the Superconducting Supercollider were worthy of receiving government support.

The Hubble Space Telescope

It is important to note that the benefits, meeting of basic needs, and value of Hubble are analyzed retrospectively here.[105] While any such field, in attempting to demonstrate its justification for receiving government support, would need to demonstrate an ability for projects in the field to meet the criteria set forth in the first chapter, there is no problem with a retrospective analysis of Hubble. The question here, then, is *was the government properly justified in granting support*? If the answer is yes, then the fields of astronomy, astrophysics, and cosmology could point to similar observatories in the future and indicate how they would produce benefits, meet basic needs, or be valued in new and different ways. Furthermore, the

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104. Cary Funk and Lee Rainie, *Public and Scientists' Views on Science and Society* (Pew Research Center's Internet & American Life Project, January 29, 2015), http://www.pewinternet.org/2015/01/29/public-and-scientists-views-on-science-and-society/.

105. Of course, this is not possible for the SSC. However, as these two projects are not being *compared*, per se, this should not be an issue.

question for this chapter was not whether this justification should thus usher in support for the fields, but simply whether it is possible, theoretically, for basic physics to meet the criteria set forth in chapter one. Lastly, though Hubble is analyzed retrospectively, none of the outcomes of Hubble (except for its incredible longevity) were *unexpected* in an astounding way. The impact of Hubble was predicted by the scientific community,[106] and though perhaps it has outperformed expectations, no grand unexpected discoveries were made that would drastically alter the value, benefits, or ability of Hubble to meet basic needs.

Benefit production

The Hubble Space Telescope has been of tremendous benefit to many people. The more-than $10 billion associated with the HST, in addition to paying for material costs, contributed to the economic benefit of many people associated with NASA, the Space Telescope Science Institute (STScI), the Marshall Space Flight Center (where the HST was constructed), the Goddard Space Flight Center (from where Hubble is administered), and surrounding communities. The scientists who planned and now use Hubble and the technicians who built and maintain Hubble are direct recipients of economic benefit of Hubble. Hubble has benefited many people economically over the last 25 years.

Additionally, it is safe to assume that there are secondary material beneficiaries from Hubble. The Marshall Space Flight Center is located in Huntsville, Alabama; Goddard Space Flight Center is located in Greenbelt, Maryland, and STScI is located on the campus of Johns Hopkins University in Baltimore, Maryland. The communities directly associated with the operations of Hubble would receive an economic benefit of being located near these loci of operations.

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106. Waldrop, "Looking Forward to Hubble."

In addition to the economic benefits of the HST derived from the operations of the HST, there has been great impact within the scientific community more broadly. The HST has been cited in more than 10,000 published scientific papers, which demonstrates the benefits derived from its creation. Astronomers, astrophysicists, and cosmologists are able to work in, and advance, their fields. In this case, there are multiple benefits to the HST. Firstly, there are economic benefits for the researchers who receive grants to conduct research with the HST. Secondly, there are the benefits that the field derives from this research being conducted.

The results from Hubble have also been very well received by the public. Might it be possible to say that they, too, have benefitted from Hubble? Though the economic benefits have already been mentioned, there may be more abstract benefits as well. The 2010 report *New Worlds, New Horizons in Astronomy and Astrophysics* assessed the public benefits of astronomy broadly. It found that photos from Hubble engaged the public with science. They found that astronomy and astrophysics engages the public in huge numbers — drawing them to planetariums, to read about science, etc. It also aids in advancing "science literacy" in the United States, given that astronomy encompasses many fundamental ideas from physics such as optics, relativity, gravitation, etc. Though it would be fair to assume that the authors of the report were indeed searching for benefits, their conclusions are nonetheless important to consider:

> Astronomical research continues to offer significant benefits to the nation beyond astronomical discoveries. These benefits include its role in capturing the public's attention and thereby promoting general science literacy and proficiency, its service as a gateway to science, technology, engineering, and mathematics careers, and a number of important and often unexpected technological spin-offs.[107]

Hubble has done an incredible service to science, astronomy, astrophysics, and the

107. National Research Council (U.S.)., ed., New Worlds, New Horizons in Astronomy and Astrophysics (Washington, D.C: National Academies Press, 2010), 114.

general public by engaging the public with issues of science.

Basic needs

From the discussion held earlier regarding the basic need of understanding, it seems as if the Hubble Space Telescope and the work that it produced would meet this basic need, if it in fact exists. Hubble allows scientists — and the public — to peer into the history of the Universe, exploring the creation of the earliest stars, the death of galaxies, etc. Due to Hubble, we better understand the structure of the universe and its associated galaxies, solar systems, and planets.

Insofar as Hubble has been able to answer our questions about the origins of the universe in a manner unlike any other telescope to-date, it seems that Hubble would be able to efficiently meet our basic need to seek understanding. Hubble has met this basic need not only for the thousands of astronomers who have worked with the data from Hubble, but also the general public which has learned from Hubble. Nonetheless, it is not clear that anyone would be *harmed* if Hubble had never been created, or if Hubble ceased operations tomorrow. Though Hubble meets an extended conception of basic needs, a more limited conception seems to leave Hubble incapable of meeting basic needs. Hubble does not lead to physical or emotional safety, nor any other common-sense approach to basic needs. Thus, its ability to meet a conservative conception of basic needs has *not* been demonstrated.

Intrinsic value

As a culture, it seems many of us place high value on being able to understand the night sky and explore space. Astronomy has been an incredibly valuable aspect of many cultures for most of recorded human history. The Greeks, Chinese, Babylonians, and myriad other ancient cultures all had forms of astronomy. Today, we know much more about our solar system, yet there is plenty about the universe that we do not know. Hubble is a logical extension to the astronomy of the ancient and contemporary worlds, demonstrating the continued value many in our culture place on having knowledge about the surrounding universe. In that manner, then, Hubble is valuable because it is part of our ability to explore the night sky.

However, an important distinction needs to be made. *Hubble* is a system of instruments, mirrors, and infrastructure orbiting earth. Hubble can be valued for the fact that it represents a pinnacle of human engineering, an impressive feat of ingenuity, design, and implantation. Hubble represents a great success for science and the scientific community, and there is indeed intrinsic value to Hubble's existence. Much like the value of Sputnik, Hubble is valuable because it represents an impressive example of the things of which humanity is capable. However, Hubble is not valued just for its physical presence and what that represents, but also for the data it records and the information we interpret. Though distinct from the physical Hubble, the actual purpose of Hubble can still be analyzed for its intrinsic value, even if it is a process that involves work and analysis.

Hubble is certainly valued because of its ability to explore the universe. It produces beautiful images that are striking not because we understand them, but because we find value in seeing and exploring the universe. For example, many people find meaning in the photograph of the *Pillars of Creation* not because it demonstrates many important scientific processes, but because of the striking beauty of the image. In fact, many associate the image with God and creation of the universe, even though these meanings are completely distinct from the scientific meaning.[108] The data from Hubble is striking, beautiful, and of value because we see beauty in possessing images from the universe.

Therefore, it seems that, Hubble possesses intrinsic value. The intrinsic value of Hubble

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108. Joshua M. Greenberg, "Creating the 'Pillars': Multiple Meanings of a Hubble Image," *Public Understanding of Science* 13, no. 1 (January 1, 2004), 83–95, doi:10.1177/0963662504042693.

can be found in the impressive feat of engineering that allowed for its creation, and also for the fact that it allows us to peer into the universe and see its beauty. It seems as if there is broad valuation for those two things, given both public opinion polling and cultural and historical trends.

The Superconducting Supercollider

Benefit Production

Similarly to the Hubble Space Telescope, the Superconducting supercollider provided many material benefits, and perhaps would have provided other benefits as well, had it been able to commence operations. $2 billion was spent on the construction of the SSC, which went towards construction costs, production costs, local development of Waxahachie, Texas, and the salaries for hundreds of physicists who were part of the development of the project. These economic benefits would have continued well into the future, with another $8 billion planned for construction, and very high operational costs.

Furthermore, particle physics often produces benefits beyond the material benefit of producing something very large and expensive. Had it been successful, it may have energized the field of particle physics. It may have engaged the public with ideas of the field, and it may have had other benefits. Particle physics has been vital in the development of superconducting materials, magnetic materials, treatments for cancer, and the development of nuclear weapons and energy.

From a romanticized point of view, the SSC would have benefited humanity insofar as it would have furthered our understanding of the basic structure of life, the universe, and everything we know. Particle physics explores the scale of the very, very small, and our understanding of particle physics benefits humanity insofar as it furthers our understanding of how the universe works. It provides another avenue for science education, engagement with science, and an understanding of how the world works.

Basic Needs

It appears that particle physics, and hence the SSC, would fall within the same conception of meeting our basic needs as the Hubble Space Telescope. If we have a basic need to understand that which is around us, then the SSC may meet that need. The SSC allows humanity to peer into the smallest parts of the universe. With the data the SSC would have provided, we would have been able to better understand the structure of subatomic particles, which would have allowed us to have a better understanding of the very fundamental forces of nature. Particle physicists strive to understand the basis for our universe and create models for understanding how everything around us works.

Beyond the fact that an expanded conception of basic needs would be required to entertain this idea, the SSC faces another challenge. It is unclear whether the questions answered by the SSC are *too* fundamental. Most people do not have a conception of the structure of protons and neutrons. Supersymmetry means absolutely nothing. Can the SSC meet the basic need for human beings to seek understanding of the world if the questions that the SSC is answering are too fundamental to be relevant to most people?

The answer to this question lies in the ability of scientists to make these questions relevant to the public. For example, the LHC found the Higgs Boson in 2012. In the process leading up to the announcement, and the months that followed, scientists spent substantial time explaining the significance of the discovery to the general public.[109] Though the terminology

109. The Standard Model is the dominant theory that explains the structure of the atoms and the relationship between the electromagnetic force, the weak force, and the strong force. What was unexplained was why particles have mass, especially given that there appears to be no pattern to the masses that exist. In order to

often irked scientists — the Higgs Boson was referred to as the "God Particle" — the public campaign to engage the public nonetheless persevered. This was an opportunity for scientists to demonstrate the purpose of particle accelerators in the modern age. They had the chance to educate the public and demonstrate how this was increasing our ability to understand the universe.

A 2012 poll found that 29% of Americans had followed the announcement of the Higgs boson "very" or "somewhat" closely.[110] Given the skepticism surrounding the conception of a *basic need for understanding* as it is, the fact that the SSC has such a limited audience does not bode well for it to have met even this extension of the conception of basic needs. Even if there is a basic need to seek understanding, it seems as if very few people would have this need met by any discovery from the SSC. The information is too esoteric and removed to satiate most people. Even those "following the announcement of the Higgs boson very closely" likely would not have a basic need met by its discovery. Though the scientists at the SSC could perhaps argue that the SSC would have met our basic need to seek understanding, this claim seems unlikely at best.

Intrinsic Value

The intrinsic value of the SSC is due to the value of the discoveries that it would have made. The SSC would have allowed us to peer into the smallest levels and highest energies we can encounter. We would have been able to better understand the universe. With the experimental confirmation of theory (or disproval of theory) provided by the SSC, we would have been able to form a much more coherent picture as to why the universe works the way it does. The SSC would have explained, essentially, why the world is the way it is.

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explain the massive nature of particles, Peter Higgs (among others) created a theory that there exists a field that interacts the fundamental particles to imbue them with mass.

110. *Colorado Rampage Tops News Interest for July*, Polling Report (Washington, D.C: Pew Research Center, August 8, 2012).

Particle accelerators were often called the "Cathedrals of the 20th Century,"[111,112] and much in the same way cathedrals have historically been the pride of many cities, there is a certain feeling among many that the United States should produce the best research facilities in the world. Many consider scientific discoveries as being part of the "prestige of the nation."[113] Thus, many may see value at having built the accelerator and made the discoveries, rather than the Europeans or others. This viewpoint is based in a rather antiquated notion of scientific competition between nation-states and the possession of scientific knowledge.

The particle physics done at the SSC has its origins in alchemy and the ancient world. The ancient Greeks originally proposed that matter was made of indivisible units — atoms. Though this theory did not prevail until more recently, the philosophical question as to the origins of matter span millennia. As such, it would seem that we value understanding how the world works. Even if most people do not need to understand the structure of a proton, there is value placed on this pinnacle of human achievement; the delving into the smaller and smaller, the unknown that can explain why everything works the way that it does. Nonetheless, the conviction of this value is unclear. This is partially due to lack of public opinion data, but also due to the fact that the science that would have been conducted at the SSC is very esoteric.

Funding the HST and the SSC

Having analyzed the benefits, ability to meet basic needs, and value of the Hubble Space Telescope and the Superconducting Supercollider, it now seems to be time to actually answer the original question: is the government justified in funding non-practical projects, such as the HST

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111. Sproull, "Federal Support of Science and Technology," 40-41.

112. Daniel Kevles, "Good-Bye to the SSC: On the Life and Death of the Superconducting Super Collider," 17.

113. Alan Dean L., "Mounting a National Space Program," in *Science and Resources: Prospects and Implications of Technological Advance*, 1st ed. (Baltimore: The Johns Hopkins Press, 1959), 227.

or the SSC?

From the analysis conducted, it seems that the HST was justified in receiving government support.[114] The HST generates sufficient material, educational, and societal benefits. Hubble has done a phenomenal job of engaging the public in science, and by doing so, has benefitted both the scientific community and the public — by educating them about science and engaging them with the scientific community. If one were to agree to the conception of the basic need to seek understanding of the universe, it is would be clear that the Hubble Space Telescope meets that need. However, as stated earlier, though a project could meet a basic need, if that need is already satisfied, the government need not continue to supply funds. Simply put, though Hubble could surely meet the basic need of understanding, — if it exists — the government does not seem to be justified on the basis of the necessity of meeting that basic need through such an endeavor. The intrinsic value of Hubble not only emanates from its impressive feats of engineering, but also from the images it produces. People value being able to see worlds beyond our own, and Hubble provides them that value. The intrinsic value of the Hubble images cannot be overstated.

Therefore, Hubble meets the criteria for funding. It benefits many members of society and its existence is of value to the public. The government was rightly justified in funding Hubble. Not only was the government *justified* in funding Hubble, this examination demonstrated that it *ought* to fund astrophysics research — Hubble included. Given the historical trends for the value of science, coupled with the fact that astronomy could not advance without patronage from the government, it seems that something with high intrinsic value would not survive without government support. Hubble is of high value to many Americans and scientists. It has also benefitted many Americans, through direct, secondary, and indirect means. Having

114. Though this analysis is retrospective, it has bearing on future justifications for the field, and is illustrative of whether it is possible for any such program to be justified.

demonstrated that this subfield of basic research in physics is justified in receiving government support, future representatives of the field could point to the fact that there are endeavors set forth by astrophysics that are justified to receive government support, and compelling in their claim for that support.

Though the SSC was never built, it is clear that it had already begun to materially benefit scientists and many others who lived near its construction site. It is possible that the SSC would have also benefitted the public through engagement with and education about the fundamental aspects of our universe. There has been public engagement with the Large Hadron Collider in Geneva, which seems to indicate that the public also would have benefitted from the creation of the SSC. However, it does not seem as if the SSC would have met the basic needs of many people, or that those needs could not have been met through other, less costly, measures. The public does seem to value advancing our understanding of science, even if they do not always understand it themselves. Given that, the SSC could have advocated for its funding on that basis alone. As was stated in the first chapter, given that the public does not always understand science, if they admit to valuing it, they must leave the actual decisions to the scientists.

The difficulty for the SSC was the lack of unity by scientists. Many disagreed as to whether the next logical step in the progression of particle physics specifically (and science generally) was the construction of the SSC. Given that the accelerator was incredibly costly and was not supported by many scientists, it certainly would have had difficulty garnering support even without the intervention of Congress. As such, though the construction of the SSC could have been justified at a purely theoretical level, there were other pitfalls that rightly led to its controversy. That is to say that, though perhaps the government had the right to fund the SSC, it was far from obliged to do so.

Importantly, this demonstrates that even when a project may have been justified on theoretical grounds, it does not guarantee its construction and operation. Both Hubble and the Superconducting Supercollider met sufficient criteria for the government to have paid for their funding. The HST and the SSC were two of the most expensive projects of the 1980s and 1990s. However, the SSC would have crowded out many projects, and may have been too ambitious a step from where science was in the 1980s. Hubble, on the other hand, was the logical next step from the ground-based observatories in use at the time of its creation. Therefore, within the scientific community and in public opinion, Hubble was able to garner support. The SSC, on the other hand, had difficulty explaining why its construction was necessary as opposed to the LHC. That is not to say that the SSC was not justified, simply that it did not necessarily deserve construction at that point of time.

Conclusion

What can be learned from this exercise, and how can the scientific community use these findings for the future? It seems that those basic research scientists who are wont to referencing the possible external benefits of their work no longer need to make such vague and farfetched promises.

The government can be justified in supporting unapplied programs, even those as expensive and esoteric as basic research in physics. Given that all commonplace justifications have been based in the external benefits, this conclusion was not presupposed at the start of this investigation. Furthermore, it has been shown that barring direct conflict with justice priorities, the government is not only *justified* in funding some unapplied programs, but that the value of those programs sometimes *compels* the government to fund those programs. Astronomy, for example, could not survive and continue to evolve without the patronage of the government. Given the value that the many in the public sphere seem to place in astronomy, it seems that the government ought to support it, to a reasonable extent.

A complaint may be lodged at the argument I have presented here. As I have avoided the issue of justice priorities, have I not set the bar too low, stating that almost every non-applied endeavor would be justified in receiving government funds? I have not. Firstly, it is certainly conceivable that one could propose an unapplied endeavor that met no basic need, provided no benefits, and was of value to no one. "*What if it was of value to very few people, have you not constructed a system that would justify the government to fund those niche projects regardless of all other considerations?*" When pressed, the answer to the previous question is affirmative, yet this masks the reality of the conclusion. Though the government would be *justified* in funding a project that is of interest to a select group of citizens, it would not be obliged to provide funding.

The bar for obligation was set much higher. It requires that the value would disappear without government support. It also requires that a project meet some basic need or generally possesses value according to many citizens — value that would not be preserved if it were not for government support. Furthermore, some people must be benefited from the government support, even if that group itself is also small. Additionally, there was a stipulation for intra-community standards for funding. That indicates that, given that the government usually funds foundations, programs, and departments (rather than providing line-item recommendations for projects) that the communities have at their disposal the freedom to choose among the projects they desire. They may choose an expensive project that would limit spending on many smaller programs, or they may focus on breadth rather than depth. It is not for me to say.

In reality, the findings of this paper are somewhat weak claims. Basic research no longer needs to tie itself to government funding of applied defense technology, or promise unforetold benefits. However, basic research support is now tied to public valuation of science and knowledge creation. The strength to this argument lies in the fact that, rather than requiring each *project* is valued, it was found that so long as the fields producing things *of value in general* to large components of the population, the government would be justified and often obligated in funding these endeavors.

Though I have demonstrated why the government could be justified in funding non-applied programs, and when it ought to fund those programs, there is more work that should be done to advance this topic. Importantly, the challenge of confronting justice priorities must be pursued. What justice priorities should the government fund, and what should happen to other projects that would lose funding due to the funding of these new programs? In this vein, research could be done to see if there is, in fact, a basic need to seek understanding in the world. This could be coupled with research to see how “big science” can meet that need.

As it stands, the government is justified for funding many non-applied endeavors, even basic research in physics. This justification can even bring about an obligation to fund some projects and fields, which is good news for researchers in basic physics. There is no longer the need to latch onto promises of technological spinoff, defense contracts, and other distractions to the true epistemic goal of the field.

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