Science, Technology and the Distribution of Outcomes: Alternative Theories of the "Handicapper General"[1]

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> ***THE YEAR WAS 2081, and everybody was finally equal. They weren't only equal before God and the law. They were equal every which way. Nobody was smarter than anybody else. Nobody was better looking than anybody else. Nobody was stronger or quicker than anybody else. All this equality was due to the 211th, 212th, and 213th Amendments to the Constitution, and to the unceasing vigilance of agents of the United States Handicapper General.***
> ***--Kurt Vonnegut, Jr., Harrison Bergeron, 1961, p. 1.***

I. Introduction: Science, Technology and Equality

Kurt Vonnegut's short story *Harrison Bergeron* tells the story of a family of equals in a society of equals in which government guarantees equality by handicapping the gifted. The story has become a staple of high school English courses, not only because of its brevity, only a couple of pages, but also because it provides grist for discussions of the meanings and implications of equality.

The philosophical core of *Harrison Bergeron* seems consistent with the political culture and political roots of the United States, a nation founded as much on liberty as equality, a country that embraced Social Darwinism even before the name for it was invented. The U.S. Constitution does not mention a social safety net. Historically, the de facto concept of the public interest is economic individualism (Bozeman, 2000). The U.S. was founded on a distrust of the "Handicapper General's" (i.e. government's) authority. As Gary Wills (1999, p. 16) explains, "Americans believe they have a government which is itself against government…there is a positive determination to see

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even in the organs of government itself only anti-governmental values." Wills (p. 17) points out that anti-government myth-making began very early in the life of the nation as "the arguments of Antifederalists *against* the Constitution were said, only a decade or so after the document's ratification, to be embodied in the Constitution." To put it another way, many of the nation's founders would perhaps have been quite sympathetic to the concerns expressed in Vonnegut's short story, more concerned with talented individuals hitting the ceiling than with others hitting bottom.

Vonnegut's *Harrison Bergeron* resonates equally well in today's political environment. The re-examination of affirmative action; a Bush tax cut in which the wealthiest 10% of Americans receive the lion's share of benefits; rapidly escalating CEO salaries and diminishing jobs for entry level workers—these developments signal that the "handicapper general" is asleep on the job or perhaps the job description has changed. An excellent local case in point: In 2002, entering freshmen at Georgia Institute of Technology achieved the highest SAT scores of any entering class at a public university (more than half of these students were from Georgia high schools). At the same time, the state ranked last in high school students' average SAT scores. The ceiling is high and the free fall to the basement a long one.

Another strong element of the American political culture, one ensured by the creatures of the Enlightenment who established the nation, is a faith in the perfectibility of humankind, especially via science and education. However, as one would expect in a nation premised on economic individualism, government support for science has, for the most part, grown from a conviction that science and technology spur economic growth. A great deal of thought is devoted to understanding ways in which the benefits of science and technology are best *produced*, much less thought goes to understanding the ways in which benefits (and costs) are *distributed.*

Our paper focuses on the distribution of science and technology's (S&T) benefits and costs and implications for equality. We are concerned with framing the issues, with concepts of equality, and with factors endemic to S&T that seem to determine or influence distributional outcomes. Some of the questions we examine include:

1) Demonstrably, the mix of benefits and costs of science and technology are presently quite unequal. What factors account for observed disparities?
2) What are the concepts of equality that one can examine with respect to the outcomes of science and technology?
3) The impacts of science and technology cannot be perfectly equal. Absent a perfect distribution of benefits, what types and levels of equality of benefit are possible and desirable?
4) How do characteristics of S&T interact with dimensions of equality to conduce social impacts and how may those impacts be conceptualized?

It seems to us that one reason distributional issues in science and technology have received limited attention is that such outcomes are often viewed as a subset of a larger problem- structural inequality in the U.S. economy. We agree that many, perhaps most, distributional issues in science and technology can be traced back to this root cause. It is socially compelling, but intellectually unchallenging, to determine just why poor people do not generally have access to the latest developments of science and technology- they do not have the money to pay for them (and our society is based on markets that seek to reward producers by allowing them to extract payment for benefit). This question is rife with nuance, but the basic answer, that people who cannot pay often do not benefit, is one welfare economists tackle with glee. While our analysis cannot possibly escape some consideration of the interaction of market economics and science outcomes, the question of greatest interest to us is this: "If we set aside causal explanations accruing directly from structural inequalities in the U.S. economy, how do the norms, regulative processes, institutional designs and behaviors internal to science affect systematically the distribution of outcomes in U.S. society?"

We recognize, of course, that S&T are embedded in a society premised on economic individualism and, thus, it is not possible to provide an economically disembodied analysis. Even if one is only interested in examining the brain of the 2,000 pound gorilla, one still needs to understand that it came from a 2,000 pound gorilla. Thus, after a brief explanation of our use of the terms "science" and "technology," we turn to an overview of the economic roots of S&T and attendant distributive assumptions.

The Relation of Science to Technology: A Simple Solution

How does science relate to technology (Feibleman, 1961)? For present purposes, this is a question we wish summarily to consider. We understand the complexity of the question and we can fully appreciate the hundreds, perhaps thousands, of engaging, sophisticated treatments of the question (see Kranzberg 1967 and 1968 for a synopsis of the question of the unity or disunity of science and technology. Both the practical and intellectual issues flowing from the question are enormous). Is science necessary for innovation and, if so, to what extent and in what ways? Is there a reciprocal causality between technology and science and, if so, how does the causal chain pay out? With popular use, does science at some point *become* technology? Is one more socially embedded than the other? Do the two require separate epistemologies; can technology even be said to have an epistemology?

By providing the illustrative questions, complex questions that have fully warranted the attention they have received, we suggest that providing answers would put a heavy and, we think, unneeded weight on our own arguments, a weight sufficient to sink the arguments before they even began to swim. Thus, we hope to set aside the relationship between science and technology by providing a simple conception that certainly does not do justice to the complexity of the issue but that seems to suffice for our purposes.

We are not interested, for our purposes, in focusing on differences between science and technology, but we must consider what they have in common. We view science and technology (hereafter S&T) as having this in common: (1) both are based on technical knowledge, that is, knowledge developed through some combination of systematic empirical observation and the use of pre-existing knowledge (including theory but also many other bases of knowledge); (2) both accumulate and are available to other knowledge producers and the utility of the knowledge is certified by others' use (e.g. Bozeman and Rogers, 2001); (3) both are subject to revision on pragmatic grounds; (4) both may be embedded in process and product innovations. This latter feature is especially important. Since our concern is with S&T outcomes, we are content to say that, when taken *together*, almost all *non-natural* physical configurations affecting human beings have their origins in S&T. Many social configurations affecting human beings have their origins in S&T and, of course, most innovations involve the melding of physical device and formal, devised social configurations to affect human beings as "technology delivery systems" (Ezra, 1975). We do not claim that, respectively, science and technology, produce social impacts by identical means and we certainly do not think the that work and work enabling social processes of scientists and engineers are identical. What we do claim is that both science and technology may be embedded the process and product innovations and the systematic knowledge that affects human beings and their quality of life and it is, thus, defensible to consider science and technology together as a single force affecting and producing change in human beings.

II. Neo-classical Economics and Production Function S&T

Our interest is in the distribution of S&T benefits and costs. With respect to S&T, most of neo-classical economics focuses on production (see Bozeman and Sarewitz, 2003; Bozeman, 2001). There is no "Cobb-Douglas *distribution* function." There is, however, an "impossibility theorem," and it relates directly to questions of optimal social choice. From a public policy perspective, the wellspring of science is the notion that S&T spur economic growth and prosperity. This is an idea that can be traced to the nation's founding. While science was not at the center of discourse surrounding the writing and adoption of the Constitution, the enacted document included one important science-related provision. Paragraph 8 of Section 8, Article I set forth the power explicitly to promote "the Progress of Science and the useful Arts, by securing for limited Time to Authors and Inventors the exclusive Right to their Writings and Discoveries." Under the leadership of C.C. Pinkney, the delegation from South Carolina, one of the leading states in developing patent protections for inventors, pressed (unsuccessfully) for government awards for invention. When the second session of the Constitutional Convention convened in 1790, President George Washington strongly supported a general patent act and urged "giving effectual encouragement" to the "introduction of new and useful inventions from abroad" and "the exertions of skill and genius in producing them at home" (Cohen, 1995: 243).

The Founding Fathers recognized the commercial benefits of science but there is no reason to believe that those assembled in Philadelphia in 1789-90 had any notion that science could be the primary driving force in the economy. In the pre-industrial, agriculturally dominated society of the late 18th Century, applied science was seen as possibly contributing to inventions of new farm implements. The very notion of "science" was much more embracing than today and included not only formal, experiment-based physical and natural science, but also tinkering, craft, and, in some contexts, any approach to systematic learning, including John Adams' idea of "science of government" (Cohen, 1995).

From the nation's founding to the early part of the 20th Century, publicly supported science was viewed as having an economic role, but a limited one, certainly something less than "engine of the economy." As Hunter Dupree (1986) explains, industry-based applied science was viewed as an enhancement to agricultural development and to manufacturing, not as a driving force behind them. Nevertheless, from the four formal industry research laboratories the U.S. could claim in 1890, by 1930 more than 1,000 had been established (Thackray, Sturchio, and Bud, 1985). But even well into the 20th Century, the Edison-style independent or corporate inventor was viewed as much more central than institutionalized science to commerce. Similarly, while universities had transformed themselves from seminaries and finishing schools for the wealthy into broad-based centers for liberal studies, sciences and engineering, the idea that the university research could fuel the economy had yet to be invented.

The notion of science as engine of economic growth gained "an overwhelming grip on the public imagination" (Poggi, 1978) in the U.S., and much of the developed world, in the postwar era. Several factors account for this qualitative change in perceptions about the role of science. The most obvious factor is the power of science demonstrated through the atomic bomb and the Manhattan Project and the rush by scientists and politicians to prove that science could be as awe-inspiring in its peacetime applications as it had been in the war. But many other factors were nearly as important, including (1) the new-found confidence in managing the economy through Keynesian ideas and frameworks, (2) the establishment in the U.S. of strong, institutionalized science in industry and, after the war, in government laboratories, and, (3) the eager assumption of the mantel of "world leadership" thrust on the U.S. by recovering nations in Europe and Asia.

The forces converging after World War II that shaped the "science as engine of the economy" myth have been analyzed in depth by others (e.g. Kleinman, 1995; Brooks, 1996; Guston, 2000). Our concern is not with the history of the myth but with its residue. Simply stated, the "science as engine of the economy" myth holds that the U.S. economy is critically dependent upon technological innovation as a source of growth and that science is the primary ingredient fueling technological innovation. Some variants of the myth embrace the notion of a "linear model," that basic science leads to applied science and technological development in a more or less linear fashion. A usually unspoken linkage in the model (unspoken because "obvious") is that developed technologies are manufactured, marketed, profitable, and contribute to economic growth and technological progress.

The extent to which science and technology contribute to economic growth is a matter about which many economists speculate and, indeed, some have won Nobel prizes for their speculations. But there is no widespread agreement about the magnitude of science and technology's contribution (though no well known economists suggest that the contribution is a small one). Nor is there much agreement on the particular ways in which science and technology are interdependent, on the extent to which the process leading from science to commercial product is in any significant sense a linear one, or even on the extent to which the forces of scientific and technological "creative destruction" (Schumpeter, 1946) are responsive to public policy manipulation. In short, there is only one point of consensus: that science and technology are vital to U.S. economic growth.

If one looks at the evidence, both case studies (Nelson, Peck and Kalachek, 1967; Rosenbloom and Spencer, 1996; Mowery and Rosenberg, 1989) and econometric studies (e.g. Griliches, 1995; Jones, 1995; Denison, 1962), "science as the engine of economic growth" is difficult to challenge. Whether familiar estimates (Solow, 1957; Bureau of Labor Statistics, 1989) are correct and the contribution of science and technology is 30%, more, or less, depends upon the particular combination of unrealistic assumptions one wishes to embrace. But the contribution science and technology, when taken along with education and human capital, does, indeed, seem to account for the majority of economic growth in most industrialized nations.

Our concern with the "science as engine of the economy" myth has nothing to do with its veracity. Rather, we are concerned that the power of this market myth sometimes overwhelms our ability to think systematically about the "science as the engine of *social* change." A second concern is that this market myth, and the other two as well, are powerful forces for conservatism. When taken together, the tacit lesson of the three myths is "leave science unfettered and the best of all possible worlds will emerge." The very idea that studies of economic growth employ production function economics says much about the worldview analysts bring to the problem. Growth is taken an object for maximization. While most analysts are, in all likelihood, pursuing a value neutral means of understanding growth, the cumulative effect of seeking knowledge for the maximization of growth (when taken with a world-wide social obsession with monitoring growth rates) is that it is all too possible to begin thinking of science and technology exclusively in terms of their contribution to economic growth while giving short shrift to the effects on social change, quality of life, or even equitable growth. There is no conspiracy; but the constant framing of public dialog and science and technology policy agendas in terms of economic growth has a limiting and conservative effect. Moreover, it is arguable that science's contribution to economic growth *is* best attained with relatively limited government planning and adjustment. But it is clearly not the case that quality of life goals or social goals will be achieved by a "hands off" approach. If one maximizes the science and technology's contribution to economic growth with a light touch aimed chiefly at adjusting tax rates and policies and cannot "maximize" science and technology's contribution to social goals by so light a touch, then we see that the ascendance of laissez faire thinking about economic growth has predictable consequences for the achievement through science of social goals: it makes them prisoner to production function reasoning.

When social goals take a back seat to economic growth no harm occurs if we assume that social and economic growth goals are entirely compatible. No one believes this. Consider one of the greatest technology-economic growth success stories of the 20th century- the commercially viable automobile. From an economic growth standpoint, the automobile has stimulated growth in almost every way imaginable and, of course, has changed lives in ways that were entirely unpredictable. Consider Baram's (1971: 536) assessment:

> The automobile represents the ultimate absurdity. The automobile birthrate is now treble the human birthrate in the United States: 10 million automobiles are produced for every 3 million human beings. Death rates occur in a similar ratio. Automobiles produce most of our air pollution, are dangerously designed, and are not economically recycled. How much longer can these absurd ratios and harmful effects be tolerated, despite the importance of the industry to the economy?

No one fails to recognize the power of science as an agent of social change and, by this point in our history, most people are well aware of that almost all fundamental technical change is a double edged sword. Our point is that the primary driver of science policy, to the extent there is a driver at all, is economic growth, not social goals. Because of the pre-eminence of market myths in science policy, it is not easy to link science and social goals. No social change theory of science exists as an equivalent to economic growth theories of science, no comparable methods and theory-linked measures exist and, indeed, there is not even an adequate parlance for discussing science in terms of social goals.

“Science as the engine of social change,” entails a different set of ideals and, perhaps, a different set of social institutions. The key ideal of this counter-myth is that science should, first and foremost, be a force for positive social change, for improving quality of life, and that economic growth created by science is beneficial to the extent it forwards quality of life. There is good reason to believe that for everyone economic wherewithal is a vital part of quality of life. But if Robert Lane’s work (1991; 2000) on the relationship between materialism and happiness rings true, then the level of material well being sufficient for a high quality life is reached at a relatively low threshold.

It one believes that the science portfolio leading to highest quality of life differs from the science portfolio leading to the greatest economic growth, then an unplanned, laissez faire approach to science seems less tenable. No one posits an efficient social choice market, much less an invisible hand insuring optimal outcomes.

In their classic treatment of the convergence of politics and economics, Dahl and Lindblom (1953: 161-168) contemplate reasons why economics centered on choice and allocation as a central problem for the discipline. As they note, “(h)ow different this situation might have been had economists felt the same enthusiasm for defining an optimum distribution of income as for an optimum allocation of resources, if they had pushed with vigor the equalitarian notions that some of them believed their cursory explorations in ideal or preferred distribution forced upon them” (Dahl and Lindblom, 1953: 163). Dahl and Lindblom go on the explain the attraction of economists to choice and allocation questions as owing to several factors, including the fact that choice and allocation questions lend themselves to the construction of mathematical models through which maximization problems could be precisely examined. One result of proscribing economics in this fashion is that "morally, politically, and intellectually, the economist was spared by his concentration on (the technical aspects of) choice-allocation processes. It was interesting to see how he attempted to find a place for the other processes under the choice-allocation rubric in order to extend his field without losing its advantages" (Dahl and Lindblom, 1953: 163). The analysis presented below presents no such advantage. In analyzing the distributional issues in science, one must at this point proceed with speculation rather than well-honed analytical tools. But the lack of analytical tools appropriate for the question is certainly not the most important problem of analysis.

III. Equality and Equity Issues in Science and Technology

The challenge of linking science to social goals begins with articulating relevant social goals. Our straw man for this endeavor is the Handicapper General in Vonnegut's Harrison Bergeron. By emphasizing an overly simplistic notion of equality – a notion writers on distributive justice have termed "absolute equality of outcomes" (Cook and Hegtvedt 1983) – the policies of the Handicapper General bring about a social state in which individuality and creativity are sacrificed to homogeneity and conformity. If we are to improve upon the Handicapper General, therefore, we must accept the inevitability – even desirability in certain cases – of unequal outcomes, and search for a more nuanced understanding of the types of equality we can confidently and responsibly stand for. Although this is undoubtedly a process that will demand continual refinement, even a tentative articulation of valued social goals should allow us to begin to deepen our understanding of the social impacts of scientific and technological processes. We can view such value articulations as “alternative theories of the Handicapper General.” (See Table 1).

Table 1: "Alternative Theories of the Handicapper General"
Four Notions of Equality, and their Links to S&T

Type of Equality - Value Statements	**Links between value for equality and scientific knowledge / technological applications** (Relevant literature and/or research in parentheses).
Political Equality People affected by political decisions should have the opportunity to democratically participate in those decisions.	**Knowledge/technical capacities are necessary for engagement in political processes, specifically:** -Access and ability to use information technology may be needed to gather relevant information. (Kellog and Mathur 2003) -A basic understanding of scientific principles is necessary to interpret scientific and technical information. (Plough and Krimsky 1990, Fielder 1992, Epstein 2000, Tesh 2003) -Being counted / making one's voice heard may require access to knowledge or technology pathways, such as voting booths, participatory citizens' panels, and communications technologies. (Sclove 2000, Kakabadse et al. 2003) -Knowledge sharing and political empowerment may require access to, and ability to utilize information and communication technologies. (Epstein 2000) General Discussion: (Winner 1992, Kleinman 2000, Mossberger et al. 2003)
Equality of Economic Opportunity People should have the opportunity to compete in the marketplace, and reap rewards as a function of their ability and effort.	**Knowledge/technical capacities are prerequisites for competitions in the marketplace, specifically:** -Possessing adequate education to understand and be able to use workplace technologies. (Solomon et al. 2002) -Access to, and ability to utilize information and communication technologies for social networking. (Schiller 1996, Wresch 1996, Thomas and Wyatt 2000, Warschauer 2003, Wilson 2003, Wyatt 2000) -Access to appropriate assistive technologies, if one is handicapped. (National Council on Disability 2001) General Discussion: (Caswill and Shove 2000, Wyatt 2000)
Equality of Basic Needs There is a certain basic minimum that all members of society should be provided, regardless of merit.	**Knowledge/technical capacities are needed to insure people's basic needs are met, specifically:** -Appropriate agricultural technology to grow food, and efficient and equitable systems to distribute it. (Jordan 1998, Kimbrell 1998, Altieri and Rosset 1999, Persley and Lantin 1999, Shiva 1993 and 1999, Senker 2003) -Affordable health maintenance technologies (medicines, tests, therapies, etc.), and access to basic health information (nutrition, reproductive health, etc.). (Stepan 1978, Farmer 1999, Tesh 1998) -Environmental health science, and sanitation technologies to insure clean land, air, and water. (Tesh 2000) -Affordable construction technology to provide basic shelter. (Coleman 1988) General Discussion:
Organismal Equality -People should not be discriminated against on the basis of biological characteristics. -Certain biological manipulations that confer excess advantage based on people's ability to pay should be constrained.	**Some of scientific knowledge and/or technological application -- given some notion of organismal equality -- may warrant regulation, specifically:** -Genetic screening, genetic manipulation, reproductive technologies (Botkin 1998, Silver 1998, Pence 1998, Pence 2000) -Nanotechnology (Tsuruoka 2003) -Neurobiological augmentation (McKibben 2003) General Discussion: (McKenney 1998)

Since the articulation of values is a normative task, it is important that we make explicit our philosophical underpinnings and predispositions. In our articulation of a framework for understanding social equality, we adopt an approach that represents both pluralist and pragmatic ways of thinking about and approaching problems. We adopt a pluralist approach to the extent that we dismiss the notion that one definition or articulation of equality will be relevant in all circumstances. Ostensibly, reducing social equality to one monothetic entity is the mistake made by the Handicapper General. The validity of a pluralist conception of equality is affirmed by recent scholars of distributive justice, who emphasize that our conceptions of equality necessarily depend on the context they are applied in (Miller and Walzer 1995, Miller 1999). The pragmatic aspect of our approach is a reflection of the fact that neither are we ethical scholars, nor do we wish to put forward a notion of equality which sounds good in theory but is hopelessly utopian or unrealistic in practice. Our strategy, therefore, is to follow the pragmatics of precedence articulated by Oliver Wendell Holmes, C.S. Pearce and others (Menand 2001). The essence of this strategy is to look for ethical concepts of equality that already are accepted, both ideologically and practically, by the general public of the United States, and to adapt them to our discussion of the social impacts of scientific and technological processes.

While absolute equality of outcomes is clearly not a dominant social value in the United States, there are other notions of equality that are present in the ideologies and mythologies that underpin our national character. That moral commitments to certain notions of equality exist is evidenced by the existence of countless governmental bodies and legislative acts designed to uphold these values. A primary motivation for this paper is that, although the institutions are in place for upholding our commitments to the kinds of equality we articulate for certain sectors of society – for example, in housing, education, and employment – such institutions are conspicuously absent from the domains of science and technology.

Our strategy is to draw on and adapt the rich body of literature in the field of distributive justice to articulate four types of equality that we believe are embraced by American society, have been promoted in different ways at different times, and are directly or indirectly impacted by the advancement of scientific knowledge and technological development. As seen in Table 1, they are: Political Equality, Equality of Economic Opportunity, Equality of Basic Needs Fulfillment, and Organismal Equality. Even though we don't always live by these values, nor do we necessarily all agree on all of them all of the time, we argue that their embededness in our ideology and practical institutions makes them worth looking into – at least as starting points from which further debate can ensue.

Before delving deeper into the different types of equality, and their connections to scientific and technological domains, it is important to point out that these are not orthogonal categories: the same scientific processes may impact both Political Equality and Equality of Opportunity, for example. However, by keeping them separate to start with, the four categories will act as value dimensions against which we can measure whether or not, and how much, the costs and benefits of science and technology are mal-distributed. Furthermore, such a multifaceted approach maximizes the points of entry into the complex connections between science and equality, and provides us with a ready-made framework within which to mount an exploration of previous literature and research into the nature of the relationship S&T and equality.   Eventually, of course, we will want to study the interconnections between different types of equality and the scientific processes that impact them.

Political Equality

A value for political equality implies that all members of a society should have an equal opportunity to participate in the democratic institutions which govern society, and particularly in the decisions that affect their own lives. Ideologically, the United States was founded on this principle. Practically, U.S. history can be seen as a history of groups struggling to achieve a semblance of political equality. African American voting history presents the most cogent example: with the ratification of the 15th Amendment to the Constitution in 1870, African Americans were granted the right to vote, leading to at least a century of attempts by both private individuals and public institutions to prevent them from expressing this right.. In 1965, President Johnson passes the Voting Rights Act, reminding Congress that "we cannot have government for all the people until we first make certain it is government of and by all the people." And the struggle continues: as recently as the last national election, allegations surfaced that African Americans and members of other minority groups were denied political equality.

While historical methods of denying political equality to members of certain groups included a variety of subtle and not so subtle means, the realities of the modern information society create a situation in which no conspiracy is necessary for the diminishment of individuals' or groups' abilities to participate in the political process. All that is necessary is that the process require knowledge and/or technical capacities that are obtainable to some, but not to others. Such capacities might include access to and ability to use information technology to gather relevant information (Kellog and Mathur 2003), a basic understanding of the scientific principles needed to interpret relevant scientific and technical information (Plough and Krimsky 1990, Fielder 1992, Epstein 2000, Tesh 2003), access to knowledge or technology pathways that allow ones' voice to be heard (Sclove 2000, Kakabadse et al. 2003), or access to, and ability to utilize information and communication technologies that facilitate networking for political empowerment.

Reconciling the technical aspects of modern society with a value for political equality is not a simple task. Indeed, some writers have argued that the technical nature of many modern political debates necessitates exclusion from the political process of citizens who lack the requisite knowledge base, on the grounds that such participation is dangerous because it will lead to poor decision-making (Levitt and Gross 1994). Plough and Krimsky (1990, see also Fielder 1992) describe modern technical debates as embodying a confrontation between two ways of thinking and communicating: "technical rationality" on the one hand and "cultural rationality" on the other. Alternatively, Tesh (2000) argues that ordinary citizens are capable of engaging in scientific discourse, but are often prevented by lack of access to financial, technical, and informational resources. This is further demonstrated by Kellog and Mathur (2003) who show how members of poor communities often lack the ability to participate in debates over environmental pollutants because of the EPA's over-reliance on the internet as a means for both distributing and receiving information.

There is at least some evidence that ordinary citizens can play important roles in technological decision-making (Epstein 2000, Kleinman 2000). For example, in the late 1980s and early 1990s, gay AIDS activists played a strong role in determining directions for AIDS research, debating research methodologies, and allocating research funds (Epstein 2000). Yet it can be argued that AIDS activists are a special group, notable for their high levels of income and education (Epstein 2000). In order for members of other groups with less education and/or income, additional social investment may be necessary. Advocates of various forms of participatory action research (Caswill and Shove 2000, Reason and Bradbury 2001, Shensul 2002) and "science shops" (Zaal and Leydesdorff 1987, Wachelder 2003) propose various strategies for the inclusion of ordinary citizens, particularly members of technically and informationally disadvantaged groups, in the political process. An alternative, perhaps complementary strategy is to conduct empirical research on the ways in which current allocations of science and technology result in political inequalities, and the subsequent adoption of policies to redress existing disparities. Either way, a value for political equality compels us to endeavor to minimize the ways gaps in knowledge, technical understanding, and technical capacity diminish democratic participation.

Equality of Economic Opportunity

While our value for political equality approximates absolute equality, in the sense of "one-man-one-vote," our values with respect to economic equality are more complex.

Most importantly, neither our ideology nor our institutions attempt to nurture anything like an equal outcome of income. However, we argue that the idea that the economic game should take place on “an equal playing field” is a value we hold dear. Indeed, we suggest that it is our allegiance to the ideal of equal economic opportunity that often serves as a justification for the extreme inequality of outcomes in terms of wealth and social standing.

Our social value for equality of economic opportunity is expressed in laws and institutions designed to prevent discrimination in employment based on race or gender, and to ensure the availability of a quality education for all young people. Like other social values, equality of economic opportunity is much easier to hold in principle than to realize in practice. One major obstacle to realizing full equality of opportunity results from the fact that past cases of unequal opportunity often play a role in present opportunities (Cook and Hegtvedt 1983). With respect to scientific knowledge, and the technology that has been derived from it, there is the potential that pre-existing disparities in income, education, and social position will be exacerbated. The primary area that researchers have focused on with respect to equality of opportunity is the “digital divide.” It is argued that, in the modern world, the ability to access, adapt, and create knowledge using information technologies is essential for both economic advancement and social inclusion (Warschauer 2003). And the evidence is substantial that both abilities and access are inequitably distributed (Schiller 1996, Warschauer 1996, Wresch 1996, Wyatt and Thomas 2000).

From the literature, two aspects of the digital divide arise as warranting further exploration. The first aspect derives from research which indicates that it is not only access to information and communications technologies that matters, but whether or not one possesses the ability to utilize the technology in ways that will further one's social or economic standing. In this vein, several researchers argue that even when access is relatively equal, disparities in ability results in a clear dividing line between the haves and the have nots (Thomas and Wyatt 2000, Mossberger et al. 2003). This points to a deeper cause: disparities in education levels between students of different income levels, and of different races. As documented by Jonathon Kozol in Savage Inequalities (1991), dollar expenditures on education per child can vary drastically between poorer and wealthier communities, and often along race lines as well. The issue of "digital equity" in the educational system is explored by Solomon et al. (2002).

The second important question that emerges is whether the digital divide is growing, staying the same or shrinking. Some argue that as technology gets cheaper and people catch up to technology, the digital divide will disappear. If this is the case, then present inequalities are actually harbingers of future gains for the temporarily disadvantaged. The alternative view is that the gap may actually be increasing as informational disparities reinforce and strengthen pre-existing structural inequalities. For example, Schiller (1996) argues that commercialization of information technologies may function to increase gaps in access and ability.

The relationships between scientific progress and differential access, and between access and usability are dynamic, and likely depend on the technology in question. To date, the vast majority of research has taken place in communications and information technology. While this is clearly an essential area for research, our aim is to expand the discussion beyond the digital divide to include other technologies that may facilitate people's ability to express themselves as political and economic agents.

Equality of Basic Needs Fulfillment

A value for equality of economic opportunity implies nothing about outcomes. As seen in American society, there is no ceiling on how much one can earn – nor do we argue that there should be. However, a review of our dominant institutions demonstrates that there should perhaps be a floor – a "social minimum" for the provision of certain basic needs (Meeker and Elliot 1987, Doyal and Gough 1991, Scott et al. 2001). Such is the notion of equality that underlies America's welfare and Social Security systems, and which provides the moral backbone for those who advocate a system of Universal Health Care. As evidenced by debates about this last policy, determining needs and arriving at a social minimum is a subjective process (Eckhoff 1974), both with respect to what constitutes a necessary amount of a basic need, as well as to our social responsibility to provide it.

Adding science and technology to the equation complicates matters even further. The outputs of scientific and technological processes have the potential both to satisfy the fulfillment of basic needs, and to inhibit them – in actuality, the impacts are often difficult to sort out. For example, agricultural biotechnology is often touted as a solution to hunger, due to its potential to produce more food on less acreage of land, with less inputs of fertilizer (Rauch 2003). Nevertheless, there is a strong and growing body of literature that suggests that food shortages are rarely the result of inadequate production, but of inadequate distribution (Jordan 1998, Kimbrell 1998, Altieri and Rosset 1999, Shiva 1993 and 1999, Poynter and De Miranda. 2000.). Far from being the solution to world hunger, these authors argue, capital heavy agricultural biotechnology favors large scale export farming over small scale subsistence farming, thus decreasing the ability of the world's poorest people to provide for themselves and their families.

Other types of technologies also present ambiguities as to whether they promote or degrade basic needs fulfillment. Industries can provide jobs and much needed employment, as well as pollute air and water. Advances in weapons technology can enhance safety, or lead to total nuclear annihilation. Medical advances can save lives, but a focus on advances that are commercially profitable can lead to inadequate funding of basic sanitation and nutritional programs for poorer individuals and groups. These and other examples demonstrate that S&T can be the problem, the solution, both, or neither with respect to basic needs fulfillment.

Organismal Equality

The final type of equality we discuss harkens back to Harrison Bergeron and the Handicapper General. In Vonnegut's story, the social imperative is that all members of the society are made physically and cognitively equal, no matter what it takes. Thus, technological accoutrements, designed to cancel out above-average traits and abilities, are assigned on a case by case basis. Elevated intelligence is diminished with the use of high pitched radio waves, plastic surgery is employed to transform beauty into plainness, and athletic prowess is normalized with weighted body suits. On the one hand, the attempt at absolute equality is both ludicrous and oppressive, and Harrison Bergeron is justified to rail against it. On the other hand, we propose that there is a way that we as a society do value absolute equality: that is, we want everyone to remain human.

Recent advances in reproductive technologies (Kolata 1998), and advances on the horizon in genetic engineering (McKenney 1998, Pence 1998 and 2000, Silver 1998), nanotechnology (Tsuruoka 2003), and neurobiology (Mckibben 2003), are challenging our definitions of what it means to be human, and thus open a new frontier for inequality. Author Bill Mckibben poses the metaphor of a motorboat roaring through a lake previously occupied only by canoes to warn of the dangers of technological advancements that will allow humans to boost their brain capacity (2003). Other authors express concern over pre-implantation genetic diagnosis, which can allow parents to select embryos according to desired characteristics, and which will likely have an – uninsurable – price tag in the tens of thousands of dollars (Botkin 1998). According to Silver, children of these advanced technologies would "only account for a fraction of a percent of all the children born on this earth" (143). In addition to allowing some humans to bypass the less fortunate, these technologies may also result in decreasing levels of tolerance for "imperfect" babies (Botkin 1998, Pence 2000), harkening back to the days of eugenics and Social Darwinism.

We think there is a boundary – a fuzzy, changing boundary, but a boundary nonetheless – held by the general public with respect to which alterations of the human organism are acceptable, and which are not. As evidence, we point to the congressional decisions to outlaw certain kinds of stem cell research, and the acceptability of in vitro fertilization. While it is not our work to define the boundary, we do wish to look at how the application of present technologies, and the potential application of future technologies, may push the limits of these boundaries and give inequality a whole new meaning.

IV. A Conceptual Model: S&T Social Impacts

The idea that S&T impacts can be viewed in terms of dimensions of equality of outcome is, perhaps, a first step, but identifying these dimensions tells or implies little about how to affect change. As a next wobbly step we present a conceptual model that discusses the relationship of these S&T equality dimensions to aspects of S&T products, their use, and social impact. Our long-term objective in developing this model is to present a set of hypotheses relating the model's S&T types to particular sets of social outcomes, ultimately providing propositions that could inform public policy and public debate.

Our model includes three constellations of variables,

1. *Equality* of S&T impact (on each of the dimensions identified above);
2. *Distribution* of S&T impact;
3. *Potency* of S&T impact

The S&T Social Impact Model is presented in Figure One.

-Figure One goes here-

In considering the *distribution* of S&T impact, the primary component of the dimension is whether the impact is primarily on the individual or whether it is broader than the individual. If it is broader than the individual then what is the breadth of social impact?

The label *potency* is not so obvious in its meaning, but our chief concern here is with the character of use of S&T. Specifically, is the S&T entity "hedonic" in its use, i.e. when the technology is used by the individual, is the S&T impact fully consumed in the application or is the S&T impact "enabling," i.e. does its use generate capacity for new and different applications? These ideas are discussed more fully below and each is considered in connection with issues of the equality dimensions of S&T impacts.

Distribution of S&T Impacts: Individual vs. Social

This component is best represented by two questions- does the S&T impact solely involve the individual or does it affect groups or aggregations of individuals? If the latter, what is the breadth of the impact. This is an obviously important question if we are to gauge the nature of S&T social impacts, but it is deceptively simple. As with each of the attributes we consider in the model, the attribute is an archetypal concept and, in reality, making distinctions between individual and social impact is quite difficult and, from a teleological perspective it may not be possible to make strict distinctions.

Perhaps the best way to make the point is to provide simple examples. If we observe an individual wearing a set of headphones attached to an MP3 player we can infer that the impact of the technology's use is on the individual. In most instances, others would not know whether the MP3 player was actually operating and, even if we noticed the on light, we may not know what music was playing and we may hear nothing at all from the player. This is a pure type individual impact of a technology's use. This example certainly makes the point we wish to make, but it also illustrates the tricky nature of this concept (and, indeed, our entire conceptualization). First, an apparent difficulty that is not really a difficulty at all. We are citing our MP3 player as an example of the impact of S&T on the individual, but, as we know, there is a market for the MP3 player and there are economic impacts in its creation, its production and sale. But we are not concerned here with the MP3 player itself but with its *use*. There are many social impacts associated with the MP3 player, but we can distinguish the individual's discrete use of the technology as a particular impact. But our illustration is a pure type. As anyone who rides urban subways knows, MP3 players and other music devices are often played at such a high volume that those nearby can hear every note. That is, even in the direct and immediate act of using the technology the user can easily generate impacts on others. To take the distinction to a next level, one could argue that even when the MP3 player is played at a low level, so low that no one else can hear it, and even when the MP3 listener does not hum, dance or engage in other potentially annoying behaviors, there is *still* potential for spillovers from the use of the technology. Another subway rider might well feel that his or her sense of community and well being is diminished if fellow commuters are so engaged in their MP3 technology that the most meager communication is impeded. To put it another way, it is almost impossible to think of any instance of S&T use or impact that is necessarily exclusive to the individual.

This fine point need not overly concern us. In examining the public goods characteristics of physical and social commodities, economists long ago showed us that there are few goods that are either purely public or purely private but that does not mean that the conceptualization is without merit. We can all understand that an individual listening to an MP3 player is a different sort of impact than, say, the subway transportation system itself. In the first case the interaction between the individual and the technology is primal and, once the technology is purchased and batteries are inserted, depends upon little else. In the second case, the subway will not function in the absence of a series of operators, attendants, energy providers who work cooperatively and will not function for long in the absence of a series of support structures including safety inspectors, fare collectors, and such. On the individual-social dimension, the MP3 is at one extreme and the subway system at the other.

Distribution of S&T Impacts: Concentration vs. Dispersion

The most concentrated S&T impact is when its impact is on just one individual. But if the impact is broader than a single individual then we can consider the extent to which the impact is concentrated (or dispersed) across an aggregation, such as a social or demographic group, a nation or even humankind. To illustrate, a question that arises from the concentration-dispersion component is "who benefits from the building of the new coal-fired electrical power plant?" The answer to the question depends upon the definition of benefit, but if what we mean by benefit is cheaper consumer electricity rates then the dispersion-concentration question is amenable to an easy answer (at least so long as there is no attribution error)- we can identify particular individuals whose electricity rates have declined as a result of the new plant coming on line. The concentration-dispersion issue as it relates to costs or "disbenefits." Thus, we might ask, "Who bears the brunt of the air pollution resulting from the new coal-fired electrical power plant?"--technically a much more difficult question but ones that is routinely asked and routinely receives answers, albeit highly variable ones.

Sub-Components of Distributional Issues

From the example, one envisions an increasingly complex set of distributional issues. Thus, one might ask about the *magnitude* of impacts in relation to distribution- if we identify those who suffer negative externalities from pollution, it is quite likely some suffer more than others. If we have knowledge of the who sustains benefits and costs we can presumably calculate the *incidence* of these benefits and costs within particular aggregations, perhaps plotting the incidence by geographic location or demographic attributes.

Potency of S&T Impact

When we use the term "potency" of S&T impact we refer to the ability to produce capacity. We contrast two poles, both pure types, of the potency dimension. If a technology is fully consumable and its use stimulates no new applications or capabilities it is said to be "hedonic." By this meaning, listening to music on an MP3 player is a hedonic impact. That is, the use of the technology is consumed fully in the enjoyment of the music. By contrast, many other technologies are "enabling" in the sense that they permit the individual to perform other tasks or pursue other technological applications and, in that sense, the technology application is not fully consumable. A good example is a computer. By using a computer the individual can, among other things, make on-line purchases, manage personal finances, communicate with friends and strangers, play computer games, engage in Internet banking, study a foreign language, and apply on-line for admission to universities. This is, then, a classic enabling technology. The notion of the "digital divide" is in recognition of the enabling aspect of the technology. There is little concern about the MP3 player divide.

As with each of the dimensions we examine, the case of the potency of the S&T impact is not clear-cut. Most S&T impacts are neither purely hedonic nor purely enabling, at least not inherently. Thus, in the case of the MP3 player, the music student may use the player to help build familiarity with music he or she intends to perform and, in that sense, it is enabling. Similarly, if one uses computers *only* for electronic games, then the application is hedonic. Many technology uses are both hedonic and enabling in their impacts, and it is the particular mix (i.e. more hedonic, less hedonic, more enabling, less enabling) that is of interest. Thus, the Internet can be enabling in a great many respects but it can also be a source of small pleasures of playing on-line solitaire or just Internet surfing for its own sake. In a single impact or use of S&T, it can simultaneously be hedonic and enabling. Thus, an older computer user can play computer-based word games for the sheer fun of it while, at the same time, understanding that this same act builds (or retains) capacity by helping stem the onset of Alzheimer's.

Relationship of Distribution to Potency

We can consider the dimensions of distribution and potency together (see Figure One). The figure suggests the possibility of locating particular technologies on a grid, a grid composed of the two intersecting dimensions. The particular location of technologies is, of course, highly contestable. But the examples are nonetheless suggestive. The Internet seems to us best described as *Social/Capacity (SC)* technology. It is social in the sense that its very existence requires "mediating technology" (Thompson, 1967), the linkage of users and providers. It is not necessarily a capacity technology-"surfing" for its own sake is common- but it is often a capacity-building tool. We consider the heart valve as *Individual/Capacity (IC)* technology because its applications are clearly on the individual (heart values are neither shared nor used simultaneously by two or more persons) and it is certainly enabling inasmuch as the very life of the individual (and all activities of life) may critically depend upon it.

In our figure, the MP3 player is viewed as *Individual/Hedonic (HI)* because (or counter examples notwithstanding) most impacts are generally on the individual users and the impact is consumed in its use rather than enabling other applications. Similarly, the cinema is a *Social/Hedonic (SI)* technology because its impacts are generally consumed simultaneously by many but with just a single application of the movie. If the movie is watched, as most are, for entertainment value, then it is hedonic in the sense that no capacity is built beyond, perhaps, the ability to provide clever conversation.

Perhaps the most contestable among our contestable examples is the personal computer. We have placed the PC at the intersection of the two dimensions because the technology lends itself to such a diversity of applications and impacts. One can engage in thousands of solitary uses but one can likewise engage in many uses that require interaction with others. One can use personal computers for the most advanced educational and creative applications but one can also use the PC for sundry entertainment or aesthetic applications. It is the ultimate chimera technology and, thus, we term it a *Mixed Use/Mixed Impact* technology.

Implications

If the typology we present above contributes to discourse about the nature of technology and its application, then we have not utterly failed. Our hope is that it is itself an “enabling” tool. We feel that the typology may be of some use in generating propositions about S&T impacts and that these propositions may be relevant to policy deliberations about S&T investments and impacts. To give a simple example, we suggest that some technology types are better public investments than others. The MP3 player has a multi-billion dollar investment and from an economic development standpoint is beneficial. But the case for public financing of Individual/Hedonic technologies seems less than compelling. By contrast, the heart valve provides a more compelling case for public investment and the Internet and the PC a still more compelling case. But another implication is that an adequate focus for policy analysis is to consider not only the economic development and growth implications of technologies but who benefits. While we do not have data on the topic, we expect that poorer people are less likely to have heart valves than richer people.

Given the ultimate enabling nature of the technology this is a concern *even though the heart valve is also a pure private good*. The fact that user pricing of the heart valve involves little inefficiency and the fact that providers can fully appropriate the profits from the sale of heart valves is not a sufficient argument to stem government "intervention." Focusing on the distributional impacts of S&T often provides a quite different set of policy heuristics than on derives from focusing exclusively on issues of production and pricing efficiency.

Intersection with Equality

Figure Two provides a view of an expanded S&T Social Impact model, one taking into account the potency and the distribution dimensions, but also the four equality dimensions. It is important to begin with the relationship between the equality dimensions and the distribution dimension. As we conceive them, each of the equality dimensions distributional, but with a different status than the issue of individual vs. social impact or dispersion vs. concentration. The latter issues are essentially neutral in content whereas the four equality dimensions are the starting point for moral deliberation. For example, we can speak of the distribution of gene therapies as a biological equality issue or the distribution of textbooks as an opportunity equality issue. The relationship is this: distribution of gene therapies is a neutral issue, at least until we have considered the relationship of distribution to human biological need, basis needs for sustenance, opportunity and political efficacy. It is these dimensions that provide the value content to be considered when examining neutral issue of the distribution of S&T impact.

-Figure Two goes here-

The Case for Inequality

How can the question of the distribution of S&T impact ever be neutral? The answer is straightforward: there is no inherently preferable distribution, including pure equality. Implicit in the S&T Social Impacts models is that pure equality of S&T impact distribution, even when possible, is not always desirable. An obvious example: society seems not to fret that breast cancer remediation S&T is disproportionately directed to women. Men get breast cancer and, when they do, it is more likely to be fatal, but the incidence is so low that the disproportionate allocation of resources to women makes sense to most people. There are other obvious examples. We expect that new technology for agriculture will be disproportionately distributed to farmers. We hope that computer dating technology will be disproportionately distributed to single adults. In some cases, of course, the normative aspects of S&T distribution change with new applications; presently Viagra's sex applications more often benefits men but the drug was intended as heart therapy with a distribution target including women and men.

A very different case of inequality of S&T impact distribution is relative deprivation. Principals of progressive taxation have been in place for centuries, giving evidence of nations' commitments, very different levels of commitment, to redressing wealth and income inequalities. We suggest that S&T impact inequalities are also worth addressing, even in those cases where they do no track well with wealth and income. In many instances, relative deprivation is coincident with wealth and income but in some cases it is not. For example, economically advantaged people of African descent nonetheless suffer relative deprivation with respect to incidence of sickle cell anemia. Similarly, the genetic roulette that determines who has such diseases as cerebral palsy and multiple sclerosis has little to do with wealth and income. In some cases the normative distributional issues become quickly complicated. A case in point: in the U.S. white women are someone more likely than women of African descent to have breast cancer, but black women are more likely to die from it. The group most likely to die from breast cancer, once contracted, is white men; but, of course, their incidence is just a small fraction of the incidence for women. What does this interaction of prevalence vs. severity imply for policies aimed at redressing S&T distributional inequalities?

V. Conclusions: Equality Reformulated

Doubtless, the benefits and costs of U.S. S&T are maldistributed. The root causes of the maldistribution are deeply etched in the grain of U.S. history and political culture as well as the norms and practices of S&T production and dissemination. But it seems clear enough that perfectly equitable distribution of S&T benefits and costs is neither possible nor desirable.

The conundrum seems to be this: given that maldistrbution is inevitable and in some instances desirable, do we (citizens and policy-makers) continue to cling to the long-standing “trickle down” ethos, assuming, or perhaps hoping, that ultimately S&T will benefit all, even if to the same degree? Or do we risk killing the golden goose by overtly directing S&T and, in our ignorance, doing irreparable harm to the vitality and autonomy science.

In our view this is a false choice and even if some accounts of the S&T enterprise raise dire warnings of social tinkering, the truth is that policy-makers and political leaders do this all the time. For example, if one looks at the largest science establishment in the U.S., the National Institutes of Health, one finds that the planning statements (*Healthy People, 2003)* not only provide explicit objectives and priorities o S&T but recognize straightforwardly distribution issues. NIH takes it as an objective to serve disadvantaged populations, often specifying particular populations with respect to particular objectives. In some instances these distributional issues relate to differential disease impacts, but in others they are more a matter of historical differences in access to medical care and medical technology or redresses of apparent disparities occurring due to maldistribution in clinical trials. The extent to which distributional objectives are achieved is unclear (for example, despite explicit objectives, little progress has been made in reducing breast cancer mortality rates among black women) but the possibility of having distributional issue drive policy is clear enough.

In previous decades U.S. S&T policy made clear choices about distributional issues, even if the choices were not always well-articulated in policy documents. Consider the following distributional choice made by S&T policy-makers, some in past years, some continuing today:

1. The predominance of white males in clinical trials (a de facto distributional choice);

2. Minimal funds devoted to "diseases of the poor," including tuberculosis and malaria, while diseases affecting a fraction of the people (but ones who vote and have strong associational interest groups);
3. Increasing funds allocated to high end, enormously expensive medical technology that can only be afforded by those with excellent private insurance;
4. Placement of garbage burning incineration plants in low income neighborhoods;
5. R&D tax credits (for profitable, "high technology" business)

Thus, there is no reluctance to make S&T policy decisions that have a strong distributional component. But S&T policy analysis and evaluation generally focuses less on these distributional issues, partly because the analytical tools available to evaluating S&T are, for the most part, rooted and economics and oriented to analysis of production and pricing efficiencies rather than distributional issues. By developing new ways of thinking about distributional impacts, relating aspects of S&T to its deployment, perhaps if will at some point be easier to bring distributional S&T policy issues into the light, even at the point choices are being made.

From Conceptual Models to Theories of S&T Impact Maldistribution

Maldistribution of S&T Impacts

Models of S&T impacts distribution can, potentially, be of use to policy-makers who have need for conceptual tools to assist in moving from near exclusive analysis of production and pricing for S&T to distribution questions. But even if such crude models as we present here help frame issues they are not substitute for testable propositions about impacts distribution and maldistribution. We have taken pains to demonstrate that equality issues are more complex than they seem at first blush and that inequality is not invariably undesirable. But, as we conclude, it is important to emphasize that unequal distribution is not the same as *maldistribution* and, moreover, that maldistribution certainly is not random. Generally speaking, it is the poor and the disenfranchised suffer maldisribution with respect to both the costs and benefits of science. In some cases this seems to relate to structural inequalities in the economy, but there are many other factors at work as well. For example, discrimination- gender, race, national origin, sexual preference- often does not track purely economic lines but can be an important element of maldistribution.

The most important research agenda for analysis of distributional impacts of S&T pertains to the causes of maldistribution, Whereas distribution is neutral, maldistribution pertains to abridgement of basic needs, opportunity, biology and health, and political access and voice. Of the many different potential causes of maldistribution the ones that merit particular attention are those stemming from the internal characteristics of science and technology as an institution. If there are structural inequalities in the economy that affect the distribution and absorption of S&T impacts then the remedies are likely economic and political. But causes owing to structures, processes and institutions of S&T may be even more pernicious and may be more difficult to identify and to address. For example:

1. Does peer review and the emphasis on the quality of research mitigate the focus on social benefit and the distribution of benefits?

2. Do the social structures and the social capital deployed by scientists and engineers systematically militate against the recruitment and advancement of minorities and women?

3. Compared to civilian technology, does a focus on defense and national security technology, and the "dual use" technologies that accrue, tend to provide less benefit to the disadvantaged?

4. What are the impacts of labor saving technologies on jobs usually occupied by the poor?

5. Does the increasing interdependence of technology systems mean that once the disadvantaged are shut in one domain that they are necessarily shut out of another?

6. How does new technology present barriers to entry in the workforce or barriers to workforce mobility?

7. Do advances in linkage technologies (e.g. banking and financial services) further disempower the poor?

8. Do technologies, including medical technologies, allow the rich to wall themselves from the poor and thereby reduce attention to issues that once affected the general public?

9. There are few S&T associational interest groups representing the disadvantaged; what are the implications?

10. What is the relation between the often sub-standard elementary and secondary education available to the disadvantaged and how does that affect the ability to recruit scientific talent from their ranks?

11. Are there selection effects such that persons choosing S&T careers are less likely to be politically and socially active and are more likely to have limited personal linkages with non-scientists? If so, what are the implications, if any, for agenda formulation?

12. In some cases, does S&T reward publication more than impact and intellectual impact more than social and economic impact? If so, does this give rise to maldistribution of benefits or to limited attention to types of benefit?

None of these questions have easy answers, but one need not be a Luddite or an enemy of science to think the are worthy of more attention than they seem presently to receive.

Bergeron Redux

As the term is used by Vonnegut, the “handicapper general” poses less threat than a general handicap- perhaps two general handicaps. In the U.S., a capitalistic economy is set up precisely to insure inequality. But this is not our aspiration for science and technology. Most Americans seem to cling to the notion that science and technologies are enablers, lifting the quality of life of all citizens, not exacerbating gaps among citizens, not creating further disadvantage. By developing better knowledge about the distribution of S&T impacts perhaps we can take steps to insure that S&T comes closer to our expectations and diminish the likelihood that S&T will serve as a perverse handicapper general, one that handicapping not the overachievers but the poor and disadvantaged.

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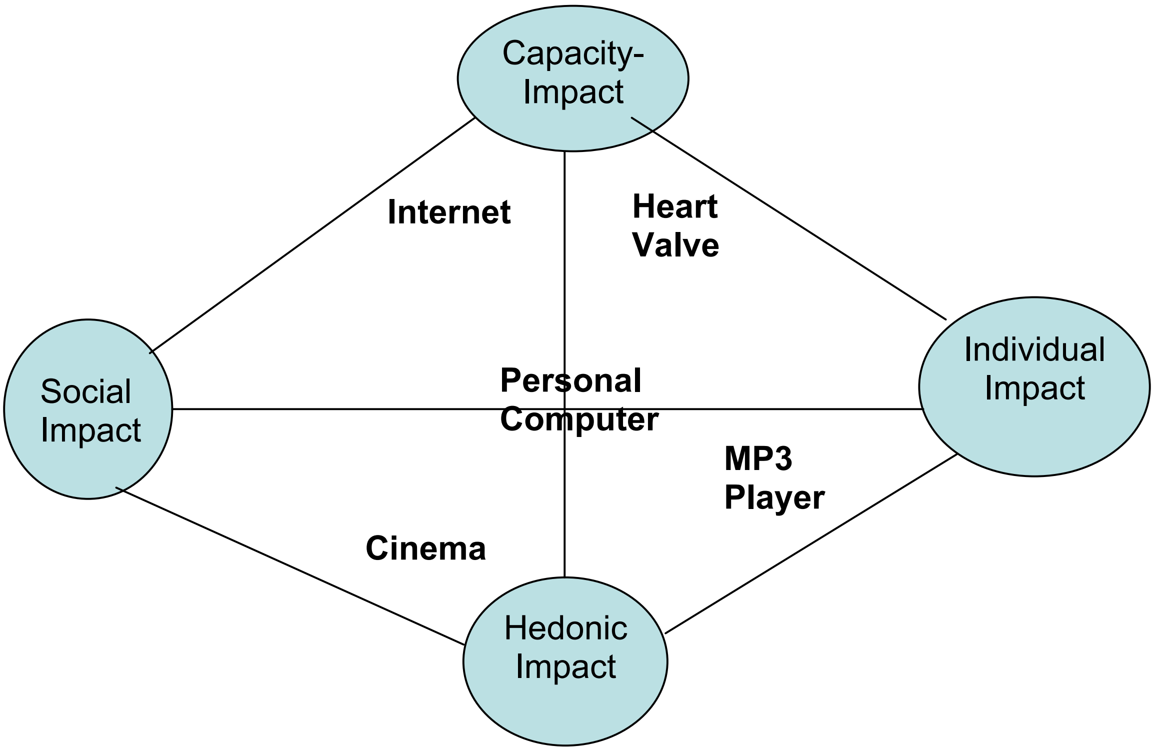

Fig. One: S&T Social Impact Model

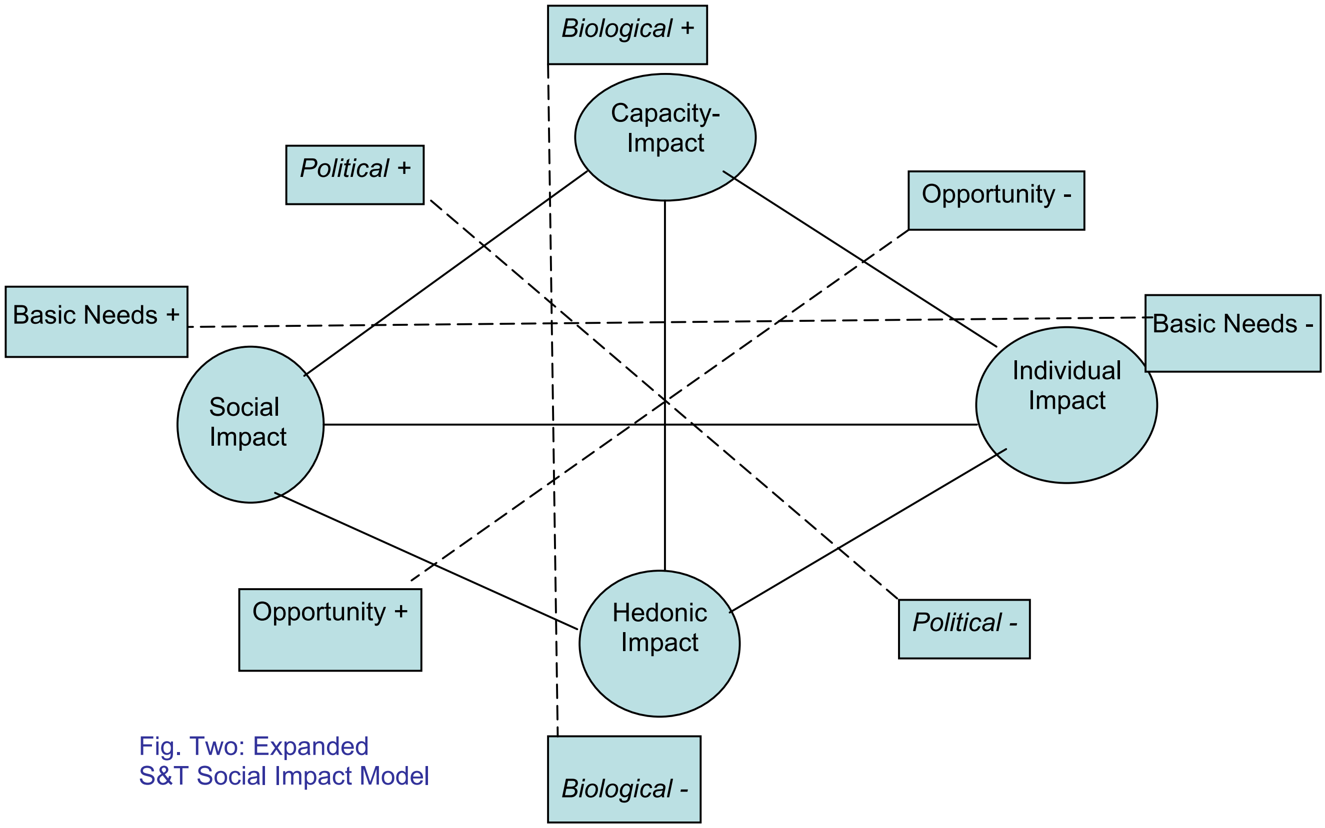

Fig. Two: Expanded
S&T Social Impact Model