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THE POLITICAL ECONOMY OF AMERICAN SCIENCE

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The aims of the scientific endeavor are straightforward: theoretical explication of the natural world. Science is one expression of a basic human yearning for understanding as old as consciousness, seminal indications of its existence being found in the earliest civilizations. Intellectual progress, however, coalesced in Europe in the period preceding the Enlightenment and gave rise to a new way of studying the cosmos. The Scientific Revolution, as this intellectual leap has been termed, has had mixed effects. On the one hand, scientific achievement has advanced in many dimensions, giving us a fresh appreciation of the depth of reality in which we take part and which we are co-constructing. It informs us of the immense evolutionary distance traversed by the universe from the primordial explosion till today. And it raises consciousness to a higher level of understanding, laying the material as well as spiritual foundations for a much more humane and rational social existence. On the other hand, the technological applications of some scientific achievements have produced new instruments of violence and destruction, of control and manipulation, which, if not sharply diverted from their present course, seriously threaten to destroy humankind itself.

The question that arises, then, concerns the factors that determine which aspects of science will prevail in a given historical situation. Since the nature of science itself doesn't offer an illuminating insight, we have to look at the system under which science operates, analyze its structure, and discern its logic of functioning. Our final goal is to assign proper weight to various institutional factors separate from the logic of science itself.

The United States, arguably the most scientifically advanced state in recorded history, provides an example. American scientific endeavor took its present form during World War II, when the federal government began funding science in the service of war. The commercial potential of that arrangement was immediately recognized and seized upon by the policy makers. The now famous Vannevar Bush Report to Franklin D. Roosevelt, "Science: The Endless Frontier," established the systemic parameters that remain in place to this day. It spells out the thinking as follows: "new products, new industries, and more jobs require continuous additions to knowledge of Nature and application of that knowledge to practical purposes" including "new and improved weapons." The purpose of science, under this system, became production of knowledge of the natural world which can subsequently be applied towards development of technologies by the private sector.

At the same time it was also recognized that "this essential, new knowledge can be obtained only through basic scientific research." Considering that the private sector, composed of corporate conglomerates of concentrated economic power, is driven by a singular logic of profit, it cannot be expected to fund an enterprise whose only objective is to understand Nature. And, predictably, it doesn't. The burden of funding basic research falls to the public. Various government agencies (National Science Foundation, National Institutes of Health, etc.) fund individual academic researchers at universities, where the preponderance of basic research is conducted. In the event that knowledge demonstrates potential for a

commercial application, it is immediately transferred from the public to the private domain through the patent system.

The private sector subsequently conducts the final phases of research and product development which is least expensive and scientifically demanding. Through tax deductions, the public subsidizes even this phase, so that ultimately, the entire cost of new product development is socialized, while the profit is privatized. Throughout the last half century, this basic structure of the political economy of American science has remained the same.

In 1980, public policy commitment to the commercial application of science was reaffirmed by laws that were enacted to improve the competitiveness of American products on the world market. This was done because, as one recent report from the National Academy of Sciences acknowledges, "the industrialized world had largely recovered from the effects of World War II and key Asian nations were devising new approaches to industrial production." These "increasing challenges from competition abroad—in markets for traditional goods as well as a growing list of goods based on advanced technological capabilities—raised new questions regarding the role the federal government should play in assisting US industry to develop and use new technology for competitive purposes."

Answers to these questions concerning the competitiveness of American industrial products on the world market can be found in the legislation of the period. The report continues: "The Stevenson-Wydler Technology Innovation Act of 1980 opened the federal laboratories to industry, making available not only specialized and unique facilities, but also opportunities for R&D partnerships with joint funding and the use of federally developed technology for profit making ventures. That same year, Congress passed the Bayh-Dole Act, which conferred ownership of patent rights on universities, small businesses, and nonprofit organizations, thus providing a strong incentive for commercial development. In 1984, the National Cooperative Research Act amended the antitrust statutes to facilitate cooperative R&D between competing firms."

The guiding principles of policy, however, have remained the same since the Vannevar Bush report: the role of the government is to place science in the service of commerce, to facilitate privatization and commercialization of publicly funded knowledge as soon as it demonstrates profit-generating potential. The process, called "technology transfer," has become institutionalized in most universities, which now have technology transfer offices for this purpose. If publicly funded basic research at a university yields potentially profitable results, the university is granted a patent which is then sold to the private sector. A recent study found that "73% of the applicants for US patents listed publicly funded research as part or all of the foundation upon which their new, potentially patentable findings were based."

The private sector thus gains a monopoly on a given product. The public subsequently pays monopolistic prices despite the fact that the research that led to product development was publicly funded. This is a hallmark of the current American system: because basic research is risky, it is conducted at public expense. Once the certainty of profit arises out of scientific knowledge, the knowledge is immediately privatized.

There are many concrete examples of this system's functioning, but, one that is particularly egregious is the case of HIV drugs, protease inhibitors. They are the first example of what has become known as rational drug design. In the past, pharmaceuticals were discovered either serendipitously or by testing large random libraries of chemicals for potential usefulness. However, with advances in structural biology—again wholly publicly funded—scientists were able to determine the structure of the HIV enzyme protease down to atomic detail and to design chemicals, specifically and rationally, to inhibit the action of the enzyme. The total cost of determining the atomic structure of protease is not easy to

ascertain, but a low estimate lies in the range of tens of millions of dollars when the entirety of research that went into its production is considered. The research was exclusively publicly funded. The final phases of drug development were conducted by pharmaceutical companies, which subsequently developed effective drugs and patented them.

Currently there are several protease inhibitors on the market and an average person with HIV pays in the vicinity of $10,000 for a year's supply. These drugs are prohibitively expensive for many uninsured patients, who suffer unnecessarily and die prematurely from the disease. Perhaps the most illuminating fact demonstrating the monopolistic nature of pricing pharmaceuticals in the United States comes from a recent comparative study by Medicins Sans Frontieres (Doctors Without Borders). They found that "the minimum price of AIDS drugs in the countries studied [was] on average 82% less than the US price." From this it is clear that, absent public policy constraints, the corporate sector sets prices to extract maximum profits from a given market with no regard for human life and well-being.

Another illustrative example is the much discussed human genome project. Putting its philosophical significance aside, let's look at the political and economic parameters. The human genome project comes at an advanced phase in our understanding of molecular biological phenomena, and it is founded on scientifically solid ground due to decades of research that was publicly funded. Most of the actual sequencing work has been conducted at universities and was also subsidized by the public. Nevertheless, the private sector has seized upon the profit potential of this expansion of knowledge and has been applying for patents on various possible applications of our genes. Again, putting aside the ethical implications, the economic factors alone are sufficiently disturbing. The private sector has monopolistic possession of a particular domain of the natural world (which also happens to reside in each and every one of us). It was discovered by the use of public funds and its exploitation is founded on a scientific understanding also gained by means of public resources. In accordance with the system's logic of functioning, the public is disposed to pay monopolistic prices for applications of this scientific knowledge, as in the past, despite its indispensable original investment in scientific discovery and its application.

These are just two examples of a systemic logic that is invariant to a very close approximation.

Even the funding priorities of the federal government reflect the prevailing systemic logic which is singularly commercial. Take the current president's latest proposal for boosting research funding. A 15% increase in funding is proposed, but only for National Institutes of Health, which funds biological research. The reasons seem straightforward: the most obvious potential for profit resides in the fruitful biological sciences, whose discoveries can be quickly commercialized through technology transfer to the nascent biotech industry. Other domains of natural inquiry are not deemed as important, not surprisingly, since the primary aim of science under the current system is not discovery of knowledge for appreciation of the Beauty of Nature, but rather discovery of foundational principles that can be used to generate profit for the private sector. The scientific research agenda is driven not by scientific curiosity or a desire to deepen our understanding of the cosmos but by a singularly commercial logic of profit.

Another feature of the system, established after World War II, concerns educational policy. The Government sets educational policy in order to satisfy private interests: a sufficient supply of highly trained labor, and an educational system that extracts a significant amount of labor in the process of education itself. In accordance with systemic logic, the public funds education as well.

Science education, especially on the graduate level, is inextricably linked with research. Graduate students and post-docs carry out the bulk of the actual research in the sciences. They are the most productive and the most innovative component of the research enterprise, and have been recognized as

such for a long time. A recent report to Congress by the House Committee on Science acknowledges that "students and post-doctoral researchers are responsible for actually performing much of the federally funded research done in universities" and that they are "a key component of the overall research enterprise." Thus, the report continues, "the potential exists for the student's graduate experience to be dominated by the faculty member's need to generate publishable research results--and not the student's own scientific and professional development." Furthermore, the conditions under which graduate students work are exploitative. They are required to put in long hours and give up external commitments, including family. They are often exposed to hazardous chemicals, such as radioactive materials and various organic solvents, and complaints are generally met with disdainful dismissal.

As is evident, science education is also subordinated to the logic governing the overall system, which is, as we have seen, exclusively defined by the imperatives of profit. Since extraction of labor is one of the key aspects of science education, it is not surprising that the average length of study, the number of PhD's granted, and the number of graduate programs has increased with the increase in the demand for labor in the biomedical sciences, as they have shown the potential to generate profitable knowledge. The resulting growth in the total number of PhD's granted causes an oversupply of highly trained scientists, who are unable to find faculty posts and now spend an average of five to seven years in post-doctoral positions. While they were originally meant for transient training following graduate study, post-doctoral positions are now becoming a way of life for many scientists. Generally, the pay is barely sufficient for subsistence, and the benefits post-docs receive vary greatly but are usually very modest. Some universities don't even consider them employees: they are forced to pay fees and they have few or no labor rights. Others regard them as employees, but give them few or no benefits.

The singular logic driving policy pays little regard to the needs of young scientists, many of whom spend years in post-doctoral positions with no job security and limited benefits. The dissatisfaction of young scientists with their educational experience has doubled in the last 20 years, according to a study by The American Society for Cell Biology. Where, in the 1970's, only 16% of PhD level scientists reported that they would "probably" or "definitely" not pursue their doctoral degrees if they had to do it all over again, the number today is double: 31%. The authors of the study observe "that although the science itself may be thriving, it is because the scientific establishment is all too willing to compromise the careers of its students and post-docs." This observation, again, is consistent with the prevailing logic of the dominance of profit.

As can be seen, the current structure of the American scientific endeavor provides for sharp asymmetries in the distribution of costs and benefits associated with science. On the one hand, the public subsidizes the costs of basic scientific research and, through tax deductions, the costs of applied research and product development by the private sector. Public policy is mobilized to assure that the educational system favors commercial interests by extracting a significant amount of labor from students in training, but little regard is paid to the needs of young scientists themselves. On the other hand, the private sector secures almost all the benefits of scientific research, through privatization of potentially profitable knowledge by means of the patent system. The patents guarantee monopolies on developed products, and the public is additionally required to subsidize the profits of the private sector.

Because the private sector is driven by the logic of profit, it is predictable that the application of scientific knowledge, when allocated exclusively to the private sector, will be subordinated to the same logic. The use of science to destroy and dominate Nature and humans is perverse, but is rationalized as productive so long as it benefits the private sector. This extreme structural disparity in the distribution of benefits of science has caused some observers to assign inherently undemocratic properties to science itself. But, as this short analysis hopefully demonstrates, a much more instructive approach to the original question is to look at the structures of the system in which science operates and to examine its logic of functioning.

Science has much to offer humanity—a deep appreciation and an understanding of Nature, along with a respect for the role humans play in co-constructing the cosmos. For science to be liberated from the abuses of the corporate sector, systemic changes are necessary, changes that can only be initiated by an informed public. The alternative offers little in the way of hope for a human planetary future.

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