PURE SCIENCE: AN OLD NAME WITH SOME NEW WAYS OF THINKING

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> "Shall our country be contented to stand by, while other countries lead in the race?"
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> —H.A. Rowland, "A Plea For Pure Science" (1883)

Over a hundred years ago, in the second-ever issue of *Science*, H.A. Rowland made an impassioned plea on behalf of his field. But he did not define his field with specificity, as scientists usually do—he did not identify as an astronomer, or a chemist, or a physicist. Instead, he identified himself with "pure science": a science, he argued, that was done purely for the sake of learning about the world in which we live (Rowland 242). In its formative stages, pure science was met with heavy opposition. In the 1850s, the influential Senator Stephen A. Douglass, for instance, heavily promoted research into agricultural technology over electromagnetism and optics (Trigilio). So, in the face of arguments for the practical, for the realistic, for the applied, Rowland published a poignant defense of the quixotic. Incredibly, Rowland's hundred-year-old rhetoric echoes across generations—political speeches still rally around getting America "back to the top" of Rowland's implied race of scientific education and research.

Modern as Rowland's ideas may sound, they are outdated, and so too is the status quo understanding of scientific research in the United States today. The idea of science research as a "race" has been a myth for quite some time; scientists have worked together across borders for years and years to learn more about the world. South Korea might always be a step ahead of America in whatever science ranking system the media chooses to publicize, but the reality of science research is that South Koreans and Americans work together in labs and groups quite frequently. And just as this collaboration spans physical space, it spans time as well. As Neil deGrasse Tyson, the popular astrophysicist, put it in *COSMOS: A Spacetime Odyssey*, "Science is a cooperative enterprise, spanning the generations. It's the passing of a torch from teacher to student to teacher, a community of minds reaching back to antiquity and forward to the stars" (Tyson). The nature of science has changed: it isn't competitive; it's collaborative.

The nature of pure science embodies this distinction. Whereas applied scientists must deal with patents, copyrights, and the business of the products they eventually create, all of which inevitably introduces some competition, pure science is almost totally collaborative. And while the method by which pure science researchers obtain money to perform their work—the dreaded grant application process—can be competitive at times, the science itself is not done to push one group of people ahead

of the other. It's done to learn more about the world. Pure science as a research field was born against strong opposition, with very few people like Rowland to defend it; yet it grew into a collaborative field across nations that has produced the most brilliant minds of our time and the most novel ways in which we consider our universe.

But this glorious bastion of knowledge and understanding is in danger of being lost—not only in America, but also across the world. The existence of pure science has been under threat from politicians and businessmen almost since its disengagement from engineering and applied science, but never before have these threats warranted extinction. And yet, that's exactly what's happening: new attitudes towards pure science, motivated by politics and economics, have driven pure science to the boundary of a bleak future. And to understand the extent of this dystopian fate, one need only look to the northern border.

Many Canadian politicians believe that the era of pure science has come to a close, with Gary Goodyear, Minister of State for Science and Technology, even going so far as to state that "the day is past when a researcher could hit a home run simply by publishing a paper on some new discovery" (qtd. in Semeniuk). Ironically, announcements about the Higgs boson, the Planck satellite, and cosmic inflation, announcements which began just as papers on new discoveries, have been all over the news in the past two years alone. Clearly, the day is not past.

But unfortunately, Canadian politicians seem to pay no heed to science news. Their government has shifted its focus on science research, only providing funding to specific applied science areas and effectively leaving pure science for dead. The current situation in Canada has painted an austere future for pure science. The new mindset of Prime Minister Stephen Harper's government is perhaps best explained by one of the foremost advocates for science within the Canadian Parliament, Kennedy Stewart: "They see [pure science] as a kind of cash cow which is taking up a lot of money in Canada, and it's not really generating short-term economic benefit, so they think it has to be radically restructured. . . . It's an ill-conceived move" (qtd. in Mancini).

To the Canadian government, "short-term economic benefits" are the only gains to be made from science—nothing more. Indeed, Canada's newfound focus on "research in areas that are in the national interest from a social and economic perspective" shows exactly what they think science should be: a financial asset (qtd. in Mancini). And this mindset is not at all limited to the Canadian government. When I, a first-year student studying chemistry and astrophysics at Columbia, return from my sheltered world of New York City academia to my decidedly non-academic household, I am quickly reminded that "You want to be a . . . researcher . . . why not an engineer?" is a question I can expect once a week. At a large research university, no one seriously questions the motivations behind pure research, and certainly no one pushes for someone to radically rethink their field of study solely because it is pure. The motivations behind the question I must answer back home and behind Canada's new science policy are largely the same: they stem from the assumption that pure science

does not contribute as much as applied science—or at all, for that matter. This status quo mindset is what threatens the continued study of pure science today.

To conserve something that is threatened by societal preconception, we must radically rethink the status quo. So goes the argument made by William Cronon in his environmentalist masterpiece, "The Trouble with Wilderness: Or, Getting Back to the Wrong Nature." In it, he argues that the public perception of wilderness is so flawed that it prevents environmentalism from achieving its goal of conservation. Rather than defining ourselves as separate from the wilderness, he claims, we must define ourselves with the wilderness. Rather than conserving some "other" entity, we must conserve something with which we coexist. A similar rationale can be used to understand how societal perceptions must change to conserve pure science. As with Cronon's "wilderness," the current perception of pure science is that of an "other"—specifically, that it is something non-human that we use to earn human profit or to benefit human society in some way. This conception of pure science is very much akin to the idea of wilderness as a "pristine sanctuary" that exists only to give humanity access to the untainted (Cronon 7).

But wilderness, as Cronon argues, is not a pristine sanctuary; "instead, it is a product of that civilization" which we fear will "taint" it (Cronon 7). In the same way, to rethink pure science, we must recognize that pure science is not simply an asset or a liability that exists for our gain. It is a collection of fields that captivate the imaginations of the least curious of children and the most brilliant of researchers. It is a mode of thinking that continues to motivate applied science today. And it is done independent of the pockets of corporations; it is done for the sake of learning about the world, of explaining and comprehending the beauty of the universe. Pure science, like Cronon's wilderness, is not distinct from us—it *is* us. Our discovery of subatomic structure was not made with economics in mind; it was made to explain the particles that make us. When pure science is misunderstood as a financial liability, it holds no importance to Harper and his business-minded model for Canadian growth. But pure science is not about business. It is science done for the sake of understanding our world and ourselves, and the worth in that understanding is incompatible with the scales of economic success so often used to judge how much things matter.

At the same time, incredibly, pure science does more than just fostering this understanding. It contributes to the financial growth of a nation just as much as it contributes to the intellectual growth. In his testimony presented to the U. S. Senate Committee on Commerce, Science, and Transportation, Tyson poignantly made this argument in a defense of the pure science of a national space program:

> Epic space adventures plant seeds of economic growth, because doing what's never been done before is intellectually seductive (whether deemed practical or not), and innovation follows, just as day follows night. When you innovate, you lead the world, you keep your jobs, and concerns over tariffs and trade

> imbalances evaporate. The call for this adventure would echo loudly across society and down the educational pipeline. (Tyson)

Pure science not only promotes long-term economic growth (which is something that Canada will surely lack if it continues to eschew pure science in its entirety), but does so by inspiring the populace to grow together as an intellectual community—as a community of "innovators," in Tyson's words.

Tyson's comments on the worth of pure science are not merely the philosophical musings of an emotional astrophysicist; rather, they are empirical, backed up by the history of the Space Race. One of the most well-studied figures in the history of pure science was the first Secretary of the Smithsonian, Joseph Henry. Henry frequently went head-to-head with the previously mentioned Stephen A. Douglass regarding the worth of pure sciences like electromagnetism and optics (Trigilio). While Douglass championed the seemingly more utilitarian agricultural engineering, Henry was able to convince one of his most important followers to learn all that he could about electromagnetism and pure science—and that follower, Alexander Graham Bell, went on to create the first telephone. The science and technology of electromagnetics would go on to become a hugely important part of intellectual revolutions in America; now, it's impossible to find products that aren't built around the functionality of a computer, which, at the core of its hardware, is based on electromagnetic systems. Even the agricultural technology championed by Douglass has come to depend on computerized processes to optimize output.

My aim is not to dismiss engineering—which was indeed necessary to build new technologies like the telephone and computer, and is still necessary today—but to exalt the pure science that created the intellectual space from which all that success derived. The historical anecdote highlights the immensely important role that pure science has played in the growth of American society—intellectually and, in the long run, financially. History does not side with Harper's model of a future without pure science. In the United States, a new understanding of pure science is of the utmost importance. America is at a crossroads when it comes to science. Historically, America has left her mark on the most pivotal pure science developments of the last few centuries—from the theorization of new systems of kinetics governing chemical reactions to the theorization (and discovery) of new subatomic particles. These discoveries have come from a variety of locations: private universities across the country, national laboratories such as Fermilab and Brookhaven, even private research firms. Regardless of the location, the United States has been intimately involved in funding and perpetuating pure science research. No research—whether through a private or public organization—could sustain itself without the funding of the National Science Foundation. But recent developments in American science policy and public perception have threatened the country's involvement in pure science to an extent almost rivaling Canada. This is not dangerous because it puts us at the bottom of some

hypothetical "science race" between countries; it is dangerous because it removes a crucial collaborator in the global conversation that pure science has become. To understand the extent to which America is being pulled out of the global scientific conversation, we must consider perhaps the most threatened scientific agency that our government has to offer: NASA.

Space science is decidedly pure: it does not seek to offer immediate economic benefit (though it has done so many times—a fact that will be addressed later), and it is done primarily to understand more about the universe. NASA, then, is certainly an organization of pure science—but it's a dying one. NASA has been on a steady decline for years, its fate championed by Michael Gough, author of the 1997 Cato Institute white paper "Don't Lavish Funds on NASA." In the article, Gough urges the government to cut funding to NASA, citing the increasing privatization of science and the high risks without reward of a manned space program as two main reasons to do so (Gough). It's worth noting that the Cato Institute is decidedly Libertarian, and thus holds the view that the government shouldn't really play a role in anything. But it's also worth noting that its calls to action have effectively been realized. Calls for the privatization of science funding have only gotten stronger, and NASA's budget has fallen to about half of what it was in 1997.

But what else has happened since 1997? For one, NASA's output has lessened significantly. And why wouldn't it? As funding decreases, so too should output. This basic consequence is something that Gough understood, but his predicted solution, privatization, has not occurred. Elon Musk's company SpaceX, the frontrunner in the private space industry, has grown over the last decade to the point that it is now valued at over a billion dollars (Wells), yet its research has not amounted to a fundamentally new understanding of rocket science. Furthermore, much of the private space industry (including SpaceX) operates on governmental contracts provided by NASA itself (Stenovec). The private space sector heralded by Gough as the solution to the space science funding problem hasn't amounted to much, and, furthermore, is still inextricably linked to NASA. If NASA, the central cog that drives both governmental and private innovation, loses funding and fails, the American presence in astronomical research will fade into nothingness.

And yet, much of the public still supports Gough's views. Debate.org recently asked the public, "Should America continue spending money on NASA?", and the rationales given for the many "No" votes are telling. Importantly, lurking behind the "No" answers is most often the statement that we cannot afford NASA, or that it doesn't produce tangible benefits to society. First, this statement is guilty of misinformation: NASA, in fact, only takes up a negligible 0.5 percent of the national budget (Tyson). But more than misinformation, this argument reveals a fundamental misunderstanding of the purpose of NASA and the benefits that it provides. To conserve NASA's funding, as with the Crononian conservation of pure wilderness, this perception must change.

Changing this perception requires a fundamental understanding of the facts, and the facts are simple. NASA is certainly a microcosm of pure science in America—it is an organization based first and foremost on the principle of research for the sake of understanding and learning—but it has had an incredible amount of side impacts, from the education of the American public to spinoff products that have bolstered the American economy. NASA not only hosts many different space exploration and research projects, ranging from theoretical astrophysics research on pulsars to the practicalities of actually sending humans into space, but also plays a pivotal role in both inspiring America's youth and granting them access to tools that will help fulfill that inspiration. And while NASA does all of these things with the genuine purpose of helping the world learn more about the universe in which we live, one of the nicer side effects is that technological spinoffs of NASA's research can—according to one conservative estimate in *Nature*—multiply the money put into the program by a factor of at least two: every dollar put into NASA has historically returned, on average, around two dollars and ten cents (Bezdek and Wendling 106). While the short-term economic benefits of NASA are admittedly small, the long-term benefits are verifiably enormous.

The critique is that we cannot afford NASA, but the reality is that no one can put a price tag on that kind of research, that kind of education, that kind of intellectual inspiration that drives innovation for generations to come. Just as pure science has worth both in the understanding that research brings and in the long-term financial stability that comes with it, NASA drives American society toward a greater state of knowing while simultaneously paving a road to a more educated, economically secure future.

This trend of pure science uncovering knowledge while providing economic and intellectual security is the reason why, fifty or a hundred years down the line, Canada will not be able to realize the long-term economic benefits of pure science while any other country currently invested in that research will; instead, it will realize the folly of Harper's business-minded science regime so many years before. The trend is exemplified by how nineteenth-century research into electromagnetism produced incredible new markets and technologies and economies in the twentieth and twenty-first centuries. And it's a trend that American lawmakers must understand both for the sake of the continued existence of pure science and for the sake of the economic vitality of our nation.

Science and society have always been at odds with each other; as John F. Kennedy once said, "Scientists alone can establish the objectives of their research, but society, in extending support to science, must take account of its own needs" (Kennedy). But when we redefine pure science as an intellectual restoration of the creativity and vitality of the human spirit as well as a serendipitous economic investment with a guaranteed payoff, we bridge the gap between science and society. We solve the age-old question of why we should choose to fund this endeavor at all. Policymakers must understand

and accept a refined definition of pure science in the context of society to ensure the intellectual progress of our society as a whole. When we recognize that we perform pure science to understand our surroundings and ourselves, that fiscal gain is not an end goal but a fortunate consequence of this important field of research, we can transform our nation—as Tyson so eloquently put it in his Congressional address—"from a sullen, dispirited nation, weary of economic struggle, to one where it has reclaimed its twentieth-century birthright to dream of tomorrow."

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