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4: Funding problems in the traditional system

At least another 50-60% of research projects could be funded and the grant selection process impedes progress.

For a long time, almost a decade, my mind worked like that of the donut maker in the old Dunkin Donuts advertisement: "got to get the grant, got to get the grant." Please watch this YouTube video of the donut ad: https://www.youtube.com/watch?v=petqFm94osQ. It is spot on, including the progression from enthusiasm to weariness to déjà vu. What is missing is the feeling of embarrassment, even shame, which I felt as rejections piled on. I was convinced that the problem was in me, so much so that when I met people who got grants, I was busy deciphering the reason for their success, and when I met people like me who did not get grants, I was sorting out commonalities with the hope of identifying the causes for failure.

It was only when I stopped writing grants and started to dispassionately analyze funding issues within the traditional system was I truly able to relate my problems to the problems faced by most scientists. I could comprehend and accept the fact that even successful scientists experience a lot of failure. Now I see 'funding failure' as the fundamental problem within the traditional system for two reasons. One, it also leads to many problems observed in the mechanism and data. Two, nothing is as inimical to science as scientists suppressed for non-scientific reasons.

The remainder of this essay, as well as the next two essays, is more or less a summary of the general view of scientists and science administrators. Whenever possible I will rely on articles written by leading scientists and science writers in reputed scientific and general publications. These scientists and articles cover many of the problems I have myself identified based on my own experience, experiences of my colleagues, and my understanding of the traditional system. When I make a personal observation or provide my analysis, it will be obvious to you that it is mine. I often use personal experiences to illustrate general points because in my view reality is what is actually experienced, which goes beyond mere reasonable thought and logic.

If you are associated with research in any capacity you might be (painfully?) aware of much of the information presented here. But continue reading, as this background information on funding problems in the traditional system is crucial for understanding the reasons for creating a new research system.

Not all research projects depend on extramural funding. Some projects are funded by in-house grants and some others might not require money. Scientists involved in such projects have only performance to worry about. All other scientists or projects depend on extramural funds for showing performance. Some might argue that obtaining funds is a part of good science performance but as you will read in the next essay, that is not necessarily true.

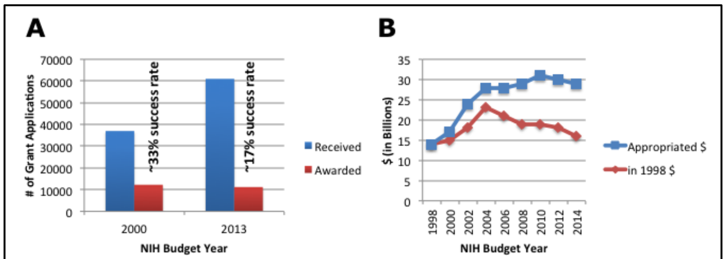
Extramural funds are required to cover direct costs related to salaries (of personnel), supplies, and services, as well as indirect costs related to infrastructure, facilities, and resources provided by the host institutions. Many institutions completely cover the salary of scientists based on other services rendered (teaching, mentoring, or administration). However, very rarely will such scientists have enough time to directly conduct research and therefore rely on other supporting members they hire using grant money (post-doctoral fellows, graduate students, research assistants, technicians, etc.). Many other institutions expect the scientists to cover a portion of their salary from extramural funds that is commensurate with the time they devote to research. In any case, extramural funding is the primary input (or fuel) advancing what is generally called investigator-initiated research in the traditional system.

The term ‘investigator-initiated’ should not be taken to mean ‘free-range’ projects directed only by natural interests of the scientists or what is required to understand a phenomenon. My understanding is that even renowned researchers rarely submit free-range grant applications. They also, like most other scientists, develop grant applications that fit areas or problems of interest specific to the funding agencies. Even the National Science Foundation, which comes closer to funding free-range projects, provides specific directives regarding the kinds of projects they are interested in funding. My point here is that researchers in the traditional system rarely pursue projects based completely on their interest or scientific merits. The grant applications they submit are tailored to fit specific directives for ‘getting the grant.’

Federal agencies are the major provider of funds for scientific research in the US: Department of Defense (DOD), National Institutes of Health (NIH), Department of Energy (DOE), National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the United States

Department of Agriculture (USDA). Of these, the agencies that fund projects that are closer to being free-range are NIH, NSF, and USDA. Therefore, the funding problems I will discuss are primarily confined to these agencies. However, this discussion would be generally applicable to all funding agencies, whether they are federal, state, or private. The reasons are simple: I do not know of any agency that funds all the applications it receives and most funding agencies follow a similar grant selection process.

When the scientific research enterprise in the US was relatively small (1960s to 1970s), apparently the majority of grant applications were funded (70 to 100% by some accounts). In the 1980s and 1990s, when there was a remarkable growth in the research enterprise, the funding rate decreased significantly. This trend has continued, as the amount of funds available has not increased in proportion to the population of individuals who are competent and interested in research careers. This is true for governmental funding agencies with a broad array of interests, as well as private agencies with a narrow spectrum of interests.



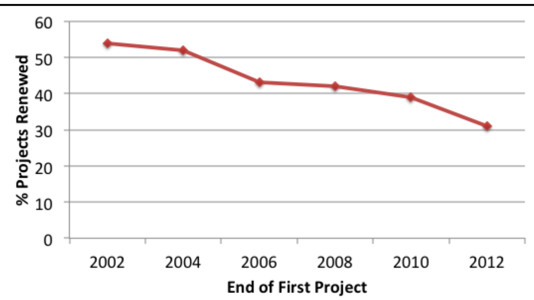
The number of grant applications at NIH is increasing and the success rate for PIs is decreasing

NIH funding for research is steadily decreasing

Based on data in Jennifer Couzin-Frankel, 2014, *Science* 344:24-25; 28-29.

Figure 1

For example, at the National Institutes of Health (NIH), the biggest agency providing extramural funds to scientists in universities and colleges, the number of grant applications has doubled from the year 2000 to year 2013 but the number of funded applications has remained more or less the same. This trend has effectively halved the success rate (Figure 1A). When the total funding amounts over those years are corrected for inflation one can clearly see that there has been a steady reduction in the appropriation of NIH funds for research (Figure 1B).



Grant renewal rate at NIH is steadily decreasing

Based on data in Stefan Maas, February 13, 2015, Examining the First Competing Renewal Rates of New NIGMS Investigators NIGMS Feedback Loop Blog https://loop.nigms.nih.gov/2015/02/examining-the-first-competing-renewal-rates-of-new-nigms-investigators/

Figure 2

Even those few who are awarded funds nowadays (10-20% of applicants) face the daunting task of securing continued support. Figure 2 shows an example of grant renewal over time. The grant renewal rate at an NIH institute (National Institute of General Medical Sciences) that used to be an unhealthy

50% in 2002 has decreased to a dismal rate of 30% in 2012. A similar trend is observed in other NIH institutes. Thus, 10-20% X 30% means that in general only about 3-6% of NIH scientists are able to continue their research projects without a break from one funding period to the next. Extending this simple math, only about 1-2% will be able to continue to the third period without a break, and less than 1% into the fourth period. If we assume that the career of a researcher spans 30 years on the average and each granting period is 5 years, in the sixth period only about 0.02 to 0.05% of scientists will be able to conduct research on the same subject without a break. Obviously, this number is very simplistic and does not apply to all scientists but is a reality that confronts the good majority of scientists that are dependent on NIH funds for their research.

Keep in mind that the longer a scientist is without a grant the harder it is to get a new grant for the simple reason that someone with a grant in that period would be more productive and therefore more competitive. This funding drought, which could be quite brutal to scientists renewing grants, could be disastrous to scientists struggling to obtain their first grants. These never funded scientists may be forced to abandon their research projects and pursue alternative careers or work on someone else’s projects.

Science projects could be loosely classified as applied research or basic research. Projects yielding results that could be useful for developing an application of economic or social value fall under applied research. All other projects yielding results for which a practical use is not immediately apparent are considered basic science. The NIH predominantly funds applied research projects and some basic research projects as long as the subject of study has some relevance to human health. The National Science Foundation (NSF) almost exclusively funds basic research projects. NSF budget is only about a seventh of the NIH budget but it has bucked the trend, increasing by about 50% since the year 2000 (even after factoring out inflation). I think this increase merely reflects a balancing of sorts: the NIH budget, and thereby funds for more applied research, increased in 1990s and has declined since 2003; the NSF budget, and thereby funds for basic research, has started to increase since 2003.

My reasoning is based on the fact that the funding rate trend at the NSF is similar to that at the NIH. While the number of NSF grant applications has increased from about 30,000 in 2001 to about 50,000 in 2013, the success rate has dropped from about 30% to about 20%. The situation at the United States Department of Agriculture (USDA) is worse than at the NIH. The situation at some other agencies is better, for example at the Department of Defense (DOD) or Department of Energy (DOE), but their focus is narrow and outside the scope of most independent scientists. Therefore, they were not considered here.

Many private organizations and wealthy individuals have injected some additional funding resources to accelerate or energize particular areas of research, such as research targeting specific cancers or diseases. It is now also possible to raise research funds from a large number of small donors with a shared interest, as through crowd funding. However, in my opinion these additional funding resources are relatively small, narrowly focused, or inconsistent to have a sustained, long-term impact on scientific fields as a whole that is so important for discovery and progress.

One simple reason is that the interest or focus of these private or popular agencies could change, even be whimsical. The second reason is that this funding is most likely designated for research projects that have the potential for yielding human or technological results that are sensational or appealing to the public. The third reason is that most breakthroughs in applied sciences happen with advances in the underlying basic science research whose value is not immediately or easily apparent. Regrettably, basic science is becoming an anathema even in federal agencies like the NIH and the explicit requirement of 'usefulness justification' for appropriation of funds threatens to erode the commitment to pure basic research even at the NSF.

I believe that in order to get the most and the best out of scientists and science, all scientifically sound projects that are proposed by investigators based on their natural interests should be funded. This is the best strategy in the long run for three reasons. One, scientists will be highly motivated if they are pursuing projects that interest them. Two, except in rare cases, it is very difficult to predict which data set is more useful across long periods of time or diverse contexts. Three, funding all scientifically sound projects will result in a more even development of data in a field, which in turn leads to more rapid and integrated progress.

The obvious next question is what proportion of grant applications received by funding agencies are scientifically sound enough for funding. After many mental exercises and probabilistic arguments, I settled on a simple criterion that is external to me. In general, grant review panels discuss about 50-60% of the applications for funding consideration, suggesting that that proportion of grant applications reached an acceptable level of robustness and completion. I think that is an underestimate because data in some of my un-discussed grant applications have resulted in good publications that are useful for the field. I think a reasonable minimum estimate is about 70-80%.

This is also closer to the level of grants funded in the 1950s to 1970s when apparently grants had to be only scientifically sound to secure funding.

In order to reach that level of funding the budgets of all agencies will have to increase 3-4 times. I do not envision this happening any time in the near future. *I also do not think that simply increasing funding in the traditional system is in the best interest of science.* The extra money will be wasted if the many mechanism and data problems are not resolved. These problems are the subjects of essays 5 and 6. After reading these essays, you will be in a good position to appreciate the reasoning, criteria, and guidelines presented in essay 7 that I used to design the new system for research with the goal of helping all interested and competent scientists sustain a research career without breaks and produce superior data most efficiently.

Cedric