Igniting the Arab Scientific Revolution

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Can the Arab world become a major contributor to the advancement of the sciences, as it once was many centuries ago? Does it need to? If so, how best to go about it?

Before I attempt to address these questions I will start by letting you in on a secret. It is about a mechanism that is central to the spectacular success of the scientific research enterprise in the American university system, which produces more research publications, discoveries, inventions and Nobel laureates than any other system in the world. This mechanism is seldom discussed, and almost completely unappreciated worldwide, and may thus well be called a "secret". It goes by the uninspiring name of "contract overhead".

The story of "contract overhead" goes back to the late 1930s and a man by the name of Vannevar Bush, who is unrelated to the Bush political family. Bush was a professor of electrical engineering at MIT and is credited today with describing a system of linking information that was the inspiration for the hypertext language which made the World Wide Web possible. However, his relevance to our topic of invigorating Arab scientific research has nothing to do with his unwitting contribution to the phenomenal rise of the Internet, but rather to his obsessive determination to transform the way scientific research was conducted in the US. He realized, at the eve of the Second World War, that much of the brain power concentrated in academia was neither well-supported, nor structured to efficiently benefit the nation and humanity at large, and that academic institutions had no strong incentives to fix the problem.

On June 12, 1940 Professor Bush managed to bypass the resistance of government officials, walk into the Oval office and present President Franklin Roosevelt with a single sheet of paper describing a radical plan for developing government-sponsored scientific research in academia. Roosevelt approved the plan in ten minutes, and that was one of the major triggers for launching the golden age of American scientific research. Within months, the plan bore the first of its innumerable fruits: the perfection of radar technology, which was instrumental for the Allies' victory in the War.

Later, Alfred Loomis, a leading researcher and one of the developers of radar, said: "Of the men whose death in the summer of 1940 would have been the greatest calamity for America, the President is first, and Dr. Bush would be second or third."

It is in peacetime, however, that Dr. Bush's plan truly blossomed. It led to the exponential growth of the most vigorous, prolific and effective intellectual enterprise of any sort in history, and one which still attracts to American universities some the brightest young people from around the world.

An essential ingredient of Dr. Bush's plan was the "contract overhead" I mentioned earlier, and which is a sort of tax the university itself imposes on the government (as opposed to the government taxing the university) on every research contract. Today for every dollar of research funding I win for my laboratory through competitions sponsored by funding agencies, Princeton University, my employer, takes away 54 cents. That seems like a huge tax for a researcher to pay from his or her research contract. However, this "contract overhead", which bolsters the university's dedication to scientific research and allows it to maintain state-of-the-art teaching and research facilities, to subsidize research and teaching in the humanities, and to raise the salaries of its employees to levels competitive with the commercial sector, has proven to be one of the "secrets" that allowed American research universities and institutes to become beacons attracting young minds from around the world. These students often stay in the US after graduation, become citizens, and are the brains fueling the continuing supremacy of the West in scientific progress. In my department at Princeton University, there are 55 professors and research scientists, 37 of whom are foreign-born. That ratio is a typical one for most research institutions in the US.

It may seem odd to start this article with a story implying the counterintuitive recommendation that, in order to fuel scientific research, institutions should take away 54% of the research funds awarded to each struggling research scientist in the Arab world. A recommendation like this, by itself, would be foolish and perilous. Contract overhead is just one essential ingredient in a complex formula that had proved immensely successful for growing scientific research – a formula that, with a few alterations, is worth copying from the West.

I will attempt here to overview the main aspects of this formula and suggest a few corrections that are inspired from lessons learned during the decades since that fateful day in June of 1940.

Of course, Professor Bush's plan did not spring from a vacuum. Its foundations laid in a scientific culture that had been growing in Europe for three centuries. The first Scientific Revolution, which began with the discoveries of Kepler and Galileo in the early seventeenth century, and culminated with the publication of Newton's Principia in 1687, established a seemingly irreversible culture of scientific progress in the West. This culture, and its rapid evolution in the 20th century, have given the West the significant edge in scientific discovery and technological innovation that it still enjoys today. In the East, a few nations, most notably Russia, Japan and, more recently, South Korea, Taiwan and China, have adopted many aspects of this culture and have become major contributors to the world's intellectual and material output of science and technology.

[In the context of this article, I will be using the term "science" to encompass the natural sciences (both physical and life sciences), mathematics, engineering, and computer science, since, at the research level, the basic methods for practicing and advancing these disciplines are essentially very similar, if not the same.]

At this juncture in their history, a few Arab countries, especially the Arab Gulf States, due to their prosperity, stability, abundance of human and material resources, cultural tolerance and global integration, are particularly suited to fuel, ignite and lead a scientific revolution in the Arab world, with the less wealthy states contributing brainpower. Since the scientific enterprise today is intrinsically global, I prefer to think of such an Arab scientific revolution not as one with connotations of nationalism or regionalism, but rather as one aimed at elevating the status and output of scientific research in the Arab world, and fully integrating it with that of the international scientific community.

I am well aware that a number of forward-thinking institutions, foundations and individuals in the Arab world are already working hard towards such a goal. I shall not attempt to review their valiant efforts, nor pretend to preach them on how to best formulate detailed policies. After all, I am a practicing research scientist and not a policy expert. I shall, however, attempt to communicate a few constructive ideas distilled from my own experience as a researcher, with the hope that such ideas may prove to be of some use in discussions of the problem.

First, I would like to briefly offer a motivation for the expensive, demanding and challenging undertaking of establishing a world-class scientific enterprise in the Arab world. In that context, two valid questions might well be asked: "Why not concentrate the Arab world's human and material resources on evolving what Arabs have traditionally done well, namely commerce, finance, and the humanities? Couldn't we rely on the West and the Far East to come up with the scientific breakthroughs from whose fruits we will eventually benefit thanks to the global economy?" To these two valid questions, I offer, in response, two compelling questions: "Can the Arab world afford not to spend a significant part of its material wealth to allow its brightest sons and daughters to participate in some of the most exciting and rewarding intellectual explorations of our times?" Could Arabs ever be taken as full and equal partners to those who chart the world's economy and security if they remain mere consumers of science and technology, and not producers of discovery and invention?"

Arab and Islamic civilizations have, historically, made tremendous contributions to the physical and life sciences, mathematics and astronomy. It is now a mainstream fact among historians of science that the creation and maintenance of the experimental spirit was primarily due to Arab and Muslim scientists up to the 12th century. However, today, the situation is sadly very different. The number of original science research papers published in international journals by scientists in the Arab world presently is less than 0.1% of the number published by scientists in the West. Only 370 patents were issued to people in Arab countries between 1980 and 2000. In South Korea, which has a population one tenth that of the Arab world, there were 16,000 patents issued in that same period.

The fact that the relatively smaller number of scientists of Arab origin working in the West contribute a far larger percentage than their counterparts in the Arab world, proves the obvious fact that the problem is not one of capability but rather of means and opportunities. The key question before us, therefore, is how to secure the means and opportunities for scientific research to prosper in the Arab world.

Instead of dwelling on the past and its problems, I will now focus on suggesting solutions based on an appreciation of the successes, and occasional failures, of the modern scientific enterprise in the West, and propose a holistic plan for igniting the Arab Scientific Revolution. The plan aims to suggest clear, critical, and synergistic roles for government, industry, educational institutions, and the media in nurturing a vibrant, prolific and world-class scientific research culture in the Arab world.

First and foremost, it is essential that the leading Arab universities and institutions of higher learning undergo a radical transformation, similar to the one that resulted from Vennevar Bush's plan in the US, whereby they would become doctorate-granting graduate institutions, and scientific research would become a primary component of their mission - a component that should be on equal footing with teaching.

In order to effect this transition and attract world-class scientific talent, universities must adopt the tenure system, whereby professors and researchers are granted long-term employment security after demonstrating to their peers their ability to continue making significant scholarly contributions. It is also essential that promotion and tenure be directly linked to accomplishments and excellence in research, and not only teaching, and that salaries be commensurate with those in the corporate sector. In granting tenure, and promotions, concrete metrics for assessing the volume, importance and impact of the research output of each researcher should be used. Furthermore, appointments of professors, researchers, deans and even presidents of universities should be done through revolving search committees consisting of peers and not government officials.

Although I am not a proponent of strong government control and regulation of education, I believe that a system of academic accreditation that judges and ranks universities and their graduate programs, according to high international standards can go a long way in elevating the stature, visibility and ability of the top schools to attract international talent to their student bodies and research faculties. It is even better, I believe, to use for that purpose the services of well-established American or European accreditation boards.

Universities and research institutions should be allowed and encouraged by the government to collect overhead fees on research contracts -a model that has proven to be critical to the success of scientific research at American universities, as I discussed in the beginning of this talk.

Governments, of course, have a number of critical roles to play. Their sponsoring of scientific research and awarding of grants and contracts should not be based on internal and regional politics, ethnic and racial parity, or demographics, but on merit-based competitions. The issuance of competitions and managing of research contracts should be entrusted to national science foundations, both private and governmental. A good model is the the Arab Science and Technology Foundation that was recently founded in the UAE.

The selection of competition winners should be made by proposal review committees consisting of scientific peers and experts, and not politicians or administrators. Furthermore, the establishment of government-funded research centers, national laboratories and think-tanks should be a priority of national spending. According to the United Nations, presently no Arab country spends more than 0.2 percent of its gross national product on scientific research. By contrast, the United States spends more than 10 times that fraction.

Governments, also, can further fuel the scientific enterprise by offering significant tax breaks and subsidies to companies, foundations and individuals that choose to sponsor scientific research; by creating a rigorous patent system that is efficient and has enforceable laws aimed at protecting intellectual rights; and by bestowing honors and awards on outstanding research scientists.

Another component of the formula that has proved successful in continuously correcting the path of scientific progress in the West, Russia and the Far East, is the role played by the national science academies, whose charters are to perform an invaluable public service by bringing together committees of distinguished experts in all areas of scientific and technological endeavor. These experts serve *pro bono* to address critical national issues, and give advice to the government and the public on research priorities. The creation of national academies of science in the Arab world is long overdue.

Given the limited resources of even the wealthiest nations, priorities for funding research should be made and continuously updated. For instance, in many research problems in the applied sciences that are of direct interest to industry, the government should give only seed funding to research institutions, then judge their performance by their ability to use their initial results to secure industrial funding and transfer technology to industry. There are, however, a number of research problems that are critical to the common good and that are not profitable enough to attract the attention of the industrial sector. A good example is in drug research. In the US, it typically takes more than 10 years for a pharmaceutical company to research, test and develop a patented drug, which, if approved by the government, allows the company to make profits for only 7-10 years before the exclusivity license expires. Less then 1 in 50,000 compounds tested actually make it to the market. So that 1 successful product has to pay for all the research and salaries associated with testing the other 49,999. Because of these constraints, drug research and development for many critical but relatively uncommon diseases tend to be neglected. These neglected research areas should receive high funding priorities by the government, private foundations and philanthropists.

We must also learn a lesson from the failed experiment of the Arabization of scientific teaching in some Arab countries, where students were kept away from learning science in English and became severely handicapped in engaging in the inherently international discourse of science. The innocuous fact that, since the middle of the 20th century, English has become the *lingua franca* of science in the world, should not be interpreted as a result of the imperialism of George Bush, but rather of the constructivism of Vannevar Bush. Today, Chinese applicants to graduate schools in the US often score higher on English comprehension tests than native Americans.

On the cultural level, there is much that can be done by the media to enhance the image of the scientist and to show that a career in the sciences can be rewarding. Today, fewer than one in 20 Arab university students pursue disciplines in the pure sciences, as the only opportunity after graduation for science majors is teaching in elementary schools. The Arab media, especially television, not unlike their counterparts in the US, are mostly focused on the entertainment industry and its celebrities. Very few people in the Arab world know the names of prominent Arab scientists. Just in my field of space science and technology, there are distinguished scientists like Charles Elachi, Farouk el-Baz, Maha Ashour-Abdallah, George Helou and Moustafa Chahine, to name only a few, who would be inspiring role models for young aspiring scientists but who remain practically unknown in the Arab world despite their great international prominence.

Some of the obstacles that faced the progress of science in Europe before the Age of Enlightenment, were due to fundamentalist interpretations of religious scriptures (as in the famous case of Galileo's persecution) which were used to cast scientific progress as a threat to religious faith. Luckily, Islam, historically and intrinsically, has a strong affinity to the vocation of learning and the seeking of truth, and has been largely immune to feeling threatened by scientific and technological progress, whose ultimate goals are the improvement of the standards of life, the eradication of diseases and suffering, and the understanding of natural phenomena.

Last but not least, there is a way to automatically more than double the numbers of practicing researchers in science and engineering in the Arab world, and that is by removing the societal obstacles for women to pursue careers in these fields. Already the percentage of university graduates in Lebanon with degrees in Science or Engineering, who are women, is above 48% –the same percentage as in the US. In the UAE, Kuwait, Qatar and Oman, these percentages are even higher. There are, in fact, more female than male undergraduates studying public health in Lebanon, chemistry in Iraq and pharmacy in Syria, with percentages significantly exceeding those in the EU and the US. The educational systems in these countries, although presently lacking emphasis on research, can, in their gender equity, be models for much of the developing world. The problem, however, lies in the opportunities women have *after* they graduate, as socio-cultural factors still severely limit their career options and advancement in these fields. If half of its workforce and brain-power is not allowed to contribute, the Arab world will continue to lag behind in these critical fields as well as others.

Lest I leave you with the impression that the path of scientific progress in the US, during the six decades between Vannevar Bush and George Bush, has been a flawless one, I should enumerate a few of its pitfalls which, in my opinion, are unworthy of emulation. These include an over-emphasis on military research, which in this age of global economic competition is unwarranted and wasteful; a recent tendency for over-protectionism and secrecy in some areas of technological research; and the recent complication of the procedures for foreign students to obtain visas to come study in the US. This last unfortunate development may well lead to a stifling of the very brain flow that had fueled the vitality of the American scientific enterprise.

As a boy growing up in Lebanon during the Apollo age, I dreamt of going to the US to study and be involved in research on space science and technology. I was fortunate to have my far-fetched dream come true. Is it too far fetched for me now to dream that, one day in my lifetime, an American girl growing up in Minnesota would aspire to come to a world-leading research university in Arabia to study astronomy in the land where astronomy was born?

For the sake of prosperity and peace, I hope that we can all work hard to make this dream come true.

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