It's (Urgently) Time to Blur the Lines Between Basic and Applied Research

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When President Obama said in his inaugural speech, "We will restore science to its rightful place," the scientific community breathed a deep sigh of relief, shed tears of joy, and gave itself a collective high five. The forthcoming stimulus package may contain major investments in scientific research, with budget increases in science that we have not witnessed for decades. And yet, while hopeful about these changes, as a scientist I feel obligated to ask the following question: how are we best served by this science "renaissance"?

With more funding, greater public awareness, and a reinstatement of the importance of science by the President on Day One of his term, it behooves scientists to reflect upon how we study and practice our fields. This reflection will not only allow us to allocate our new influx of federal money most prodigiously, but even more importantly it will allow us to practice the best science possible for the challenges that our planet urgently faces.

I believe that the crux to maximizing the impact of science lies in dismantling a longstanding tradition within the science disciplines, the tradition of dividing scientific scholarship into two major pillars: Basic and Applied. If the scientific community could bridge the divide between these two approaches to doing science, our scholarship, our community, and our world would be the better for it.

What is the difference between basic and applied science? The term *Basic Research* has been and is still often used to imply some sort of *fundamental* work, involving analytic theoretical investigations to reveal new physics, or experimental characterization to elucidate new phenomena, or any of a number of other approaches for understanding fundamental behavior. The term is typically used in the "discipline" sciences, namely math, physics, chemistry, and biology. Basic research is meant to be contrasted to *Applied Research*, which traditionally refers to work carried out in engineering departments, including materials science, chemical, electrical, mechanical engineering and so forth.

Traditionally, these two pillars have looked down on one another, and unfortunately this particular tradition runs quite deep. Basic researchers will not do applied work because it is not "deep enough" and applied researchers will not do fundamental work because it is not "real enough." Exacerbating the matter, university departments tend to segregate the basic and applied disciplines; all too frequently the chemistry department works entirely independently of the chemical engineering department.

More and more, we are recognizing the massive potential for new and creative ideas that form *only at intersections* between disciplines: physicists participate in the “century of biology,” mathematicians work with chemists for a focus on applications, chemists are more interested in the solid state, and biologists draw new connections to chemistry and physics at the atomic scale. Yet, today’s interdisciplinary approach is still not nearly as evolved as our current crisis warrants. The boundaries between the Basic and Applied pillars of science must lower dramatically because of the *need for these categories to overlap in order to actually do the science itself*. Today’s challenges not only require different disciplines to come together at a collective table, today’s problems require that *both basic and applied scientists* within each discipline have a seat.

Many of the most important solutions we need to meet our global challenges – such as cheap, clean energy conversion, high density energy storage, and abundant clean water – will rely on two key pieces of scientific discovery: (1) new fundamental understanding of the basic properties and mechanisms that make these materials do what they do (for example, convert sunlight into electricity or store hydrogen), and (2) new ways to make new materials and ramp up manufacturing to levels that can impact these problems on a worldwide scale.

And here’s the real opportunity: (1) cannot change the world, and nor can (2). Only the *combination* of these will genuinely allow us to accelerate the pace of innovation. Understanding the fundamental mechanism operative in a given material might historically be where “basic research” stops. Finding a slightly better efficiency in a material after a combinatorial search might historically be where “applied research” stops. The two communities have had the following traditional attitudes: for (1), “Someone else can use this new insight to make something of it,” and for (2), “Someone else can go back and figure out really why compound ABC works best.” But (1) and (2) need one another more than ever before, because for these problems, in this time, there is simply no other way to do it.

The materials that we have yet to discover that might one day save the world are far too complex. Yes, we absolutely need to understand their behavior, but only in the context of being *relevant.* And yes, we absolutely need to engineer manufacturable devices, but true breakthroughs will only occur in the context of *maximum understanding*.

This is why the barrier between basic and applied research must fall. Each one needs the other and working together, spanning across this boundary, the possibilities for success are exponentially greater.

Government funding is at present the dominant force urging basic and applied sciences to work together. The National Science Foundation and Department of Energy often require large grants to be filled by teams that combine both basic and applied approaches. Unfortunately, what happens all too frequently is that the scientific community’s modus operandi and academic culture is so entrenched that the research still takes place in a highly segregated manner.

For real change to take place in the scientific community, the impetus for these transformations must come from within. Scientists are the ones who have to work in teams that come together around common excitement to solve a problem, not around the common need (and in some cases greed) to simply obtain funding. That is, scientists must re-commit their science to being problem-driven rather than grant-driven. And with this recommitment, there should be an examination of how to problem-solve fully, with *all* types of approaches – both basic and applied – involved. Without this recommitment to the urgency of scientific problem solving, new understandings, innovations, and even serendipitous discoveries will simply not occur nearly as rapidly as they could.

For millennia, science has enlightened us with knowledge of how the world works and led to magnificent discoveries and extraordinary innovation. As a result, we enjoy higher standards of living (and live much longer and healthier), have a greater appreciation for the wonders of our universe, and can be inspired in new ways that challenge and extend our imaginations. And yet, rarely, *if ever*, has there existed a role for science and a scale for science and an absolute need for science as there exists today.

The problems we face now are global in nature, not local. The problems we face now will have long-term consequences, not short term. The problems we face now threaten our entire way of life and indeed life itself, not just a small part of our lives. And the problems we face now have an urgency to them we cannot afford to test.

If we stay entrenched in our traditional ways and old divides, scientific discoveries will still occur, but the necessary focus for the challenges at hand will not be in place. Simply put: business as usual will not allow us to respond to the urgent crisis that we face.

For science to save the world – which it must – science itself must be saved from its status quo. Practicing a new science that fuses basic and applied approaches and draws from multiple disciplines can create the innovation we need in this urgent time. To innovate the world, first we will need to innovate the way we practice science.