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THE VALUE OF BLUE-SKY RESEARCH

by Tasneem Zehra Husain

Upon winning the Nobel Prize, Peter Higgs expressed a hope that "this recognition of fundamental science will help raise awareness of the value of blue-sky research". By this, he means curiosity driven research, with no definite goal, no expectation of a practical outcome; research fueled by questions like 'why is the sky blue?'

That such questions arise naturally is undeniable, but the act of following them through to the answers is some times looked upon as a luxury. Is it intellectually decadent to expend mental and financial resources going down apparently useless paths, in a world where there are so many concrete problems yet to be fixed? This debate has, in one form or another, gone on for centuries. Whenever there is news of a discovery, one of the first questions asked is 'what can it be used for'? When Faraday displayed his new electric dynamo, this inevitable question was put to him, too. It is said he retorted "Of what use is a new born babe?" A remarkably apt response, that. A baby may grow up to perform spectacular feats, but you cannot predict at birth what these will be. In any case, most people do not bear and raise children because of what they might possibly accomplish in the future.

Any judgement of scientific value depends on your definition of science and what you consider to be of value. According to Nobel Laureate, Erwin Schrodinger, the 'objective, purpose and value', of science, as of any other branch of knowledge, is simply to "obey the commandment of the Delphic oracle: 'Know yourself.' That is science, to learn, to know; that is the rising truth of every spiritual human enterprise."

As a species we have an innate urge to make sense of the universe around us. Instinctively, we look for patterns, organize information, abstract from particulars, and make predictions for the future, based on the past. Questions bubble up in our minds, unbidden, and float around until they are addressed. To a large extent, this need to understand, to uncover hidden order in apparent chaos, defines us. Science is merely the name by which we refer to this process.

Of course, once we succeed in understanding a natural phenomenon, we acquire some degree of control over it. There might, then, be ways in which we can manipulate a system to achieve certain desired outcomes; and where we cannot modify natural workings, we can often still derive some material benefit from the predictive power we have gained. These applications however, are the results of science, they are not the the driving force. This is a crucial distinction. The spark is always lit by a question; if later it becomes a raging fire, many may gather to warm their hands, but one must remember that they did not ignite the flame. Just as a fire needs oxygen to keep burning, science feeds on intellectual freedom - on the ability to spot a question from afar and follow whichever rambling path it leads us down.

When we conduct research for practical reasons, there is a list of questions we want answered. When we engage in blue-sky research, it is to search for questions we don't even know how to ask yet. Goal-oriented research can be subsumed into science, but it cannot become the whole story, without destroying the nature of scientific endeavor. If we have a definite destination in mind, we already know where we will end up; even if our journey is circuitous, there are only so many unknowns it can circumscribe. We aim to move from where we currently stand, to a place we know of, or have seen, or at least, are able to imagine. In doing so, we are stay firmly within the limits of what is conceivable.

Blue-sky research, on the other hand, sticks to no trail, no terrain. We simply follow our fancy and often end up on uncharted territory that lies beyond the known horizon. Even if nothing else results from this expedition, we will have added to the map of knowledge we are collectively constructing. To us, the new lands we encounter may yet appear too foreign to consider inhabiting, but novelty fades fast; in a generation or two, these strange lands will be built and cultivated by people who grow up taking them for granted.

Thus expands knowledge. Each brave soul that ventures out, past the borders of what is known, widens the playing field of our imaginations and stretches the scope of possibility. Each time we push the boundaries of knowledge a little further, we raise the stakes. With every triumph, we add to the dignity and potential of our race. The resulting inspiration trickles down to us all, and just the act of being human becomes a grander thing. At times when, as

individuals, we feel stuck, shackled by the minutiae of our lives, it is soul-satisfying to know that as a species we are gaining ground.

So, yes, the practical problems surrounding us do require attention, but to paraphrase Oscar Wilde, even while we are in the gutter, some of us should be looking at the stars. Dreamy as it may seem, star-gazing can sometimes have strange and unexpected benefits. 'Blue-sky' research is a somewhat tongue-in-cheek name. It conjures up images of people, lying on the grass, gazing at the clouds floating by, lazily wondering why the distant sky is blue. In truth, it was the prolific British physicist John Tyndall, who in the late 19th century, realized that when the white light of the sun scatters off particles in the earth's atmosphere, the colors of the rainbow are scattered off at varying angles. Blue light, having the shortest wavelength, is scattered far more than the others, so this is the color that appears to prevail and we see a sky bathed in blue. Tyndall's discovery had many implications, most of which seem logically quite unrelated to the color of the sky; it was used, for example, to prove Pasteur's claim that living organisms could not be 'spontaneously generated' from inanimate matter - like maggots from dead flesh.

There are, of course, countless other times when the by products of blue-sky research have yielded immense tangible benefits. A century ago, newspaper headlines declared Einstein's general relativity so abstract and difficult 'only twelve people in the world can understand it'. The theory had all the hall-marks of a beautiful mathematical sculpture; connoisseurs gushed, while everyone else gazed upon it in admiring un-comprehension. On a practical level, the difference between newtonian gravity and general relativity was slight; it lay hidden in the decimal places, deeper than most situations merit digging. On a philosophical level, however, the two diverged greatly. Newton offered a working prescription, Einstein provided an explanation. No one at that time, not even Einstein, had any inkling of the role his theory would play in satellite navigation a few decades later. The incredible precision of calculations made using general relativity is what enables the GPS navigation systems in our smartphones to locate the nearest coffee shop or gas station, and lead us there step by step.

PET (Positron Emission Tomography) scans have become indispensable in the diagnosis of cancer, heart disease, and Alzheimer's, among other things. The technique involved hinges upon the detection of radiation emitted when an electron, and its anti-particle, the positron, meet and annihilate each other. The demise of positrons has been reduced to a routine statistic today, but in the 1920s, their existence was almost unfathomable. Positrons burst on the scene as legitimate mathematical solutions to Dirac's golden equation. This equation itself was a triumph; it described the electron as a relativistic particle, thus representing the first successful union of special relativity and quantum mechanics. The problem was that there was another solution to this equation, in addition to the electron, and mathematically speaking, it was equally plausible. If this second solution had a physical manifestation, it would look identical

to the electron in every way, except that it would carry negative energy. Such a thing could barely be conceived of at the time, and Dirac suffered his share of agonies at the outrageous demands his beautiful equation was making. A few years later, the positron was experimentally detected and it was proved that Dirac's equation knew what it was saying, even when we were not ready to hear it.

There are many other such examples. The fact is that we have benefited from fundamental research in almost unimaginable ways, but that is not why we do it. Our quest for reason is part of what makes us human. The need to search for answers is woven into the fabric of our being. It gives us purpose, dignity and pleasure. This opinion is shared by most of the giants of science. Max Planck, the reluctant emissary of quantum mechanics, claimed "the roots of exact science feed in the soil of human life". Polymath Henri Poincare said "the Scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it; and he takes pleasure in it because it is beautiful. If nature were not beautiful, it would not be worth knowing and life would not be worth living. . . " Einstein summed it up brilliantly when he said "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He to whom the emotion is a stranger, who can no longer pause to wonder and stand wrapped in awe, is as good as dead."

Every great scientist through the ages has been motivated by curiosity, spurred on by mystery, been rapt in wonder. That is as it must be. Blue-sky research lies, inextricably, at the very core of science.