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THE DICTIONARY IS NOT LITERATURE

by Tasneem Zehra Husain

Science is beautiful. Or so they say. When Werner Heisenberg, one of the fathers of quantum mechanics, made his major breakthrough, he wrote "the whole area of internal relations in atomic theory is unexpectedly and clearly spread out before my eyes. What these internal relations show in all their mathematic abstraction, is an incredible degree of simplicity, a gift that we can only accept with humility. Not even Plato could have believed that it would be so beautiful. In fact these relations cannot have been invented: they have existed since the creation of the world." Such pronouncements are not rare; the splendor of theories and the elegance of equations has been extolled by generations of scientists. Unfortunately, however, these sentiments aren't always shared by the general public, most of whom assume that this particular form of beauty lies only in the eye of the (highly educated) beholder - a tragic misconception which precludes many from claiming the profound relationship with the universe that is their birthright.

It is true that the deeper we delve into any subject the more subtle our appreciation of it becomes, but just as we do not need a degree in Art to enjoy a painting, or a degree in Music to enjoy a song, a formal degree is not a prerequisite to experiencing the joy and wonder of science. Scientists find aesthetic pleasure in their subject, not just because they know more than the lay person, but because they have imbued what they know with meaning. They are aware of the context in which statements are made, and of the connections that exist between one idea and another; through long years of practice, they have trained their ears to hear the beautiful and passionate harmonies that lie implicit in apparently bland scientific laws.

To those of us who lack such associations, the very same statements fall flat. They do not evoke emotion, any more than a printed musical score would. But if someone plays the composition, that is another thing entirely; suddenly, the monochrome pattern of notes weaving through staff lines becomes a living entity, with a story and a soul. When non-scientists read textbook passages, or newspaper articles distilling the latest discoveries, it is only natural that they remain unmoved. Most people lack the experience, the mental images and the knowledge networks which would allow them to create meaning from a string of facts; in the absence of such connections, statements that should rightly inspire awe, dwindle into mere trivia.

Nobel Laureate Richard Feynman declared that this age could not yet be termed scientific, because science was confined to evening lectures, not expressed in song or poem. But, being a uniquely gifted science communicator, he then went on to show how this music could in fact be read. “For instance, the scientific article may say, 'The radioactive phosphorus content of the cerebrum of the rat decreases to one- half in a period of two weeks.' Now what does that mean? It means that phosphorus that is in the brain of a rat—and also in mine, and yours—is not the same phosphorus as it was two weeks ago. It means the atoms that are in the brain are being replaced: the ones that were there before have gone away. So what is this mind of ours: what are these atoms with consciousness? Last week's potatoes! They now can remember what was going on in my mind a year ago—a mind which has long ago been replaced. To note that the thing I call my individuality is only a pattern or dance, that is what it means when one discovers how long it takes for the atoms of the brain to be replaced by other atoms. The atoms come into my brain, dance a dance, and then go out—there are always new atoms, but always doing the same dance, remembering what the dance was yesterday.”

Left to our own devices, few of us would thrill to a recitation of our elemental makeup, yet Carl Sagan - who knew how to interpret this list - found in it both poetry, and hope. In a sentence that has achieved almost cult status, he wrote “All of the rocky and metallic material we stand

on, the iron in our blood, the calcium in our teeth, the carbon in our genes were produced billions of years ago in the interior of a red giant star. We are made of star stuff." Once we see this link between ourselves and invisible giant stars populating the dark cold depths of space, the skies glow with a renewed fascination.

As a species, we are enthralled every time we see ourselves reflected in a physical phenomenon - like a baby mesmerized by a mirror. One could be cynical and call this narcissism, but I think it has more to do with the mechanism through which we make sense of things. The need for association is wired into our being; emotional links determine what we care about, what we ascribe importance to; intellectual understanding depends on us being able to connect the new and unfamiliar to what we already know. We move out from our little island of knowledge by building bridges - that is simply how the mind works. Isolated pieces of information that resist being incorporated into our network leave us feeling flat, at best; apprehensive, at worst.

A few decades before Sagan's grand pronouncement that 'the cosmos is also within us', British physicist/astronomer James Jeans expressed this unnerving feeling of disconnection. He wrote "We find the universe terrifying because of its vast meaningless distances, terrifying because of its inconceivably long vistas of time which dwarf human history to the twinkling of an eye, terrifying because of our extreme loneliness, and because of the material insignificance of our home in space - a millionth part of a grain of sand out of all the sea-sand in the world. But above all else, we find the universe terrifying because it appears to be indifferent to life like our own; emotion, ambition and achievement, art and religion all seem equally foreign to its plan… For the most part, empty space is so cold that all life in it would be frozen; most of the matter in space is so hot as to make life on it impossible; space is traversed, and astronomical bodies continually bombarded, by radiation of a variety of kinds, much of which is probably inimical to, or even destructive of, life."

To me, the contrast between Sagan's and Jeans' points of view proves physician Martin H. Fischer claim that "Facts are not science, as the dictionary is not literature!" All facts are in themselves inert while they lack the context that gives them meaning. From years of reading, we know that our interaction with literature is most meaningful when a story reaches out and draws us in. The fantasy author Neil Gaiman spoke recently about the transformative power of reading; books have the potential to change us, he said, because when we read we actively construct a world, taking our cue from the words on the page, and punctuating them with personal meaning. It is perhaps less commonly known that one can do the same thing with science, and imbue that relationship too, with emotion.

Just as literature is created by establishing links - deep, beautiful, often unexpected - links between words, so is science created by joining facts into a consistent and meaningful narrative. The power of scientific laws lies in their abstract quality and their sweeping nature which allows them to have a wide range of possible manifestations. And yet, our attempts to understand these vast statements begin invariably by the conjuring up of an illustrative example in our mind. We comprehend vague generalities by anchoring them in the specificities of our unique experiences. We can write ourselves into the stories of science just as well as those of literature; we just need to know how.

One way to learn - or simply appreciate - this art is to read the writings of those who have been in love with science, and voyeuristically experience their relationships with the object of their affections. Given the highly personal nature of such writing, one encounters a wide range of vocabularies and voices; people approach similar facts from many different angles, and yet there are certain themes that stay unchanged through the ages - like the wonderment we feel when we realize that all-powerful Nature has constrained herself to obey laws and logic, which can be accessed through symbols scratched on paper.

In the early seventeenth century Galileo wrote about his work on terrestrial motion: “It was indeed a laborious task for me to discover how such effects could be accomplished in nature. Yet I finally found something that served me admirably. In a way it is almost unbelievable. I mean that it is astonishing and incredible to us, but not to Nature; for she performs with utmost ease and simplicity things which are even infinitely puzzling to our minds,and what is very difficult for us to comprehend is quite easy for her to perform”. Well over three hundred years later, working on a vastly different problem, Freeman Dyson echoed the same emotion: “Here was I sitting at my desk for weeks on end, doing the most elaborate and sophisticated calculations to figure out how an electron should behave. And here was the electron on my little oil drop, knowing quite well how to behave without waiting for the result of my calculation. How could one seriously believe that the electron really cared about my calculation, one way or the other? And yet … somehow or other, all this complicated mathematics that I was scribbling established rules that the electron on the oil drop was bound to follow. We know that this is so. Why it is so, why the electron pays attention to our mathematics, is a mystery that even Einstein could not fathom.”

It is not esoteric concepts alone that benefit from interpretation. In the hands of a maestro, even the most basic and familiar statements burst into splendid song. From grade school, we are aware that this universe contains matter, upon which various forces act. We take this as

self-evident. Yet, years out of graduate school, I still thrill to the lyricism of Michael Munowitz's simple thought experiment. Suppose that matter suddenly lost the ability to interact, he suggests. There would be no attractions or repulsions, and hence no organized structures of any kind.

"A world without interactions" he writes "is a world without preferences, a world without differences, a world without cause. When interactions disappear, one particle has no cause to change its position relative to another, since all positions are alike. If there are no interactions, there are no differences. There is no agency to effect a change. With interactions gone, a particle at rest remains at rest. No agency forces it to move. A particle in motion moves uniformly in a straight line, always in the same direction, always with the same speed. No agency … alters its path. In a world without interactions, each particle becomes a world in itself: a solitary system, forever isolated, unaffected by its neighbor. Indeed, if [particles cannot recognize and respond to each other] the notions of "near" and "far" also have no meaning. If the bodies truly do not interact, then the same condition prevails when they stand at opposite ends of the universe as when they touch. For a world to contain structures more complicated than single particles, there must be a distinction between near and far. The particles must have a way to interact."

Having plunged us headfirst into this shocking scenario, he then slowly brings us back. "Let there be interactions" he says "Let one particle be able to influence another, to push it away or bring it near. Let the effect be different at different distances, so as to give meaning to each position in space. Let there be different kinds of influence and thus different kinds of particles, each responding in its own way to some particular agency. And then— whatever these agencies may turn out to be, whatever the particles may turn out to be, whatever the groupings of particles may turn out to be— there will be this one essential element of design governing them all: the potential to be different."

Suddenly, the seemingly obvious fact that forces act on particles begins to seem quite marvelous - just because someone was able to show us what it really *means* instead of merely telling us what it says.

By opening ourselves up to experience science, we let more than joy and wonder into our lives. Faraday expressed this quite eloquently when he wrote "[Science] teaches us to be neglectful of nothing, not to despise the small beginnings – they precede of necessity all great things. Vesicles make clouds; they are trifles light as air, but then they make drops, and drops make

showers, rain make torrents and rivers, and these can alter the face of a country, and even keep the ocean to its proper fullness and use. It teaches a continual comparison of the small and great, and that under differences almost approaching the infinite, for the small as often contains the great in principle, as the great does the small; and thus the mind becomes comprehensive. It teaches to deduce principles carefully, to hold them firmly, or to suspend the judgment, to discover and obey law, and by it to be bold in applying to the greatest what we know of the smallest. It teaches us first by tutors and books, to learn that which is already known to others, and then by the light and methods which belong to science to learn for ourselves and for others; so making a fruitful return to man in the future for that which we have obtained from the men of the past."

As we ramble through the pages of history, probing the thoughts of scientists, we see the vast range of personalities that have come to bear on the laws of nature, each new mind unpacking these universal truths in a different way. The greater the number of distinct voices we expose ourselves to, the easier it becomes to find some that resonate with us. There are passages which read as memoir, others as love stories, yet others as conversations. People bring with them their emotional biases and intellectual preferences, their own unique points of view, and this multitude of voices enriches the subject endlessly. Some scientists hold experiment to be the only true lodestone, while others are convinced that the elegance and beauty of equations should be the compass we use when seeking the truth. Some think in images, some through abstract symbols, some in words. Each of them tells a story worth listening to. Inevitably, as we hear these tales, we become aware of a faint hum that had always been at the back of our minds, slowly growing louder. If we tune in, we can finally hear the intimate conversation that has been going on all our lives between ourselves and the Universe.