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Prologue to
WHERE IS SCIENCE GOING?

by Max Planck
Norton, 1932

by Albert Einstein

MANY kinds of men devote themselves to Science, and not all for the sake of Science herself. There are some who come into her temple because it offers them the opportunity to display their particular talents. To this class of men science is a kind of sport in the practice of which they exult, just as an athlete exults in the exercise of his muscular prowess. There is another class of men who come into the temple to make an offering of their brain pulp in the hope of securing a profitable return. These men are scientists only by the chance of some circumstance which offered itself when making a choice of career. If the attending circumstance had been different they might have become politicians or captains of business. Should an angel of God descend and drive from the Temple of Science all those who belong to the categories I have mentioned, I fear the temple would be nearly emptied. But a few worshipers would still remain—some from former times and some from ours. To these latter belongs our Planck. And that is why we love him.

I am quite aware that this clearance would mean the driving away of many worthy people who have built a great portion, and even perhaps the greatest portion, of the Temple of Science. But at the same time it is clear that if the men who have devoted themselves to science consisted only of the two categories I have mentioned, the edifice could never have grown to its present proud dimensions, no more than a forest could grow if it consisted only of creepers.

But let us forget them. *Non ragionam di lor.* And let us fix our gaze on those who have found favor with the angel. For the most part they are strange, taciturn and lonely fellows. And, in spite of this mutual resemblance, they are far less like one another than those whom our hypothetical angel has expelled.

What has led them to devote their lives to the pursuit of science? That question is difficult to answer and could never be answered in a simple categorical way. Personally I am inclined to agree with Schopenhauer in thinking that one of the strongest motives that lead people to give their lives to art and science is the urge to flee from everyday life, with its drab and deadly dullness, and thus to unshackle the chains of one's own transient desires, which supplant one another in an interminable succession so long as the mind is fixed on the horizon of daily environment.

But to this negative motive a positive one must be added. Human nature always has tried to form for itself a simple and synoptic image of the surrounding world. In doing this it tries to construct a picture which will give some sort of tangible expression to what the human mind sees in nature. That is what the poet does, and the painter, and the speculative philosopher and the natural philosopher, each in his own way. Within this picture he places the center of gravity of his own soul, so that he will find in it that rest and equilibrium which he cannot find within the narrow circle of his restless personal reactions to everyday life.

Among the various pictures of the world which are formed by the artist and the philosopher and the poet, what place does the world-picture of the theoretical physicist occupy? Its chief quality must be a scrupulous correctness and internal logical coherence, which only the language of mathematics can express. On the other hand, the physicist has to be severe and self-denying in regard to the material he uses. He has to be content with reproducing the most simple processes that are open to our sensory experience, because the more complex processes cannot be represented by the human mind with the subtle exactness and logical sequence which are indispensable for the theoretical physicist.

Even at the expense of completeness, we have to secure purity, clarity and accurate correspondence between the representation and the thing represented. When one realizes how small a part of nature can thus be comprehended and expressed in an exact formulation, while all that is subtle and complex has to be excluded, it is only natural to ask, what sort of attraction this work can have? Does the result of such self-denying selection deserve the high-sounding name of World-Picture?

I think it does; because the most general laws on which the thought-structure of theoretical physics is built have to be taken into consideration in studying even the simplest events in nature. If they were fully known, one ought to be able to deduce from them by means of purely abstract reasoning the theory of every process of nature, including that of life itself. I mean *theoretically*, because in practice such a process of deduction is entirely beyond the capacity of human reasoning. Therefore the fact that in science we have to be content with an incomplete picture of the physical universe is not due to the nature of the universe itself but rather to us.

Thus the supreme task of the physicist is the discovery of the most general elementary laws from which the world-picture can be deduced logically. But there is no logical way to the discovery of these elemental laws. There is only the way of intuition, which is helped by a feeling for the order lying behind the appearance and this *Einfuehlung* is developed by experience. Can one therefore say that any system of physics might be equally valid and possible? Theoretically there is nothing illogical in that idea. But the history of scientific development has shown that of all thinkable theoretical structures a single one has at each stage of advance proved superior to all the others.

It is obvious to every experienced researcher that the theoretical system of physics is dependent upon and controlled by the world of sense-perception, though there is no logical way whereby we can proceed from sensory perception to the principles that underlie the theoretical structure. Moreover, the conceptual synthesis which is a transcript of the empirical world may be reduced

to a few fundamental laws on which the whole synthesis is logically built. In every important advance the physicist finds that the fundamental laws are simplified more and more as experimental research advances. He is astonished to notice how sublime order emerges from what appeared to be chaos. And this cannot be traced back to the workings of his own mind but is due to a quality that is inherent in the world of perception. Leibniz well expressed this quality by calling it a preëstablished harmony.

Physicists sometimes reproach the philosophers who busy themselves with theories of knowledge, claiming that the latter do not appreciate this fact fully. And I think that this was at the basis of the controversy waged a few years ago between Ernst Mach and Max Planck. The latter probably felt that Mach did not fully appreciate the physicist's longing for perception of this preëstablished harmony. This longing has been the inexhaustible source of that patience and persistence with which we have seen Planck devoting himself to the most ordinary questions arising in connection with physical science, when he might have been tempted into other ways which led to more attractive results.

I have often heard that his colleagues are in the habit of tracing this attitude to his extraordinary personal gifts of energy and discipline. I believe they are wrong. The state of mind which furnishes the driving power here resembles that of the devotee or the lover. The long-sustained effort is not inspired by any set plan or purpose. Its inspiration arises from a hunger of the soul.

I am sure Max Planck would laugh at my childish way of poking around with the lantern of Diogenes. Well! why should I tell of his greatness? It needs no paltry confirmation of mine. His work has given one of the most powerful of all impulses to the progress of science. His ideas will be effective as long as physical science lasts. And I hope that the example which his personal life affords will not be less effective with later generations of scientists.

I draw your attention first to the year, 1932, just six years after the Copenhagen interpretation, which reinterpreted physics as inherently nonmechanical and irrational. I also draw your attention to Einstein's description of theoretical physics as "a scrupulous correctness and internal logical coherence, which only the language of mathematics can express." The first part of that is worth considering more deeply, since it succinctly states both Einstein's and Planck's problem with the new physics: its lack of coherence. Of course we know that Einstein and Planck lost that argument, since physics no longer even bothers to fake a bow to coherence. Modern physicists have become masters of decoherence.

That said, I must take issue with Einstein's tack-on—that only math can express this logical coherence. The tack-on is not coherent itself, for several reasons. One, Einstein was not a great mathematician, and he needed help in math from his first wife, his friends (see Grossman, etc.), and then from Klein and Hilbert. This is known, and I am not stating anything revolutionary. Two, Einstein's contributions to physics were not mainly mathematical. They were systemic, synthetic, and primarily concerned with ideas, not math. Einstein was an innovator and synthesizer. Three, other paragraphs in this very prologue contradict this tack-on. Einstein tells us outright that the discovery of the laws of physics is not done through logic, but through intuition. His method confirms this like no other: he knew where he was going before he got there, and the math was only used to prop up his intuition after the fact. Unlike other modern physicists, Einstein rarely let the math lead him.

This is important because physics is much more than math, or it was until recently. Physics has been taken over by the math department in the 20th century, but this was no sign of progress. In fact, it has been one of the primary causes of dissolution. Planck and Einstein were among the first to recognize this, which is why both criticized Heisenberg's matrix equations so fiercely. They disliked the math, but they disliked the interpretation of the math just as much or more. It was at that point that the math dislodged from the physics, and began to overwhelm it. We are still paying for that mistake now.

But I posted this prologue for other reasons than the ones above. I wanted to remind my readers of my regard for Einstein and Planck. I have spent much time correcting Einstein, and some will have taken this in the wrong way. Einstein's first paragraphs here say it well: there are different sorts of physicists, and he and Planck and Schrodinger and a few others stand out in the 20th century. I do have a disregard or even contempt for many top physicists, but I have no such disregard for Einstein. He was always clear-headed, broadminded, and extremely sharp. His writing here is indication of all these things, and it stands out in a century of purposefully obtuse communication.

I also posted this to answer those who have dismissed me as an artist, a poet, or a philosopher, and therefore not qualified to question theoretical physics. Einstein explicitly makes the connection here between artist, poet, philosopher and physicist, reminding us that all seek a “tangible expression of nature.” In previous centuries, one might move freely among these fields, as did Leonardo, Joseph Wright of Derby, Pascal, Kant, Leibniz, Descartes, and many others, with no loss of honor, in fact with a gain of it. Even in Einstein's time, specialization had not become a requirement, or generalization a demerit. It is only the new careerism that has given most scientists a reason to abuse “outsiders.” Openness is no longer seen as a guarantee of new ideas, it is seen as a danger to those with old ideas.

Although we are assured that the world is different now than it was in the past, it is not so different as we are told. We are told that generalists cannot prosper, because there is too much known and too much to know. Every field is complicated beyond measure, and one man cannot comprehend more than the updates in his own specialization. Beyond that, the fields are crowded with competent specialists, trained for years by their own colleges. Tens of thousands of brilliant people now inhabit the sciences, and the best one can hope is to make a small contribution to the hive.

All extravagantly false, historically as well as now. I will answer these claims one by one, going way back to begin. Sicily at the time of Empedocles (460BC) was not a collection of caves. Its population was large, and competition was fierce in any number of fields. And yet Empedocles stood at the top of several, including politics, science, medicine, oratory, athletics, and poetry. Despite his broad interests and abilities, he was not considered a dabbler then and is not considered one now. Florence at the time of Leonardo (1480) was not a town of mud huts. Its population was large, and many talented people lived there. And yet Leonardo distinguished himself in many fields, including painting, sculpture, music, engineering, science, and medicine. He was not considered a dabbler then and is not considered one now.* Descartes, Pascal, Leibniz, Kant, and Goethe may also be mentioned as later examples of the same thing, each being a type of universal genius, more adept at most things than all those around him. All five distinguished themselves in both philosophy and science/math, making the current schism between the two fields appear all the more forced.

But we may look at the question from the other side as well. Are the arts and sciences really that complex or difficult to comprehend? Or is it, rather, that they have been loaded down with minutiae, trivialities, jargon, fake systematizing, and fudged math, in order to make them appear more learned than they are? Once any field is cleared of all its bombast and effluvium, very little content is left. I

can say from experience that it takes ten times longer to clear all the deadwood out of ones path than it does to memorize the remaining flora. No, make that a thousand times longer. One could memorize all the pertinent facts of any given field in a matter of months, but it would take several lifetimes to dig out and haul off all the impertinent falsehoods in the same field. Unfortunately, what we currently call an education dumps both facts and falsehoods upon us simultaneously and indiscriminately, in a horribly inefficient manner, making any progress extremely unlikely.

And this takes us to the question of numbers. We are told that we have an embarrassing glut of PhD's, so many that no one person could know something that they don't already know. Problem is, all these PhD's have been educated by the method above, whereby they have had a load of information dumped on their heads over the course of a decade, and this load is mainly of the impertinent falsehood kind. Unless they happen to have the intuition of Einstein, and the independence of Copernicus, they won't have been able to sort the pertinence from the impertinence, and they would have been better off with *none* of it polluting their brains. I say this in all seriousness, since we daily see examples of the most highly educated people who are more stupid than an honest eight year old. Yes, they have memorized a huge list of impertinent falsehoods, but that is hardly the road to wisdom.

In such a case, numbers mean nothing. It wouldn't take a universal genius of the Leonardo type to trump all these people. They are immediately trumped by a clever child. And again, I mean that seriously. I have shown many instances of it in my papers, by quoting real questions asked by real children of real physicists on the web. It is clear at a glance that these children have clearer and brighter minds than those they are trying to learn from, and we only wish we could warn them off before it is too late.

So when I claim to know something all these people do not know, I do not have to make the claim that I am on a level with Pascal or Leibniz. I believe in such exceptional people, but it does not require a Pascal to penetrate the current falsehoods. In my own mind, I am more like the honest child who asks the bright question, in a spirit of free inquiry and unclouded idealism. The only difference is that, unlike the child, I am not cowed by the adult's impertinent response. I no longer back down to make the grade, get the diploma, or land the job. I don't need the grade, diploma, or the job, I am only interested in an answer to the original question. If no one else can give it to me, I will find it on my own.

In an upcoming paper I will look at Planck's book, "Where is Science Going?"

*except by a few sad people in the mold of [Clement Greenberg](#).