RETROSPECT AND PROSPECT

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I KNOW well that at my time of life I should guard against the tendency to reminisce. I have one reason for hoping, however, that a reasonable indulgence might prove interesting. I was born in 1892, five years after the Michelson-Morley experiment, the fateful event that started as profound a revolution in thinking as the one that gave birth to modern science; so my contacts with science since then may ever and anon have produced something worth recounting. I can at least try if this be so—and you shall be the judge.

I begin, then, with a boyhood on the North Side of Chicago in what then was an all-but-suburban location called Sheridan Park, west of the present Wilson Avenue L station. It was a moderately well-to-do community of single-family homes in which life seemed most pleasant; and this, I believe, was generally true of middle-class living in the United States at the time. At least, I find reference often enough to the smug middle-class contentment of the Victorian age, so I venture to use the characterization.

Scraps of overheard conversation gave me the idea—although at my age the idea could have been little more than a parroting of political war cries—that my elders were content because the McKinley protective tariff assured prosperity and Bryan could not endanger the gold dollar. There was also a feeling of burgeoning destiny after Admirals Dewey, Schley, and Sampson, plus Teddy Roosevelt and his Rough Riders, settled the hash of the Spaniards and made the United States a world power.

In material advantages in living, I saw the change from Welsbach gas mantles to electric light, and I realized that our home telephone was still quite a novelty. Automobiles first became numerous in our neighborhood in 1904 and 1905, but in those early years they seemed only a sort of show-off gimmick, for they offered little improvement upon our existing transportation. Our horse Bessie served beautifully for Sunday afternoon jaunts, and steam trains ran about where the elevated is today. We could also go downtown on electric trolley cars to Clark and Diversey, then by cable car through the delicious tarry smell of the La Salle Street tunnel.

I come closer to matters that will concern us tonight with a few items of scientific achievement. I remember well the hush in our house when one of my brothers lay dying, we thought, of diphtheria and the sense of a miracle's happening when our family doctor brought a specialist who jabbed brother with something called antitoxin and brother promptly got well. I remember also, while on a visit to relatives in Texas, being taken to visit a doctor friend in a large hospital and having him show me the bones in my hand with the ghostly green light of something called an X-ray machine. That was also about the year when the rescue of the complement of the S.S. "Republic" in response to wireless distress calls set my buddies and me to winding wire into Ruhmkorff coils and otherwise equipping ourselves to spark CQD's all over the neighborhood.

Such was the background in general affairs, science, and technology when I entered high school in February, 1906. It was not long before I absorbed the prevailing attitude toward science. The delight over what science was achieving matched the middle-class contentment with affairs in general; and everyone seemed to feel that achievement would be limitless with the structure of fact, law, and theory that science was building with such care and success.

The substratum of the structure was Euclidean space, with three dimensions at right angles to each other and extending thus to infinity. Invariable time ticked off the same durations throughout the universe, just as it had done before the beginning and would do to beyond the end. Most trim and tight of all was the invariability of causality. If, in any given setup, A causes B, then in the same setup A will cause B anywhere else in the universe and at any other time whatever. This invariability and the belief that man could always trace it were perhaps the greatest reasons for complacence. They hinted that, given time, science might explain all.

Certainly I felt so, and I was eager to see science get on with the job. I even tried my hand at an advance in scientific understanding that I thought I saw in the making. Plainly, electrified particles of subatomic size were active in Crookes and X-ray tubes. Magnetism was the product of aligned molecules in iron and steel. Finally, the phenomena of electrolysis suggested that this seeming fundamental granularity in matter was matched by a granularity of electric charge. So I came to wonder whether the atoms of matter might not be composed of electrified particles, arranged to cause the properties of the chemical elements.

I still recall my physics teacher's cautious commendation when I broached this idea. "That's a sharp guess, Stevers—but don't ask me if you're right or wrong! Ask again when you get to college—they'll know a lot better than I do!"

This I certainly was agog to do when I entered the University of Chicago in the autumn of 1909, and I arranged to do it by enrolling in freshman physics. As my good luck would have it, I drew an afternoon class with Professor Millikan; to give an idea of why I say "good luck," I relate an experience with him as a teacher at the end of the very first day. After announcing the next day's assignments, he said, "Every year some students get by the deans without the prerequisite year of high-school trigonometry. How many are there this time?"

He laughed when only a few hands showed reluctantly.

"Oh, come, come! There are always more than that! To encourage you, I'll say that no one will be put out for lack of trig. Now how many are there?"

The increased show of hands brought a broad grin.

"That's better! Now I have a proposition. If you'll stay half an hour, I'll teach you all the trig you'll ever need."

Well, I had had my year of trig, so this was not for me. Still, a year's work in half an hour seemed a pretty colossal order, so, since I had no other class, I stayed to see how he would make good. To my amazement, he did. After showing the functions and how they change, he worked a few formulas; then he said, "For the rest, just use common sense. Sort out what you know and what you don't in your problem; then you can always find a formula in the book that will take you from what you do know to what you want to know."

That was Millikan, when he wanted to cut through needless protocol of training. I may add, however, that I cannot remember his ever again laying down knowledge so flatly and dogmatically. On the contrary, he hated to tell one anything that could be learned for one's self. I got a good sample of this when I asked my question from high school.

After a quick glance to see whether I was showing off or truly wanting to know, he answered cordially: "That's what we are all wondering these days," he began, "but nobody knows too much as yet. For the latest that we do know, I suggest that you read Rutherford and Soddy on radioactivity. You can get it in the departmental library." This was "do it yourself," as I have said; but I enjoyed being a discoverer, in view of what I found. As many of you know, this was the epoch-making study that clinched the case for atoms' being made of electrified particles.

My next milestone for the year came when Millikan gave us a climactic addition to this view in the winter quarter. After two weeks or so of being utterly absorbed in class, drumming his fingers on a windowpane and failing to hear recitations, he realized what he was doing and offered apology and reparation. He explained his oil-drop experiment, soon to become world-famous, and added that he was absorbed in closing the record for publication. He concluded with the thrilling statement, "Now, if you like, we'll adjourn to my laboratory, and you can see the oil drop dance." Thus I was among the first, aside from Millikan's assistants, to see this epochal proof that electricity, far from being fluid-like as we then were taught, was composed of or carried in unit charges by subatomic particles, the electron and, as we learned later to say, the proton.

This, of course, was far above freshman level at the time, but Millikan did not mind this. He often suggested readings that gave us glimpses of advanced work, and he discussed our findings briefly after class. Thus we got an idea of Planck's 1900 quantization of energy and Einstein's 1907 explanation of the photoelectric effect, discovered by Hertz in 1887.

Einstein's explanation with the energy particles that he called photons was disturbing, for it seemed to reverse the supposed triumph, early in the nineteenth century, of the Huygens wave theory over Newton's corpuscular theory of light. Millikan, however, was quite debonair about this. "A lot of work must be done," he said, "before any view about light can be said to have triumphed over any other. And who knows—it may turn out that light has properties of both waves and corpuscles"—a striking bit of prescience, as the event turned out!

The reply seems worth relating also for illustrating perfectly the color of thinking at the time, a scientific variation of the general smug contentment. Actually, discoveries such as those I have mentioned were veritable bombs dropped upon nineteenth-century thinking; but neither Millikan nor anyone else I knew about seemed to realize this. Their attitude was foursquare with what I later learned was the feeling of the Renaissance pioneers, from Copernicus and Kepler through Newton and Boyle, toward ancient science. These men all revered the ancient heritage and saw only a few blemishes of error here and there. These, they felt sure, could be corrected within a lifetime or so of work, and they saw themselves as doing just this.

It seems understandable that the same feeling should prevail in 1910, for the new corpuscularity did not seem too irreconcilable with a universe of invariable space, time, and causality. There was, of course, one veritable blockbuster for such complacency in Einstein's special relativity, for it would stand accustomed thinking on its head, so to speak, to replace Euclidean geometry and Newtonian mechanics with space and time that vary as the speed of a phenomenon approaches that of light. But I never knew what anyone thought about this at the time, because it was the one advance that Millikan never mentioned to us. I have often wondered why. I can only surmise that he shied from immediate acceptance of anything so revolutionary, in the hope that something would make it go away like an evil dream. I have one inkling of support for the guess—I once heard A. A. Michelson say just about this in one of his rare public addresses.

My contact with Millikan ended here, for family circumstances now compelled me to earn my way, and I could not give the hours required for laboratory work in physics. I received my Bachelor's degree in 1914, then spent some twenty years in advertising and magazine editorial work. During this time, I shaped up a philosophy of a sort.

From knowing the tight, trim universe of the natural sciences, I came to feel that something of the sort should obtain for all human knowledge. The ideal would be to have the personal and social sciences able to say how individuals, social groups, and nations should order their institutions and affairs as well as, say, physics deals with its problems. Then everyone would know how to live productively and happily for themselves, their families, and their fellows.

Having been through the First World War and its aftermath, I knew how far the state of affairs in the world fell from this ideal. I hoped, without knowing much about it, that sciences such as economics and sociology would have sound counsel to offer; but I doubted this more and more when I heard not one voice raised while selfish, blind political leadership and unbridled private greed plunged the world into the boom, then the panic, of 1929 and the terrible depression that followed. I fear that I was pretty much a cynic about human intelligence when a new day dawned for me in 1934, through joining *Compton's Pictured Encyclopedia.*

Since, of the senior staff editors, I alone had background in the natural sciences, this area became my charge. This not only provided opportunity; it imposed a duty to watch developments over the entire field of science. And so began my many years of studies and appraisals, some fruits of which I present to you tonight. I was not long in realizing that an astounding change had occurred since 1914.

In the twenty-year interval a veritable revolution had overtaken scientific thinking. It was centered in physics, but it had spread over chemistry, biology, and the other natural sciences, and it was affecting thinking profoundly in the humanities and all other non-mathematical disciplines.

The basic change was the realization that, whether or no the universe might be completely determined, science could never uncover completely the structure of such a giant cosmic engine. Einstein had dealt one heavy blow by forcing replacement of right, tight Euclidean geometry with variable or relativistic space and time, and the conclusive blow was loss of ability to trace invariable causality. The latter change is far too subtle for capsule explanation, but there is a rough analogy that will make the point. It turns upon the difference in filling an irregular, confined space with a fluid and using a granular substance.

By definition, a fluid will fill the space exactly, for it will fit exactly into the bounding surface. Also, given the same surrounding conditions, the same amount of fluid will do this on every trial. The presumed ability to obtain such invariable answers with entities having fluid nature was, of course, what gave men hope of uncovering invariable causality.

You cannot, however, do this beyond a certain limit with any granular or corpuscular medium. You may use gravel, sand, dust, or—to make the real point—the quantized particles that have replaced the earlier fluid concepts of energy and electricity; but always, when you get fine enough, the minimum size of particle fails to fit exactly into still tinier interstices in the bounding surface. Moreover, since the limit-size particles will lie differently, so to speak, in successive trials, you can never get the best fill with the same amount of material. Therefore, to say how much it takes, your best answer is an average of trials, amounting, in the jargon of the subject, to a *statistical event*, or *range of probability*.

This is, as I said, only a rough analogy, an effort to make the point without going into the complexities of the actual explanation; but the conclusion reached is not rough. On the contrary, it states exactly why the prospect of finding the universe fully determined by invariable causality stood destroyed. Invariability cannot be claimed for any answer that has a wobble in it, an uncertainty over a range. Also, you cannot build a pattern of a completely determined universe with such answers. This would require linking countless chains of causality together, end to end, in space and time; and how could you make a firm pattern, if you had to link chains that end in wobble in some way?

I must hasten now to add some clarifications to this broad statement, lest I be guilty of both overstatement and understatement. To avoid overstatement, let me say that this finding does not impute uncertainty or wobble to all science. On the contrary, the findings of nineteenth-century science hold as true as they ever did where they apply, and for a simple reason. In working with the speeds and dimensions of phenomena that workers attacked during that time, the quantitative outcomes of single events were indistinguishable from the related statistical averages. It is only when we get into twentieth-century areas of dealing with the superfine, the superlarge, and superspeeds approaching that of light that the divergences become meaningful. This is why it seemed possible as long as it did to envisage finding the pattern of a fully determined universe. Let me add, however, that this does not lessen the generality of the finding. If a scientific theory fails anywhere, it fails everywhere. Hence we say that we cannot trace invariable causality, even though we seem to do this well enough in areas where nineteenth-century science still holds good.

Next, to forestall understatement, I must deal with two questions that might fairly be asked. First, if uncertainty is operatively important only on the frontiers of research, how does it apply over all of science? Second, if the change occurred in the domain of physics, why should it have impact upon the humanities and the social disciplines?

I can answer both questions by dwelling a bit upon the nature of truth. Two views concerning this have persisted ever since the ancient Greeks began trying to rationalize the cosmos and the life of man. I start the answer, however, from the less-sophisticated thinking of earlier ages.

In those days, men reached considered decisions largely by consulting past experience for help in dealing with current problems. A thinker would, of course, also be influenced by any emotional reactions to the problem and the social code; he would boil all this down somehow to a solution. We know the process well enough, for this is how we still solve problems, when we are not trying to be scientific. We call the process "hardheaded," "practical," or "common-sense" thinking. Formally, we are said to reach *pragmatic solutions*. To this I would like to add a related term—*pragmatic truth*. A pragmatic truth is a statement that is believed as long as it squares with experience. When it fails, it yields to something else.

A second view of truth arose when the ancient Greek philosophers decided that the gods had provided immutable, eternal laws for governing the cosmos and man. They called each such law an *eidos*, meaning literally a pattern or a form. We translate the word as "an idea" or "an ideal" and give various meanings; but, in the ancient Greek sense, an ideal cosmos was one in which a pattern of invariable laws governed everything.

As it happened, the philosophers took a dim view of ordinary men's understanding this. These humbler folk would have to get along with poorly understood experience, folklore, and pronouncements from the temples. But occasionally, the philosophers thought, men with exceptional mental power would glimpse fragments of the ideal universe, and gradually, they hoped, such fragments could be assembled into a complete understanding. Then men no longer would have to rely upon pragmatic solutions and pragmatic truth. This immutable, eternal universe would supply all the answers. To this day, idealistic-minded philosophers have hoped that some day they can attain to this understanding.

In the light of this, the impact of the revolution should be plain. If we cannot find unique answers for single events or trace invariable causality, all hope for attaining understanding of an ideal universe and ideal laws is dead in the natural sciences. The ideal universe may exist; but, if it does, we never can win understanding of it with the scientific method. Pragmatic solutions and truth are the best that we can win in this way.

Unexpectedly, however, the loss of hope for idealistic knowledge, far from weakening the power of science, brought a burgeoning of new power. Once physicists turned from the futile and frustrating effort to find ideal solutions for problems that would not yield such answers, they soon saw how to use statistical averages fruitfully, and, by working this way, they soon solved their most fundamental problem, the structure of the atom. From this, chemists worked out the nature of the chemical bond, and with this powerful new knowledge biochemists began solving many hitherto unsolvable problems concerning life. Among these were the nature of life and death, the mechanisms of heredity, and the origin of life upon the earth.

Thus any objective appraisal of how matters stand in the natural sciences can have nothing but high confidence for the future. There will be limits, of course, upon what they can attain, as we shall see in connection with the social sciences; but within these limits there is no limit upon what they can do to enlarge and enrich knowledge and the material well-being of man.

I come now to why this dashing of idealistic hopes in the natural sciences should have any impact upon the humanities and the social disciplines. I begin by entering a disclaimer. I say at once that some areas will feel little if any impact. In these areas workers will continue to believe that they can find idealistic solutions and truths —standards for beautiful or ugly, helpful or hurtful, true or false, right or wrong, and so on; and they will continue believing this because they trust sources of truth other than the fact-testing methods of science. Creative contributors to the arts rely upon bursts of creative insight or inspiration. Thinking in religion accepts divine revelation as complete and irrefutable truth.

There can be no quarrel with this thinking, when pursued in appropriate areas. As to the future of it, we can expect to see much the same as we have in the past, for the thinking will rise from the same roots. This is the disclaimer that I wanted to enter, lest I claim too much for the revolution in the humanities and the social disciplines. Having done so, I can now turn to areas where the revolution will have impact.

In these areas for more than a century there have been strong drives to develop science, so naturally the revolution can follow. The effects will differ, however, from those in the natural sciences, because the nature of the problems will differ. One great difference will lie in the respective burdens of *fact*-thinking and *value*-thinking in the two classes of sciences.

In the natural sciences, interest has focused upon facts for facts' sake, and the sciences expressly leave humanitarian evaluation of the facts to other disciplines. In the humanities and the social disciplines, however, evaluation often is the crux of the problem—as in evaluating works of art, weighing the merits of a social program, or weighing application of the commandment "Thou shalt not kill" to situations of, first, self-defense; second, police defense of society; and, third, national defense in war. We also know how subtle and elusive the determinants may be in value decisions. So much is this so, we often say that reaching such decisions must always be an art and never can be a science.

From this difference we would expect to find diverging patterns of thinking in the two types of science. Each one should be rooted firmly in its postulates, and these should be linked to the more basic material by rigorous fact-thinking. At higher levels divergence would appear. The natural sciences would retain fact-thinking to their outermost frontiers. In the others, fact-thinking would gradually give way to less rigorous modes, colored with value judgments. And, in sciences concerning man, we might expect to see man himself, with his drives, hopes, fears, and the like, figuring as a primary datum, a living center in the phenomena. We have a sample of this in Adam Smith's *Wealth of Nations*, with human self-interest figuring as the driving, organizing force.

This, however, was far from being the case in many such disciplines, as my colleagues and I found in 1934, when we analyzed them for encyclopedic coverage. At the time, the favored depression remedies reflected Fabian socialism and Keynesian economics; but apparently nobody in power cared whether the remedies would command popular acceptance. The idea seemed to be that the programs could be made to work, regardless of whether they fitted human nature. If they did not, simply force nature to obey the law!

At times this was called "new thinking"; but to us it all seemed nothing but sheer political and social zealotry. We could and did let it go at that, but we could not be so tranquil when we found a similar state of thinking in the two great sciences about man, psychology and sociology. Apparently, they too believed that their content could hold together as a scheme of knowledge without being rooted in human nature. That is to say, they could treat individual or social man as an aggregate of isolated drives and tendencies that they found at work in phenomena, without bothering whether this aggregate might be consistent with the personality of man as we know it. Such indifference to the coherence that should obtain between areas of knowledge would have been surprising indeed if analysis had not revealed ample reason for it in the history of each science.

Throughout the nineteenth century psychology had tried bravely to explain man's ego and personality and to build upon this a rounded picture of human nature. By 1915, however, J. B. Watson and others were trumpeting that this was impossible and the attempt was condemning psychology to frustration and futility. So they proposed renouncing this and concentrating upon man's *behavior*—meaning measured responses to measured stimuli.

Psychology did this and soon was marching toward its present high status as a science; but the price—dropping out man's ego and personality—cut psychology loose from the unifying, logical core of all sciences about man, namely, man himself, meaning human ego and personality. Psychology could, of course, build a connected web of behavior around the vacated core, but lack of the core would make linkage with other sciences about man a most pragmatic and uncertain business.

Sociology was in similar state, save that its situation stemmed from its founder, Auguste Comte. He envisaged a living pattern of society enmeshing man in a web of causality that would act as mechanistically as in any natural science. To weave the net, he adopted a test of truth that followed Descartes's use of his famous *cogito ergo sum*—"I think, therefore I am." Descartes, you will remember, said he would accept as true only those items that had the clarity and certainty—or, as we might say, the axiomatic quality—of the *cogito*. Comte adopted the same test under the name *positivism;* for a scale of truth and certainty he arranged the sciences in order, from the most positive to the least, the most positive being the astronomy of the time, namely, the 1840's. If it seems ironical that today, in the frontier areas of astronomy, cosmology and cosmogony, there are probably more guessing and less certainty than in any other science, you must remember that descriptive astronomy, the motions of the heavenly bodies, which was the entire content of the science at the time, is as true today as it was for Comte.

The sad consequence of this, however, was confinement of sociology to being a strictly inductive affair, a gathering of facts for facts' sake, since helpful organizing postulates that could pass the positivist test would be hard to find. The most helpful one, social man, would appear, if he ever did, only as the growing array of tested facts might fall into small patterns, then larger ones, that might point toward a dynamic center. There were, however, two handicaps, arising from the nature of the subject matter, that would make this at least unlikely.

For one, the great stand-by of most natural sciences, experiment, was almost completely barred, for no mere science could manipulate society. Sociology would have to content itself with watching the vast powers of government, business, and religion doing this in pursuit of their objectives and discerning whatever it could of causal linkages in the events. Also, since the logical dynamic datum would be social man and he would be a synthetic aggregate of individuals, the use of statistics and statistical averages was forced at this point; this perforce introduced a kind of rootlessness that can be illustrated with life insurance mortality tables. These tell to a dot how many in a thousand will die in a year of what causes and at what ages; and this will hold true virtually without change from year to year, saving impact of epidemics, famine, or war. Hence the tables are good enough for life insurance.

Such statistical returns are not good enough, however, for building a satisfactory social science. They tell us what has happened, and this may provide a basis for predicting what will happen in normal mechanistic and naturalistic cause-and-effect progressions. But, often enough, man will inject something unpredictable into a situation and produce utterly unexpected and even revolutionary effects upon the march of events and social institutions. Such drives spring from wellsprings of man's irrational but potent yearnings, hopes, fears, and sense of values; and statistics about what has happened will not provide a strong enough base for predicting such eruptions. For this we need much better understanding than psychology has given us of these deep wellsprings of human nature, and we need the understanding tied in with social settings and determinants, thus making man himself, as I have said, a dynamic center and datum in the social sciences.

This observation will serve as my springboard from retrospect into prospect, from what was to what is and what may come. My remarks so far have been addressed to the state of affairs in the social sciences between the two world wars. I can bring us to the present by saying that since the second war immense progress has been made toward understanding human personality.

Psychology with its present wealth of knowledge about behavior and its powerful techniques and tools, has been giving increasing attention to the problem; and psychiatry, neuroanatomy, and physiology have added penetrating insights. While it would be impossible in the time at my disposal even to mention the highlights of what has been accomplished, perhaps I can give an idea with one sample: a sketchy indication of the psychophysical mechanisms that conduct fact-thinking, reach value decisions, and the like. In other words, I shall try to give you a glimpse of what I call the ***brain-mind team*** at work and then show how this applies to the state of affairs in the sciences.

Two observations will, I am sure, be sufficient for the brain. First, since I shall deal only with the conscious, intelligent thinking that I have mentioned, I shall use only the brain structure that conducts it, namely, the outer layer or cortex, the so-called "gray matter that does the thinking" (including, of course, its connecting fibers). Second, I can deal with much of brain-mind teamwork with one description.

This portion includes reflex and purely habitual responses, all emotional states and reactions, and simple learning from experience. The neural process that underlies all this, as many of you know, is the presumed fact that every nerve-impulse message leaves an imprint on every nerve-fiber connection that it traverses, and this imprint makes the path more permeable for the message should it come again. Prenatal grooving of this sort provides reflexes and instincts; postnatal motor experience grooves in habits; and once self-awareness is established, stimulating the trace of an experience by starting one resembling it brings the trace to awareness and recognition. The recognition is recall, and the total process is memory.

Indeed, this action explains most of what we want to know about fact-thinking. This is a conscious process, to be sure, with contributions by imagination and discriminatory judgment. Most of the activity, however, is a straightforward linking of new sensory signals with remembered data and processing by language, arithmetic, and so forth, until the aggregate sums algebraically to a decision concerning fact or action. And the distinctive part, the data-linkage that leads to the decision, is as mechanistic as the workings of an adding machine. Not only this: we know the brain mechanisms that conduct the activity, the centers and connecting fibers, well enough to make a good pattern of a living thinking machine.

There is a residuum, however, that cannot be explained in this simple, mechanistic way. It includes the higher generalizations and abstractions, creative imagination, generation and appreciation of ethical and aesthetic values, and so forth. In point of brain anatomy, we can seat such activity in the frontal lobes, but there is a qualitative, functional something that we cannot localize. The nuances of value-discrimination and creative, imaginative thinking involve more than mere data-linkage and algebraic summation, but we can find nothing special in the frontal lobes—nothing that differs sufficiently from other cortical structures—to be taken as the seat of these activities. Since we do not like confessing that, as far as we know, "all this comes from nothing," we say that it is contributed by the mind, an *ad hoc* something that we invoke to explain whatever we cannot explain by brain action alone.

The supreme fact that we explain in terms of mind is man's unique attribute, his sense of self-awareness, or ego. This is the dynamic core of man's psychic being, the part that drives and holds back, indulges in hopes, fears, loves, and hates; it also holds all else together as a recognizable personality. Yet how the ego does all this is almost a complete mystery. We know that it draws upon the brain for sensory and memory data, and the like; but, as said earlier, we cannot identify anything in the brain that contributes this dynamism and organizing power. So once again, for a source we are thrown back upon saying, "The ego is supplied by the mind." And, since the mind is only an *ad hoc* assumption, a concept that we whistle up to meet a need, we deal here, from a scientific standpoint, in a mystery upon a mystery, the ego drawn from the mind.

To complete a showing of how we stand in trying to place personality as a dynamic center in social disciplines, we need only add one statistical fact about the cortex. This contains several billion units called *neurons*. Each one has a central cell and fibers for exchanging nerve impulses with other neurons; usually there are scores of these. If now you compute how many paths this provides, the number outruns any real comprehension.

Now, matching this range from the simple to the incomprehensibly complex is a similar progression in thinking—from an infant's first perceptions through primitive and folk-thinking; fact-thinking in the natural sciences; value-thinking in the arts, humanities, and social disciplines; and mystical and religious thinking. Thus we have a double march in complexity going hand in hand—complexity in thinking using corresponding complexity in the cortex.

Usually, when we find such a correlation, we can establish causal linkages between the chains and so advance our detailed knowledge of what makes events happen. We can, of course, do something of the sort here, but we cannot expect a complete solution. The unbelievable complexities of cortical connections undoubtedly will forbid tracing linkages beyond certain coarse limits, broad pathways that connect cortical areas for sensation, association, memory, and action. This might do well enough to work out blunter aspects of fact-thinking but probably no more than that. This may be disappointing; but in many ways our knowledge of the limitation has immense clarifying value in delineating and characterizing the various areas of knowledge and the modes of thinking used in them.

We can, for example, assess the impact of the scientific revolution quite accurately upon the various disciplines. We can array them upon a scale along which we pass smoothly from fact-thinking to value-thinking, and so on; once we do this, we see that the effect of the scientific revolution will be felt accordingly, from full in the natural sciences to almost none in the areas that still retain idealistic thinking.

One immediate fruit of this should be complete liquidation of the suspicions, animosities, and bitter clashes that have obtained between different modes of thinking ever since thinking began. I refer particularly to efforts by religion to rule all other thinking and the fear during recent centuries that science might consume religion, the arts, and other disciplines.

Taking the latter first, we know now that the fear is groundless, because the power of science will always run out at the limit to which it can push fact-thinking. And we know also that there will always be a limit. It is not temporary, set by lack of knowledge not won yet, as many nineteeth-century scientists were fond of claiming. It is real and enduring, because it is set by our inability to trace causal linkages beyond a certain limit of complexity. Our cortical connections, however, subserve thinking far beyond this limit—value-thinking, bursts of creative thinking, and so forth; such thinking underlies man's deepest hopes and aspirations, as well as his greatest fears and dreads. Hence the disciplines that use these modes of thinking will always have their high place in the scheme of human thought and conduct, and this should liquidate the age-old effort by religion to control all thought. This was always defensive, but the present clear assurance of domains ends all need for this, as against science.

All this raises a large question. If science cannot project rigorous fact-thinking into these areas of such high import, how can we think fruitfully in them, to win helpful guides and working rules? We can do as man always has done! We can use *ad hoc* speculation, making guesses at answers. We then match up the guesses with all pertinent experience. If the guesses seem to work, we can accept them as pragmatic truth, until some finding forces a change.

I submit that this is not as unscientific as it might seem, for such *ad hoc* assumptions, such speculations, have led us to many of the great generalizations in science. Take, for example, the two related concepts "electricity" and "electric charge." Can you make clear what either term means in terms of what the predicated entity *is?* You cannot. You can only make them meaningful in terms of what each entity *does*. And how do we know what each entity does? By patient work through the centuries, after pioneer workers had created the terms as *ad hoc* devices to identify what little they knew! It seems not unreasonable to hope that something like this may come to pass in dealing with these higher flights of thinking.

In this effort we shall have many great advantages over the pioneers who dealt with electricity. Even though rigorous fact-thinking cannot explain the higher flights of thinking, that thinking still is rooted in the workings of the brain-mind team, and our thinking must always be consistent with these processes. Since we are coming to know these quite well on the lower levels, we shall not be groping in an unlit wilderness, as the pioneers were compelled to do. We shall have patterns of the known that point toward the unknown, and we shall be helped further by a rich background of pertinent material. All this should save us from wild guessing and keep us fairly close to possible truth.

Also, the fact that we must work pragmatically by no means compels us to denounce ideals in the disciplines that hold to them. They are indubitably influential factors in man's thinking and conduct; we can believe in them to whatever extent we like. We must be pragmatic only in assessing how this idealistic thinking fits into man's personality.

Now, to put a capstone to all this, I submit as an example of such speculation a model, so to speak, of a core of human ego and personality. In order to emphasize that in such speculation we can strike out as boldly as we like, I am going to make my model purely mental, a veritable thinking machine, without any dependence upon a physical body. And to what can I turn for the pattern of such a model?

Some speculation has used an analogue of a television scanning beam as the basis of a model. This has some merit; but, from my tinkering with the idea, I doubt that the beam can provide all that such a model should have. At least, I think that I can come closer to what such a model should offer with one that I worked out a few years ago. It is a model of a human soul, which I put together in terms that are compatible with modern science when I was irked by presentation in our times of nineteenth-century arguments that the very notion of such a thing is fantastic and impossible. This model should at least be suggestive in the present connection, for a soul and a personality are closely related indeed. According to the usual terminology, a soul *is* a personality while embodied in a living human body, and it becomes a separate, surviving entity when the body dies.

I shall present my model substantially as I developed it to meet the objections that I resented. These zeroed in their fire largely upon the text ". . . in my flesh shall I see God" (Job 19:26). Typical ones ran as follows: "If, in the course of a lifetime, an individual loses a leg or an eye, will the soul also lack a leg or an eye?" and "If, in his or her lifetime, an individual developed syphilis, will the soul also have syphilis?"

Such questions, considered so devastating and conclusive in their time, irked me because I could not believe that such thinkers as Matthew, the legalistic-minded Paul, and the so-called beloved mystic, John, used the term "flesh" to mean the temporary mass-energy knots of protein, carbohydrate, fat, water, and minerals that constitute the literal flesh. I followed modern apologetics and exegesis in believing that these apostles, as oriental writers and Jesus himself often did, were using allegory to present highly abstract concepts to unsophisticated minds in terms that these minds could understand.

What was the concept so presented by the word "flesh"? The answer seems plain enough, for throughout the ages it has been the essence of man's yearning in this respect. It is preservation of *self-awareness* and *personality*, the array of traits, memories, and reactions that sets any one individual apart unmistakably from all others. And, you notice, this is exactly the core that we want to set up as an *ad hoc* proposition for use in the social disciplines. So, how may this be done in terms that are compatible with modern scientific thinking?

To me, a broad hint of an answer literally stares us in the face whenever we watch television. Certainly here personalities are preserved and projected in fine detail. And it seems to me that the hint can be developed into the stuff for a model with only a few postulates.

First, of course, I need something other than an electromagnetic wave, for I have no intention of suggesting that the human body is some sort of telecasting station. I get something workable, however, simply enough, by postulating a cosmic pool of psychic energy, existing coextensively with the pool of mass-energy that serves the physical universe. I postulate next that this psychic energy can behave in space exactly as does an electromagnetic wave. Last, just as physical mass-energy can jell, so to speak, in all the ways needed to make a human body and brain, I postulate that psychic energy can jell to equip the brain with a mind. This provides all that we need for a brain-mind team, and from now on I shall speak in terms of the electromagnetic wave in order to appropriate its properties for enabling my model to meet nineteenth-century objections, one by one.

One difficulty that vanishes instantly is capacity, the ability to carry millions of information bits, as a model must to preserve personality. Every carrier wave demonstrates this whenever it provides a television performance of grand opera.

Another supposedly overwhelming nineteenth-century objection was "overcrowding." To start, the argument assumed that each soul fills some moiety of space exclusively, as solid aggregates of mass are supposed to do. "But if this goes on indefinitely," the argument proceeded, "would not the universe be filled to bursting? And what would happen then, if another soul be added?"

In the face of electromagnetic wave properties, however, this objection is simply silly. Whenever a carrier wave animates a television screen, the space before the set is being crisscrossed by a multitude of other waves carrying television and radio programs, visible light, and so on; and all the waves crisscross without any one being altered in the slightest by the others. Thus space can hold any number of electromagnetic personality images anywhere, and overcrowding is impossible.

Two more items will, I think, complete my model sufficiently to demonstrate what can be done. Again I approach the first item through a possible objection. Someone might accept my argument about overcrowding but then say: "But if souls are these waves crisscrossing in space, would not this produce a mishmash of souls at any place you name? How then would you pick one out?

And if they are all traveling at electromagnetic speed, how would you ever catch up with one you know? Is this a satisfactory model of a soul?"

This might indeed be a poser, did not modern atomic theory offer an escape. So far in my discussion I have been using the traveling electromagnetic wave, the kind that carries television. But there is also a *standing* wave, which figures in atomic theory by providing the so-called orbits of every electron that whizzes about inside an atom. The wave is made to "stand"—that is, not radiate into space—by confinement between nodes, somewhat as a violin string is compelled to vibrate between the string's tuning peg and the bridge of the instrument.

Now, cannot our model be a system of standing waves, with one wave for each detail in a personality? Such a system could stand or move in response to circumstances, and, whichever it does, the system could radiate personality as an excited atom radiates heat or light, even if it is traversing another.

Finally, the commonly held idea of a soul requires our model to endure eternally. This, however, presents little or no problem for an analogue of an electromagnetic wave. Today, visual and radio telescopes receive signals over spans of billions of light years, and the signals retain fidelity enough to characterize the sources in stars and galaxies by chemical composition, temperature, and age. Also, there is no known reason why these spans cannot be extended indefinitely, that is, in point of time, to eternity. And if some obstacle to extension should appear, I for one would be content to let those who uncover the difficulty cope with it. To me, billions of years is a satisfactory approach to eternity.

With this I feel that my model is developed sufficiently for my two purposes—the old one of creating a plausible model of a soul and the present one of presenting an *ad hoc* core of human personality. The latter can be trimmed down from the former, but I presented the soul *in extenso*, for who can say what future needs may be? Even the immortality feature might be worth retaining. As stated, it can do no harm to any scientific thinking about the model, and having it present might help in bringing religion into a unified pattern of human knowledge with the other disciplines, if anyone should care to attempt this.

A last question and answer now about possible truth in my model and conformity with reality! You will have been granting, I hope, without my having made the disclaimer before now, that I have not made the slightest claim for any truth or reality in my model. I have been offering it simply as a demonstration that such a model can be set up in terms that are compatible with science, and I have done this in the faith that, since this can be done, some day, somehow, better minds than mine will create a model that not only has the properties I have atrributed but will conform to reality and provide the core that we need for the humanistic and social disciplines. If and when this happens, I am confident that the impetus given thereby will develop the disciplines to the place where they can carry conviction to the minds of all men and the resulting conduct of affairs the world over will make our times, as seen in retrospect, seem like a disturbed and shocking nightmare.

With this last word, I thank you for your kind attention and bid you all good night!

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