"Pilate saith unto him, 'What is Truth?'"
—JOHN 18:38

The Search for Truth

by

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REYNAL & HITCHCOCK

NEW YORK

THANKS!

THE pleasantest part of a writer's task is thanking those who have helped with their sympathy, encouragement, and constructive criticism to make the book. To Doctor Edwin Hubble and his wife, Grace, my debt is especially great. But this must not be taken as meaning that either of them "endorses" anything in the book. They are not that kind. Doctor Hubble in particular is not responsible for anything the outrageously honest Toby says about "the astronomers," although he personally has done as much as any man living (some say much more) to extend our definite, non-gaseous knowledge of the universe as revealed by the finest telescope on earth. My debt to Grace is beyond payment. I have known for years that Grace has a rare instinct for picking good (not pious) books, and when she picked one of mine I felt as if I had been crowned.

Psychologists advise us to have a "frank talk" with our adolescent sons and daughters on certain delicate matters when it seems necessary. Anyone who has been fool enough to try it is only too glad to leave the next frank talk to the teachers or the preachers. Remembering this, I asked Dean Stanley Wilshire to do the talking on a rather delicate question which gains nothing from being ignored. The Dean not only talked; he wrote out his candid remarks with his own hand.

Last, there is the woman called Toby, who generously offered to prepare the manuscript for publication, and who made outstanding contributions of her own—acknowledged later, where they occur. When I got the "prepared" manuscript I scarcely recognized it. Toby likes pepper. Whether she deserves a vote of thanks is beyond me, so I leave it to the reader.

E. T. BELL.

Pasadena, October, 1934.

INTRODUCTION

WHENEVER I see some brilliant young scientific theory dashing along toward the final solution of the last and toughest of all the many riddles of the universe, I am reminded of black Sam's mule.

After about two hundred years of the race track, the Kentucky colonels decided that there was nothing more to be learned about horseflesh, and they were fed up with it anyway. Who or what could deliver them from boredom?

The silence lasted twenty-five years, till Colonel Cornbottle broke it with an eloquent oration that lasted almost as long. Boiled down to its quintessential element, the Colonel's speech advocated that mules be substituted for the played-out horses, and that the races proceed. Colonel Cornbottle was elected by acclamation on the spot to scour the whole beautiful state of Kentucky for mules worthy to succeed such famous trotters as Blue Moon, Silver Belle, and Long Julep.

In the course of his travels the Colonel kept hearing rumors of a fabulous mule, "fleeter of foot than the fleet-foot kid," which was being jealously hidden by the black folk from the covetous eyes of their white masters. Voodoo was hinted, and one rumor insinuated that this speediest of all mules was being worshipped as a god by the superstitious blacks. The story of how the Colonel finally traced the rumors to their true sources, not five miles from his own back yard, and located the legendary mule in the flesh, is an Odyssey in itself that must be passed over here.

The mule was the pet and constant companion of black Sam. Although Sam himself was poorer than a crow, the mule was as plump and enticingly sleek as .... (name your favorite!) .... and just about as full of the devil.

The Colonel's mouth watered for the mule. One look at its chest and legs were enough to convince any expert that the long-eared loper could beat anything on four legs that ever cantered onto a race track. But Sam loved his mule, and being a better business man than the Colonel, held out till old Cornbottle had promised him half his estate for the beast. The bargain was already sealed, when it occurred to the Colonel that he really should find out whether the beast could run before reporting to the committee.

"You start him off up the road, Sam. He won't kick you."

"Yass sah, Cunnel Cornbottle. Ah can start him all right, but ah can't stop him. Nobody can stop dat dar mule when he starts." Sam removed what had passed for ten years as his hat and smacked it down with a crack on his knee. "Git, Mister Mule!"

Mister Mule gitted to the tune of forty miles an hour straight up the road toward a stout telephone pole about half a mile away. The Colonel whooped and capered in ecstacy; Phar Lap was just another case of creeping paralysis compared to this marvelous mule. The Colonel was just winning the English Derby from King George when suddenly his paean of joy cracked in shrill alarm.

"Stop him, Sam! Don't you see he's headed for that telephone pole?"

But, as Sam had warned the Colonel, Mister Mule could be started but not stopped. It was too late, anyway. The mule had crashed head first into the telephone pole with an impact that would have shattered the skull of an elephant, and was now squatting on his haunches before the pole, dreaming of his mother.

"Why, you black rascal," the Colonel roared, "your mule's as blind as a bat!"

"No sah, Cunnel Cornbottle, mah mule ain't blind."

"Then why did he run into that telephone pole?" the Colonel spluttered. "You say he isn't blind—."

"Honest, Cunnel, he ain't blind. He just don't *give* a damn."

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Chapter I

LOOKING FORWARD

I. JESTING PILATE

EVERY civilized person will recall the following dialogue between Christ and his judge:

"To this end was I born, and for this cause came I into the world, that I should bear witness unto thetruth . . . ."

Pilate saith unto him, "What is truth?"

No answer is recorded.

In the nineteen centuries since Pilate asked his flippant question, thousands of replies have been given, no two much alike.

Something seems to be loose; it is scarcely credible that there can be as much truth in the world as the professional purveyors of that rare luxury would have us believe. It is just possible that Pilate's question received no answer because it was meaningless. Christ was not the man to lose his temper and refuse to answer merely because the question was asked in a spirit of jesting cruelty rather than in an honest endeavor to learn something.

Until recently those who have taken it upon themselves to tell us what truth is have for the most part been theologians, philosophers, metaphysicians, cranks, and visionaries suffering from some disorder of the ductless glands, or combinations of two or more of these. Of late a new claimant has entered the list, and science now makes more noise, if no more sense occasionally, than all the others combined.

The claims of the newcomer are impressive, to say the least, the more so as much of the jargon in which they are expressed is unfamiliar to most of us. Particularly is this the case when the ultimate justification for some wild speculation or dismal

prophecy is an airy wave of the hand in the general direction of mathematics. "Of course you wouldn't understand any of that; but you can take my word for it that it is all perfectly sound, and you may believe with full confidence that it is true. Why, *it has been proved mathematically.*"

Having noticed many such lofty snubs being handed out to those who have no opportunity to look into the matter for themselves, I decided it was about time for someone who makes his living at this mysterious stuff called mathematics to see whether the latest answers to Pilate's question make any better sense than the old. It is not necessary to fling the wave equation of quantum mechanics, the indeterminacy principle, or even the field equations of general relativity, at any bewildered head in order to convince anyone outside of a lunatic asylum that the new answers leave us precisely where we were before.

The evidence can be presented from start to finish with nothing more abstruse than what any child in the eighth grade knows. This can be done by unravelling a single strand of the tangled epic of our human kind's attempts to think straight, or even to think at all. Those who enjoy asking unanswerable questions may still amuse themselves by echoing Pilate, and no harm will come of it, provided they do not force others to believe the answers they get.

The history of sane thinking can be traced back by documentary evidence a full four thousand years, and by reasonable inference another one or two thousand years beyond that. We shall find that the steps at first were slow and confused. As we should expect from the histories of the arts, periods of intense brilliance and amazingly rapid progress alternate with rather longer stretches of dullness and apathy, where conservatism and tradition throttled liberal thought, and where no significant advance was made for centuries. Petrie's explanation (noticed in Chapter III) may account for the tide-like ebb and flow, but it is neither necessary nor helpful for our simple purpose to theorize about causes; the main facts are sufficient. Reading them, we shall be in a fair position to judge for ourselves

whether Pilate has been answered by science, or whether he is likely ever to be answered by anyone. He may have been making what Russell calls "a meaningless noise."

As we follow the story down from the hazy past to the present, we shall see an ever-accelerating speed in the piling up of new guesses as we approach our own time. There is nothing miraculous in this. Nor need we congratulate ourselves that our age is a thousand times as fertile as its predecessors, merely because one year in the present decade spawns a hundred theories instead of the nine or ten per century a few hundred years ago. Our greater productivity is due partly to the fact that scores or hundreds of workers dig like demons side by side in a single narrow field which, only a century ago, was abandoned to one cogitating, dyspeptic hermit and the crows. This, by definition, is progress. Put a lot of goldfish in a bathtub, give them all they can eat, and naturally they will breed.

2. FUNDAMENTAL QUESTIONS

To understand Pilate's question and, if possible, either answer it or silence him, we must see in broad outline what human beings in the past 4000 or 6000 years have imagined "truth" to be. This will be done in later chapters. Incidentally, we must glance occasionally at what has been held as to the nature of "proof" and the basis for human beliefs of any kind whatever.

The questions thus raised are fundamental. This is not a rhetorical exaggeration; "fundamental" means, literally, "at the foundations," or "at the beginnings" of everything considered. It is no paradox to say that the utter simplicity of fundamental questions is what makes them difficult to grasp. "Fundamental" habits of thought are drilled into us from infancy, and it is only after much patient scrutiny that we can discover anything which may be taken hold of for closer examination. Complicated problems are much easier than simple, fundamental ones to handle.

To avoid even the suspicion of paradox or mysticism, I shall labor this point a bit and try to bring out its simple meaning by a personal reminiscence of a man who had rediscovered for himself one of the devices by which scientists and mathematicians make some of their most striking advances. Incidentally this story contains an invaluable hint for any beginner who may be hoping to make some contribution—if only a humble one—to the advancement of science. It may suggest to him one way of overcoming the initial difficulty which stops many, that of finding something to do that is radically new, not trivial, and within one's powers.

In my student days I kept hearing tales of one of the professors—I shall call him Z, as he is still going strong, and I have no wish to embarrass him—who was a wonder for the amount of high-grade scientific research which he turned out apparently without the slightest effort. His seminar, where he developed his ideas in plain view of anyone who cared to watch, was jammed, mostly by men on the lookout for some hint of a good problem. Z dropped hints all over the place, and he never seemed to mind who picked them up or what became of them. His stock was inexhaustible.

Three of us, trying to start in another field and caring nothing at all about Z's brand of mathematics, decided to drop in on his seminar to find out, if we could, the secret of his prolific success. The first month passed in total darkness. Z was finishing up some elaborate investigation or another, and we got not the slightest idea of what he was talking about. Nevertheless we hung on, in the hope that the night would not last forever. Our hope was not disappointed. Running out of interesting ideas in what he was doing, Z very sensibly dropped the subject like a hot brick. He was not the man to waste months embroidering something that any competent worker could pick up and slave over for years.

"That's enough of that," he remarked in the middle of an involved proof. "It's gone stale on us and I'm sick of it. Let's drop it and look for something fresh. Any suggestions?"

One man half jokingly proposed a seemingly trivial subject that everyone in the room had known all about since his first year in high school

"All right," said Z "let's see what's in it."

We all saw the truth of the trite proverb, that it is the first steps which count, developing before our eyes. While we looked on, Z proceeded to write out, in minute detail, every *assumption* from which the trivial subject proposed is developed in the schoolbooks. Even statements so universally accepted as "things which are equal to the same thing are equal to one another" were not omitted. To most of us this wealth of detail seemed a waste of Z's time and ours. The collecting and writing out of these *fundamental assumptions* took the full working time of four days. Z wanted to be sure that he left out nothing, no matter how obvious it might seem.

Satisfied at last that everything was nailed down, Z proceeded to the next step. This was the step that gave him something new. Each of the long list of assumptions was an "axiom" or "self-evident truth" which some of us had accepted as a necessary element in any sane thinking about the subject, and most of them were simple subject-predicate declarations. Z pointed out that there were at least three possibilities with regard to each of these "axioms": an axiom might be contradicted or denied; it might be erased, ignored, and not used; it might be either slightly or radically modified. Any one of these possibilities would violate our accustomed habits of thought. Common sense also protested strongly against the whole seditious business. Nevertheless Z went ahead and proceeded to modify the simplest one of all the assumptions *very slightly*. That was the only change he made, but it was, as I have intimated, a flagrant breach of common sense. Seeming to feel that some of us were ill at ease, Z comforted us with a remark which left us rather deflated; "Common sense is not what you need if you're going to find out anything worth knowing; it is *un*common sense." However, having seen him do the trick, I fancy that those who have any sense at all can find out some-

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thing for themselves, provided they have the interest and patience.

The next steps took many weeks of slow, careful labor. The consequences of the *slightly modified* set of assumptions were developed with great care and thoroughness—by the laws of common logic. Nothing very exciting appeared. The original subject and its almost-identical twin were so much alike that we grew to loathe the sight of both of them. The original had been plain enough for any taste; two of her were a surfeit.

Then, gradually, we began to catch distant glimpses of a vast unexplored territory. Our new road was *almost* parallel to the old, well-travelled highway; the extremely slight divergence, if pursued far enough, must ultimately take us into regions whose existence no traveller of the old road had ever suspected. Confident that he was at last penetrating rich new territory, Z went ahead as fast as we could follow. Ten months after his first, careful steps, he had put us in possession of a boundless new province of knowledge, not one of whose landscapes resembled in the slightest degree the somewhat drab country from which we had set out. He had, in fact, made a *radical* advance. To make a *radical* advance one must tamper with the *roots*, not with the *branches*, of the tree of knowledge. That is what Z did. We shall see the same sort of radical advance in basic thinking gradually developing as we trace the thread of deductive reasoning through its long history.

It is easy enough for a competently trained man to pick a pretty flower or a glossy leaf off someone else's tree. To create a new tree of one's own, one must get at the very life of the tree itself and interfere with the seed. This demands more patience and possibly more insight than does the choosing of even the most beautiful flower on a growing tree. But the effort is rewarded many thousandfold.

The difficulties in the way of radical advances in thinking are chiefly two: our inability to throw off traditional patterns of thinking or reasoning which we have acquired through years

of hard work at school, and the natural difficulty of taking hold of anything *fundamental* that is so completely *simple* that nothing sticks out from it to offer a hand-hold. It is something like trying to pick up a smooth, heavy box without handles. Again, the more familiar an "accepted truth" is, the harder it is to dispute, to modify, or to doubt. Yet that is precisely what we must do if we are not to remain content with what we have inherited from the dead, inadequate past.

To illustrate the difficulty of radical advances, one such may be recalled here. Is it not "obvious" that two events can happen in *different places* at the *same time*? To assume that such is the fact is sufficient for most human purposes, but is insufficient for some parts of physical science. Until 1905, when Einstein analysed this simple *assumption* about the simultaneity of events in different places, no sane mortal had seen anything suspicious about it. It is so simple that it must be a "universal truth."

But suppose we ask ourselves how we would set about establishing the "fact" that Jones shot Brown in New York, at exactly 12 p.m., last Monday and that Claude shot Phillippe at precisely the same instant in Paris. We should need wireless signals, clocks, and other apparatus to give our procedure a meaning. In short, we should be able to describe some set of physical *operations*, which we or other human beings could *perform*, which would give us the two shootings "at the same time"—*the same time as measured on our clock*, and not as imagined in the mind of some mathematical philosopher. This might be possible. But, if we think it out, we begin to doubt the possibility if Jones and Brown, instead of being motionless in New York, should stage their event on an asteroid shooting through space so fast that wireless signals would be slowed down in communicating with it. The argument is presented in detail in any book on relativity. All we need note here is that this particular "obvious truth" is neither obvious nor necessarily true when picked to pieces. By analysing it, Einstein was

led to his invention of the special theory of relativity—a radical advance. It violated common sense and tradition. The radical advances made in the technique of cold reason during the past four years are, at first sight, equally repugnant to common sense and accepted tradition.

3. DOES IT EXPAND?

Since the beginning of this century the physical sciences have made one radical advance after another. The *fundamentals* of the science which our century inherited from its predecessors have been *modified*, now slightly, now quite perceptibly, till our outlook on the physical universe today bears but little resemblance to that of only thirty years ago. Great and striking as these advances are, there has been another, most rapidly developed since 1930, which has been slowly gathering momentum for all of 2300 years, which is of far deeper significance for "truth"— or Pilate's query—than any of the radical advances of science of the past thirty years. Being more fundamental, more radical, and simpler than any of the spectacular advances in science, naturally this new advance has escaped the notice which its far-reaching importance merits. Yet it is of profound significance for all theorizing and truth-seeking, scientific or other.

It seems reasonable that those whose interest in scientific advances is chiefly that of the onlooker interested in all progress should be keener for the *theories* of sciences than for the detailed comprehension of the laboratory technique behind the theories. Only a man who spends most of his life trying to locate elusive leaks in vacuum pumps can get any real thrill out of a minute description of complicated apparatus and the endless refined measurements which are the justification of his existence. What the man outside the laboratory wants to know is what all these measurements "mean" in terms of the world or the universe at large. Leaving aside the apparently inevitable applications to peace and war of the most far-fetched or seemingly useless

experiments, the unprofessional follower of science is interested in the broader philosophical implications of the scientific theories and speculations growing out of the experiments. This obviously is a matter for reasoning rather than for experimenting to handle.

For instance, we have heard much in the past two years of the "expanding universe." It is a fascinating theory. The whole universe of spiral nebulae—"island universes," each with its millions upon millions of intensely brilliant suns—is expanding like a soap bubble. In the not infinitely distant future this universe will have dispersed into the depths of space like a capful of bees in a summer sky. That is one of the possibilities predicted by the mathematics. Another is that the whole swarm will alternately contract and expand, pulsating like a cosmic jelly fish. Another is that all the nebulae (our own Milky Way included) will rush together, to flash up and out forever in one transcendent blaze of annihilation. This one, however, is less "mathematically probable" than either of the others.

To continue with the universe for a moment, let us follow the father of the expanding theory back for a step or two on his bold exploration of the abyss of time. If the universe is expanding—notice the cast iron *logic*, the *reasonableness* of the conclusion—it *must have been more condensed, more concentrated*, at some time in the past. As it may be expressed, the nebulae *must* have been crowded into a smaller space than that which they now occupy. Knowing the rate at which the expansion is taking place, we can easily calculate how many years ago *all the nebulae were packed together*, or if not that exactly, the approximate date at which the nebulae began boiling out of whatever matrix it may have been in when they were created. That is, *we can fix the date of the creation of the material universe.* All of this, notice, is reached by strict *deductive or mathematical reasoning from hypotheses.* Deductive reasoning is the kind in which we shall be chiefly interested. It is the breeder of theories, and it is the kind of reasoning that has been revolutionized since 1930.

Let us follow our guide another step or two. The outstanding riddle of physics today is the problem of cosmic radiation. Intensely penetrating rays of some kind have been detected shooting through our atmosphere in all directions. What are they, what causes them, and where do they come from? These questions are not yet answered scientifically. But see what a beautifully *logical, simple* answer we get if we interrogate the expanding—or rather contracted—universe.

Radium, we recall, emits intensely penetrating radiation, and in doing so gradually loses its mass. Given time enough, a lump of radium would dissipate itself away to a microscopic speck. Now imagine the matrix out of which all the stars and nebulae swarmed when the universe began expanding. What could it have been like? To jog our imaginations, let us recall that radioactive elements (like radium, for example), in emitting their radiation, *break down into simpler, less radioactive elements*. With this hint we can proceed.

The universe, when it was created, was nothing more nor less than one gigantic atom of an intensely radioactive element. Indeed this monstrous atom was so supernaturally active that it forthwith began exploding in a blaze of cosmic radiation. As the rays shot off in all directions—these rays are still shooting, physicists find and measure them every day—the single, "noble" element of which the atom was composed began breaking down into baser gold, quicksilver, copper, iron, tin, oxygen, hydrogen, etc., etc., etc.,—in fact into the 93 elements which chemistry has discovered or suspected. Thus at one step we have given a *consistent, logical explanation* of the creation of the universe, the origin of the familiar chemical elements, and the genesis of cosmic radiation. And, to repeat, *all of this has been done by perfectly sound mathematical, deductive reasoning proceeding from hypotheses* (*assumptions*), *which in their turn have been framed to fit a certain narrow range of experimental data* (*observations*) made by experimentalists working with tangible clocks, meter sticks, telescopes, and so on, in labora-

tories and observatories constructed, for the most part, of steel and concrete. All this, surely, is solid enough. What could be solider?

One step more, and we shall come to the end of this true parable. If the magnificent sweep of this sublime speculation obviously embraces the destiny of man and the universe—as it does—must it not also overshadow the loftiest aspirations of man's spiritual nature? After all the other steps we have so successfully taken we need not boggle over this, the last. Whether we personally take it or not does not much matter here. Others have; we shall greet one of them in the next chapter.

Now for the conclusion of this inspiring parable. As I write this, it is 6:30 p.m., March 30, 1934. This date may prove to be of some importance in the history of speculative science, not because I am writing this, but because of what began happening exactly two hours ago. At 4:30 sharp, the man upon whose cautious, unspeculative astronomical work—observations—the speculators on expanding universes of any kind base all their speculations, began reporting to a group of scientific workers the carefully analysed results of his brute-fact observations for the past several months. Most of those who heard this man's report had known for months what to expect; the two or three gentlemen from the press did not. As the report was delivered in severely technical language from start to finish, it is unlikely that tomorrow's morning paper will contain more than a line or two mentioning that so-and-so reported.

The expanding universe was mentioned only once, and then by someone who asked a question. But the report *could* have been played up as the latest *scientific* verdict on the theory of the expanding universe and all the theories—physical, astronomical, cosmological, theological—to which that prolific speculation has given birth.

What is the verdict? Simply this. The experimental data, so far as they have been obtained, will support *any one of three*

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