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For though we walk in the flesh, we do not war according to the flesh, for the weapons of our warfare [are] not fleshly but mighty in God for pulling down strongholds, casting down arguments and every high thing that exalts itself against the knowledge of God, bringing every thought into captivity to the obedience of Christ. And they will be ready to punish all disobedience, when your obedience is fulfilled.

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Science and Truth

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Centuries ago it may have been possible to ignore science—in fact centuries ago there was little science to ignore—but today its successes are so phenomenal that it is usually accorded the last word in all disputes. The younger generation can hardly realize that so simple a thing as the incandescent electric bulb came only yesterday. Today science receives its praise and respect by reason of the atomic bomb, bacteriological warfare, and the possibility of interplanetary travel. None of this may be desirable, but truth is not a matter of desire; and the methods that have produced these wonderful products of civilization are capable of answering every question.

T. H. Huxley asserted that the foundation of morality is to renounce lying and give up pretending to believe unintelligible propositions for which there is no evidence and which go beyond the possibilities of knowledge. In a similar vein W. K. Clifford said, "It is wrong always, everywhere, and for anyone to believe anything upon insufficient evidence." The import and context of these statements is a general repudiation of theism in favor of a scientific method that obtains indisputable truth.

Science and Christianity

To show the bearing of science on theism, some quotations from distinguished contemporary scientists should be made. Without doubt Professor A. J. Carlson is a distinguished scientist, as is attested by his writings and by his presidence over the American Association for the Advancement of Science. Religious ideas and their relation to science have attracted his attention, and his conclusions are found in the twice-published article, "Science and the Supernatural." One must note what he says on the nature of science as well as what he says on its relation to religion. He writes, "Probably the most common meaning of science is a body of established, verifiable, and organized data secured by controlled observation, experience, or experiment…. The element in science of even greater importance than the verifying of facts, the approximation of laws, the prediction of processes is the method by means of which these data and laws are obtained and the attitude of the people whose labor has secured them…. What is the method of science? In essence it is this—the rejection *in toto* of all non-observational and non-experimental authority in the field of experience…. When no evidence is produced [in favor of a pronouncement] other than personal dicta, past or present 'revelations' in dreams, or the 'voice of God', the scientist can pay no attention whatsoever, except to ask: How do they get that way?"

Karl Pearson presumably speaks for all science when he says, "The goal of science is clear—it is nothing short of the complete interpretation of the universe." And, "Science does much more than demand that it shall be left in undisturbed possession of what the theologian and metaphysician please to term its 'legitimate field'. It claims that the whole range of phenomena, mental as well as physical—the entire universe—is its field. It asserts that the scientific method is the sole gateway to the whole region of knowledge."

What Is Science?

Reflection on these quotations raises a series of puzzling questions, some of which ought to be answered by the serious theologian and scientist alike. Clifford and Huxley, and anyone who opposes them, ought to make clear what is *sufficient* evidence. Is evidence sufficient only when it is logically demonstrative? Would Clifford and Huxley be satisfied with something less than demonstration, and if so, how much less? More fundamental is the plain question, What is evidence? Comte and Pearson assume that facts and classifications can be empirically discovered. But can they? Comte was certain that the positive character of knowledge, now that it has passed beyond the theological and metaphysical stages, will never again change. But if Comte is the father of sociology, it is one of his own sons, Sorokin, who is sure that it will change again and again. Further, must we hold with Karl Pearson that the judgments of science are absolute? Will a judgment or fact, once for all discovered, never be abandoned in favor of a more up-to-date fact or judgment? Do scientists never revise their conclusions? And very much more to the point, is the scientific method the sole gateway to the whole region of knowledge? What experiment or what evidence is sufficient to prove that science is the sole gateway to all knowledge that is yet to be obtained? If there is a God, is it absolutely necessary that his existence be discovered by some infinitely sensitive Geiger counters? If moral distinctions and normative principles exist—in particular, Carlson's principle that a scientist has no right to believe anything—must such principles be discovered through a microscope? And finally, and very generally, what is scientific method? One must seriously question not merely the desirability but the possibility of rejecting *in toto* all non-observational and non-experimental authority in science. In other words, What is science?

What Is a Fact?

The practical mind that loves facts and distrusts theory should acquire some patience and pause a while over the theory of facts. There may at first be reluctance to face the question, What is fact? Yet, if facts are unyielding absolutes, it ought not to prove too difficult to show what a fact is. Let us try.

Is it a fact that the Earth is round? In the Middle Ages the common people thought it was flat. Since then, evidence has accumulated (considerable evidence was known to astronomers during the Middle Ages) and has been disseminated, until today everyone takes it as a fact that the Earth is round. But strictly, is it the Earth's roundness that is a fact, or is it the items of evidence that are facts on which the conclusion of the Earth's roundness rests? For example, the shadow of the Earth on the Moon during a lunar eclipse has a round edge: Perhaps this is a *fact*, and the roundness of the Earth is a *theory*. Of course, it is not a fact that the Earth is a sphere: it is flattened at the poles. But if it is not a fact that the Earth is perfectly round (spherical), what is the fact? Is it a fact that the Earth is an oblate spheroid? But this term embraces a variety of forms and proportions. Which form exactly is the absolute unchangeable fact? —though science does not pride itself on sticking to facts such as this.

Above, it was said that the shadow of the Earth in a lunar eclipse is a fact—on which the roundness of the Earth is erected as a theory. But is even the shadow a fact? Is it not rather the fact that a certain darkness on the Moon has around edge, and is it not a theory that this darkness is the shadow of the Earth?

This type of analysis seems to lead to the conclusion that all, or at least many, alleged facts are theories developed out of simpler items of perception. The problem naturally a rises whether there is any fact that is not a theory. Is there anything seen directly as what it is? No doubt many people in Atlantic City on a fine summer's day have seen an airplane high in the air pursuing an even course; and as they have watched the plane so high and so small, it has flapped its wings and dived to get a fish. Was it a fact that it was an airplane, or was this a theory about a small object in the sky? What is a fact?

How Long Is a Line?

There is one type of fact that seems to be pre-eminently scientific: it is the length of a line. When a scientist measures the boiling point of water, he measures a line—the length of mercury in a tube. When he measures the density of gold, he measures a line—the distance on a piece of steel between a scratch called zero and another scratch called, perhaps, nineteen. Similarly he measures another length to determine the amperes of an electric circuit. It may be that scientists never measure anything else than the lengths of lines; at least it is quite safe to say that no significant experiment can be completed without measuring a line. Therefore if science is to be understood, careful thought must be given to this exceedingly important step in experimentation. It has been shown that science is not a body of fixed truths, and if the length of a line turns out not to be a fact, the essential nature of science will have to be sought—not in its results—but in its methods. The experimental method, rather than the particular laws or facts discovered, is the important thing. And to understand the experimental method, an analysis of the process of measuring a length is as instructive as it is for determining whether or not science deals with facts.

Fact or not, the length of a line, be it mercury in a tube or the distance between scratches on a dial, is most difficult to ascertain. To put a ruler against the line and say, "nineteen," would be altogether unscientific. The scientist does of course put a ruler of some sort to the line and does read off nineteen spaces, or whatever it may happen to be; but he never supposes that this is the fact he wants. After he measures the distance between the two scratches on his bar of steel, he measures it again. And strange as it may seem the length has changed. The lump of gold that a moment before weighed about nineteen units of the same volume of water now weighs less. When the scientist tries it a third time, the gold seems to have gained weight; that is, the line has become longer. The experiment is continued until the rigorous demands of science are satisfied, or the patience of the scientist is exhausted, and he finds himself with a list of numbers. Now it may be a fact (the empirical evidence seems to favor it) that the lump of gold, weighed the same way many times, is constantly changing; or the fact may be (not an impossibility) that the scientist's eyes blink so much that he cannot see the same length twice; or both of these may be facts. But instead of sticking to these facts, the scientist chooses to stick to the fact that he has a list of numbers.

These numbers he adds; the sum he divides by the number of readings; and this gives him an arithmetical average, 19.3 for example. This new value, 19.3, does not occur, we may well suppose, in the original list. That list contained 19.29, 19.28, 19.31, 19.32, but never a 19.30. But if this is he case, could the arithmetic mean be the "real" length of he line, the fact itself? By what experimental procedure does one determine that the average is the sought-for fact and that none of the observed readings is? Or, further, would it not be justifiable for the scientist to choose the mode, or the median, instead of the arithmetic mean? Is it not a fact that the mode is the length—as much a fact at least as that the average is? Really, is it not more the fact, because the mode occurred several times in the list, while the mean has not occurred at all? Or, should we say that in this essential item of scientific procedure, science throws all the facts (observations) out the window and sticks to what is not a fact (the unobserved average)! Perhaps there is an aesthetic delight in averages that is not found in modes. Unless, therefore, some balance, some vernier, some scale shows our senses that averages are facts and that modes are not, can the scientist do anything but trust his aesthetic taste?

Further Complications

However, in any experiment that goes beyond a student's exercise, there is more to be considered. The scientist not only calculates the average, but he also takes the difference between each reading and the average, and calculates the average of these differences to construct a figure denoting variable error. The result of the previous example could be19.3 +/- 01. Suppose now that these repetitions of one measurement are a part of a much more complicated problem designed to determine a law of nature. The problem might be the determination of the law of gravity. As is known, the attraction of gravity, in the Newtonian theory, is directly proportional to the product of two masses and inversely proportional to the square of the distance between them. How could this law have been obtained by experimental procedures? It was not and could not have been obtained by measuring a series of lengths and (assuming unit masses) discovering that the value of the force equaled a fraction whose denominator was always the square of the distance. A length cannot be measured. If it could, the experimenter might have discovered that the force between the two masses, when they are a unit distance apart, was 100 units; he might then have measured the force when the two masses were 2 units apart and have discovered that it was 25 units; and a similar measurement at 4 units distance would have given the value of 6.25. The experimenter presumably would then have made a graph and indicated the values so obtained as points on the graph. Measuring 4 units on the *x* axis, he would have put a dot 6.25 units above it; and at 2 units on the *x* axis he would have put a dot 25 units above it; and so on. By plotting a curve through these points, the experimenter would have *discovered* the law of gravity. But as has been seen, the length of a line cannot be measured. The values for the forces therefore will not be numbers like 6.25, but something like 6.25.0043. And since the same difficulty inheres in measuring the distances, the scientist will not have unit distances but other values with variable errors. When these values are transferred to a graph, they cannot be represented by points. On the *x* axis the scientist will have to measure off 2 units more or less, and on the *y* axis, 6.25 more or less. It will be necessary to indicate these measurements, not by points, but by rectangular areas. But, as an elementary account of curves would show, through a series of areas, an infinite number of curves may be passed. To be sure, there is also an infinite number of curves that cannot be drawn through these particular areas, and therefore the experimental material definitely rules out an infinite number of equations; but this truth is irrelevant to the present argument. The important thing is that areas allow the possibility of an infinite number of curves; that is, measurements with variable errors allow an infinite number of natural laws. The particular law that the scientist announces to the world is not a *discovery* forced on him by so-called facts; it is rather a choice from among an infinity of laws all of which enjoy the same experimental basis.

Thus it is seen that the falsity of science derives directly from its ideal of accuracy. It may be a fact that gold is heavier than water, but it is not a scientific fact; it may be a fact that the longer and the farther a body falls, the faster it goes, but Galileo was not interested in this type of fact. The scientist wants mathematical accuracy; and when he cannot discover it, he makes it. Since he chooses his law from among an infinite number of equally possible laws, the probability that he has chosen the "true" law is one over infinity, *i.e.* zero; or, in plain English, the scientist has no chance of hitting upon the "real" laws of nature. No one doubts that scientific laws are useful: By them the atomic bomb was invented. The point of all this argument is that scientific laws are not *discovered* but are *chosen*.

Science Is Always False

Perhaps both points should be maintained. Not only are scientific laws non-empirical, they must indeed be false. Take for example the law of the pendulum. It states that the period of the swing is proportional to the square root of the pendulum's length. But when the scientific presuppositions of this law are examined, it will be found that the pendulum so described must have its weight concentrated at a point, its string must be tensionless, and there must be no friction on its axis. Since obviously no such physical pendulum ever existed, it follows that the law of the pendulum describes imaginary pendulums, and that physical pendulums do not obey the laws of physics. Note especially that the analysis does not separate pendulums under laboratory conditions from pendulums in living-room clocks, and does not conclude that in the laboratory, but not in the living room, the laws of physics hold. The analysis shows that no physical pendulum, no matter how excellent the laboratory, satisfies the scientist's requirements. The scientist's world is (on pre-Heisenberg theory) perfectly mathematical, but the sense world is not.

Naturally a great many people, steeped in nineteenth-century scientific traditions, react violently to the idea that science is all false. Did we not make the atom bomb, they say? Does not vaccination prevent smallpox? Cannot we predict the position of Jupiter and an eclipse of the sun? Verified prediction makes it forever ridiculous to attack science. This reaction is, of course, understandable, however irrational it may be. The argument has not "attacked" science at all; it has insisted that science is extremely useful—though by its own requirements it must be false. The aim nowhere has been to attack science; the aim is to show what science is.

How science can be useful though false is illustrated in a delightful textbook on inductive logic. Milk fever, the illustration goes, until late in the nineteenth century, was a disease frequently fatal to cows. A veterinarian proposed the theory that it was caused by bacteria in the cows' udders. The cure therefore was to disinfect the cow, which the veterinarian proceeded to do by injecting Lugol solution into each teat. The mortality under this treatment fell from a previous ninety percent to thirty. Does not this success full treatment prove that the bacteria were killed and that Lugol cured the disease? Unfortunately another veterinarian was caught without the Lugol solution one day, and he injected plain boiled water. The cow recovered. Had water killed the bacteria? What is worse, it was found later that air could be pumped into the cows' udders with equally beneficial results. The original science was wrong, but it cured the cows nonetheless.

A closer examination of the logic of verification should be made. In the example above, the first veterinarian probably argued: If bacteria cause milk fever, Lugol solution will cure; the disinfectant does cure it; therefore I have verified the hypothesis that bacteria cause milk fever. This argument, as would be explained in a course of deductive logic, is a fallacy. Its invalidity may perhaps be more clearly seen in an artificial example: If a student doggedly works through Plato's *Republic* in Greek, he will know the Greek language; this student knows Greek; therefore he has read Plato's *Republic*. This is the fallacy of asserting the consequent, and it is invalid whenever used. But it is precisely this fallacy that is used in every case of scientific verification. If the law of gravitation is true, a freely falling body will have a constant acceleration, and the eclipse will begin at 2:58:03p.m.; but freely falling bodies do have a constant acceleration and the eclipse did begin at 2:58:03 p.m.; therefore the law of gravitation is true. Or, if the periodic table of atomic weights is true, a new element of such and such a weight must exist; this new element has now been discovered; therefore the period table is verified. And, if I eat roast turkey and plum pudding, I lose my appetite; I have lost my appetite; therefore, we had roast turkey for dinner. All these arguments are equally invalid. But sometimes there is an adverse reaction if it is claimed that verification never proves the truth of a scientific law. Is it worse to "attack" science, or to "murder" logic?