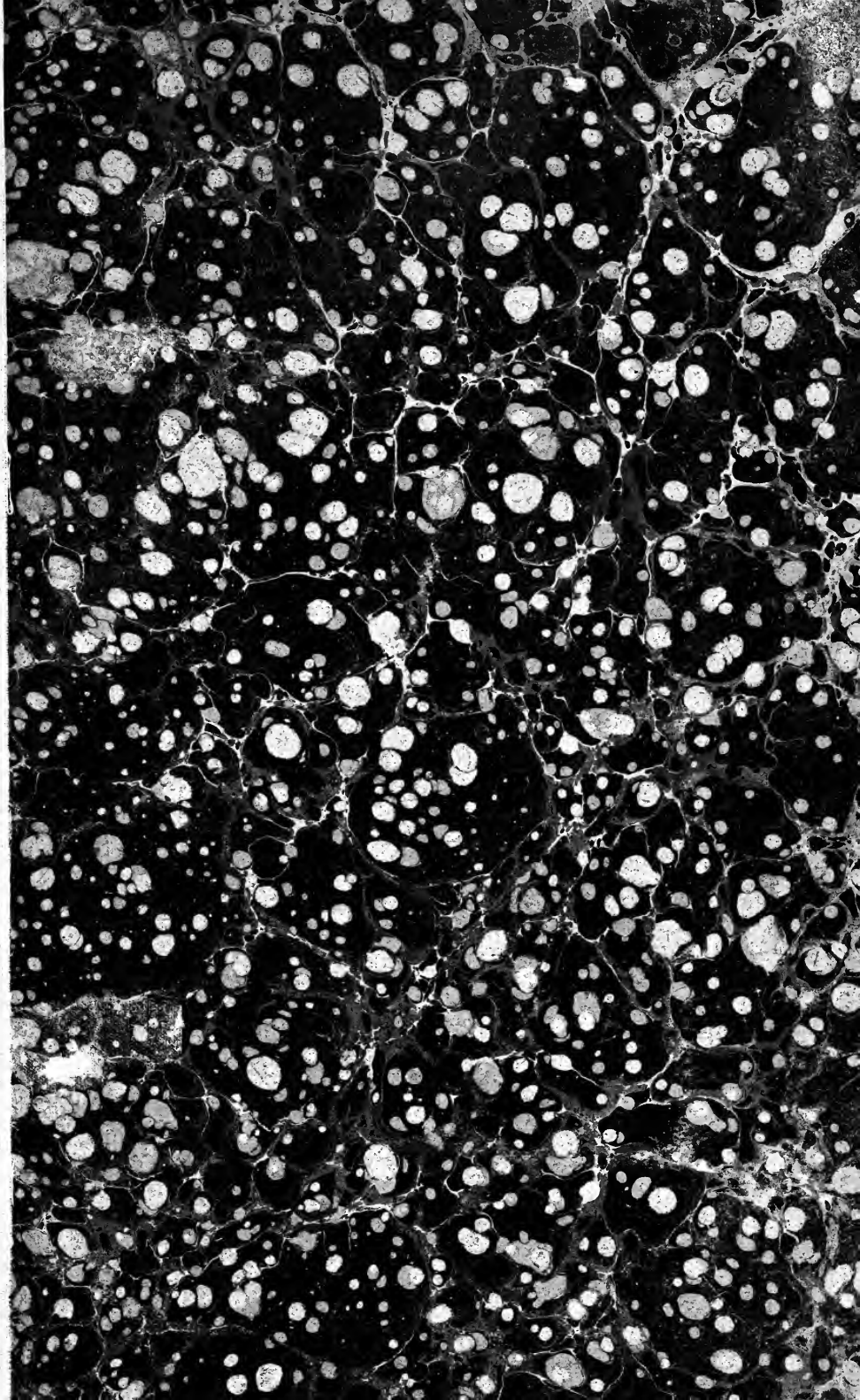


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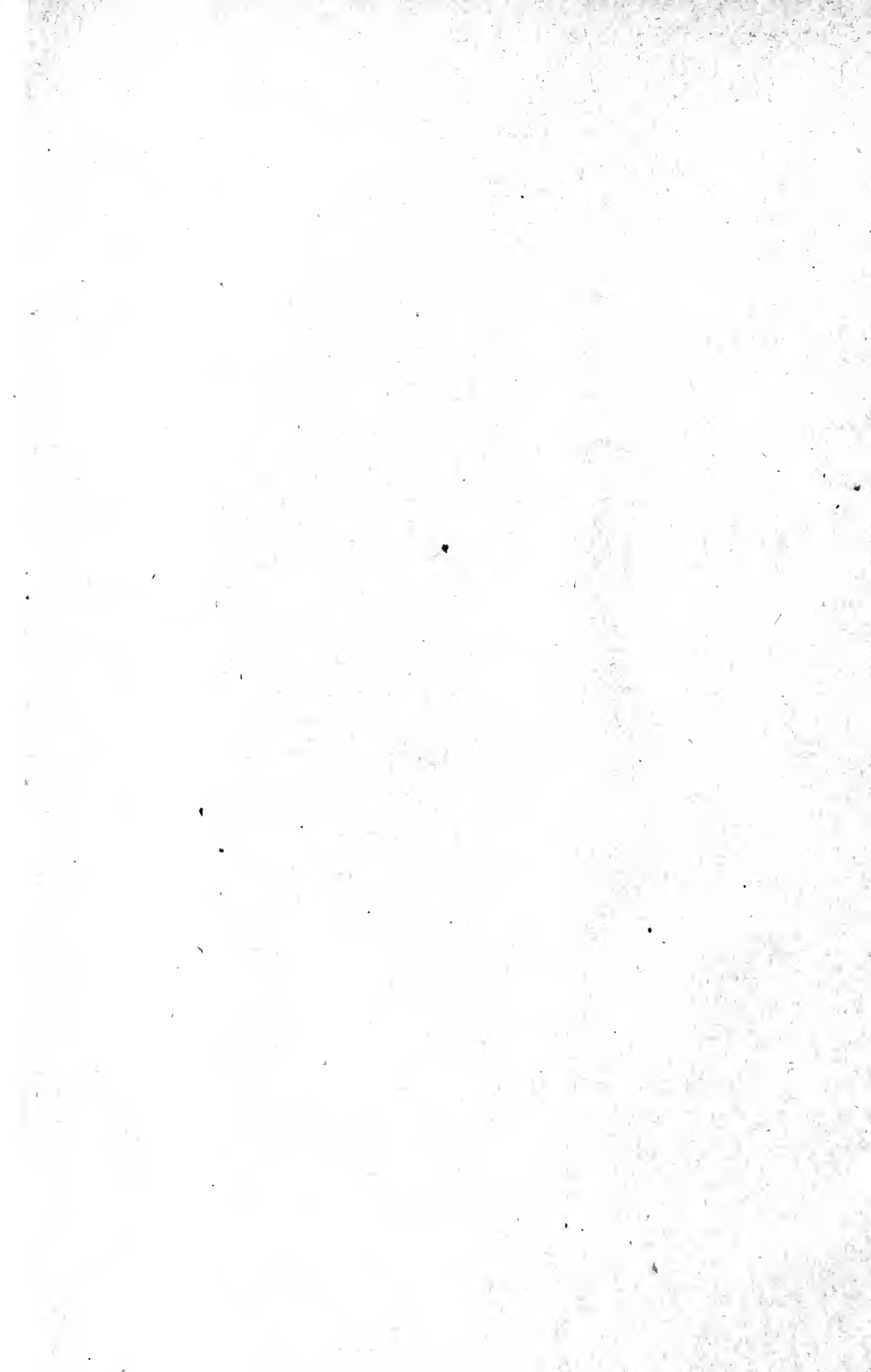
THOUGHTS
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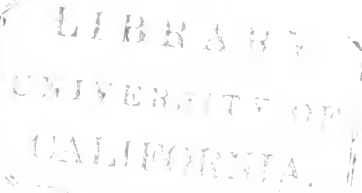
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Thoughts of Our Conceptions

—OF—

PHYSICAL LAW.

BY PROF. FRANCIS E. NIPHER, ST. LOUIS, MO.

An address before the Alumni of the State University of Iowa, June 19th, 1878; delivered at Kansas City, December 23d, 1878.

In the short time at my disposal, I wish to point out some reasons for the more general cultivation of a certain cardinal virtue which is so rare that I fear it has no name. Perhaps the words, *Intellectual Modesty*, would come as near as any others in expressing what I mean. The world is very full of people who are ready to make assertions upon subjects which are evidently too difficult for them—in many cases too difficult for any one—to handle with any degree of certainty; and it doubtless often happens that some who have meditated studiously for years upon some such subject, arriving at no satisfactory conclusion, are regarded as objects of profound commiseration by others, who rush upon conclusions like the unthinking horse into the battle. It is as natural that people should thus differ, as that some should have darker skins, taller frames, or more irritable tempers than others. To what extent these, and other differences which we shall point out, are blameworthy, we cannot attempt to discuss, but shall study the mental habits of men in precisely the same spirit in which we would study the habits of other animals. But I wish to show some tangible reasons for thinking that there are very few subjects upon which we can dogmatize, and that in any case it is unnecessary. I wish to advocate the cultivation of intellectual modesty, not merely because it seems to me to be one of the brightest ornaments of the human mind, but because of its vital connection with another cardinal virtue—intellectual honesty.

Perhaps this end will be best attained by considering the difficulties which

are met in the investigation of any subject, when the sole aim is to find out the truth of the matter, and I have thought it proper to point out some of the difficulties to which we are subject in arriving at our conceptions of physical law.

The study of physical science has endowed the human mind with an attribute which is usually ascribed to and is thought to be characteristic of the Divine Mind. I refer to the power of prophecy. The astronomer can predict the position of the planets for generations to come, basing his predictions on the assumption—an unproved assumption—that only those causes which he has considered will act in the future, or, in other words, that the present order of things will continue. His power of prediction does not, however, extend indefinitely into the future, for there are, doubtless, many minor disturbances or perturbations, too small to be detected by the instruments which he can command, without many centuries of observation, the effects of which will become plainly apparent after the lapse of ages—that is to say, his power of prophecy is limited by his ignorance of certain facts, and, possibly, by his inability to solve the equations involved in a complete discussion of the subject.

It is for precisely the same reason that *we* cannot foretell the future destiny of every person in the world. But to a mind possessing all knowledge, and of infinite power, the one problem would evidently be as simple as the other.

We can readily imagine a being, possessing sufficient knowledge and ability, to calculate the orbits of every person now living. Such a being must know all that is to be known in regard to our mental and physical organisms, and the circumstances under which we are and will be placed. Having thus the initial stage and being able to trace succeeding events as logical sequences of the present, *such a being could predict exactly what each of us will decide to do, under the present and all succeeding circumstances—could predict how far we will be physically and mentally able to carry our resolutions into effect.*

But how awful must be the mind which could perform such a task! The most gifted mathematicians, have, after enormous labor for two centuries, given an approximate solution of the interaction of three gravitating bodies, but they tell us that the methods used would not apply to four bodies, each of which exerted appreciable effects upon the others. How utterly beyond human power it would be to discuss the motions of the millions of chemical atoms contained in a single ounce of matter. Herschel has said that each of these particles is forever solving differential equations, which, if written out, might belt the earth.

But our imagined ideal mind must deal with the physics of our globe, and the interaction of its myriads of men. The whole phenomena of meteorology must be calculated, not only for every part of the earth, but for all time. The effect of these climatic influences upon each man, and upon the grain or other productions of his industry, must be determined. The repressing effects of political and social tyranny, and the conditions of their existence; the refreshing effects of food and sleep, and the circumstances which may sometimes prevent communities or individuals from obtaining enough of them; the moral influence of men upon each other—to come to smaller matters, the effect of the present address up-

on each member of the present audience—all must be taken into account in this stupendous calculation. And now, given the myriads of vibrating atoms, and whatever else may constitute a man, and the external forces which act upon him, the manner in which the atomic motions of his body will be modified, and the resulting effect upon his thoughts and decisions must be determined. The calculation must be comprehensive enough to include the thoughts and actions of all men through all time. Such a being would be able to determine, by aid of some high order of mathematical analysis, how many men will exist upon this earth five hundred years hence, would be able to locate each man, as astronomers predict the position of planets, and must be able to predict what task will then employ his hands, what train of thought will then be passing through his mind. A great famine occurs in China: it is produced by a combination of unfortunate circumstances, and the exact limit of its ravages could have been predicted, ages before.

A certain closed line drawn upon the earth, would mark out the area where 25 per cent. of the inhabitants would starve to death. Outside of this area would lie a belt of country, where 20 per cent. would die, and in this manner the whole of the melancholy facts could be represented. The discussion of the distribution of people and food, the means of transportation, the physical strength and wealth of individuals affected, and other matters involved in the question, would enable an all-powerful mind to determine to what extent each individual would be affected and which ones would be strained beyond physical endurance. The position of each atom of matter in our world must be deducible, and the exact manner in which each atom moves and vibrates. Some portion of matter may repose for ages, locked in some rocky ledge. Infinite intelligence can calculate when a chance stroke from a workman's hammer may beat it loose, at what time it will be borne aloft on the fickle and inconstant winds, and when and where it will again fall, now it becomes part of some animal or plant, but everywhere its existence is recognized and its path is traced by infinite mental power.

When we consider that our earth is but a speck in this universe of universes, that untold millions of suns and worlds are scattered through space, and that all are grasped by a knowledge equally profound, we begin to get some faint idea of the magnitude of that mind which can solve the general equations of the universe, and we can begin to realize, how comparatively insignificant, how necessarily imperfect, are our highest mental achievements.

Whether or not there be such a being as the one we have here imagined, it would be foreign to our purpose to discuss, but it seems to me that very few who talk fluently on either side of the question, have ever tried to weigh, in a calm and dispassionate manner, the awful import of the words they use.

In such a calculation as the one we have here supposed, mental philosophy would become an exact science. The intensity of mental action, the strength of different minds, and quantities of pleasure and pain would be determined. The logic of the wise and the foolish, the learned and the ignorant, the virtuous and the vicious, would be followed out to the conclusions which these minds would severally reach, under the particular circumstances in which each is placed.

Let us assume that one of the secret springs of human action is this: that any given case we decide to do that which we then think will give us, on the whole, most pleasure or least pain, often deciding, however, to give up a greater pleasure, to be enjoyed only in the future, for a lesser one which we can enjoy immediately, precisely as we sometimes allow a note to be discounted in order that we may realize upon it at once; or, to take another case: we have in mechanics a principle known as the "principle of least action." Applied to the solar system, it affirms that each of the planetary bodies so moves, that the sum of the energy lost by counter attraction, is less than if they moved in any other way. If this law holds in the interaction of men in society, it would mean, that however erratic the orbits of individual men may be, however much trouble may come upon them, or however much they may bring upon themselves, taking men as they *are*, the sum of human trouble is less than if men *did* differently, *being* what they are. Assuming that man is wisely constructed, mentally and physically, this is merely saying, in other words, that the present order of things is a wise one.

We are hardly in a position to assert that either of these statements is really a law of social physics. They are referred to here merely to indicate the nature of the results, which could be reached by mathematical analysis if we were able to discuss the interaction of moral and mental centers of action as astronomers discuss, approximately, the interaction of worlds.

Not only are we unable to predict for an infinite future, on account of the summing up of disturbances which cannot be detected in a short time, with our means of investigation, but, as before suggested, events wholly unexpected to our partially instructed minds—apparent breaches of continuity—are liable to happen at any time. A tribe of savages, not acquainted with fire-arms, may acquire a loaded musket. In toying with it for a time they become familiar with its appearance, and, as they think, with its properties. But some day they succeed in discharging it, an event which they are powerless to bring about again by an exact repetition of the act which brought it about before. Who shall say that there are not hair triggers in the universe, upon which we may sometime stumble? * "We can imagine intelligent beings living on a world surrounded by an atmosphere of oxygen and hydrogen. So long as they were unacquainted with fire, they might live for ages in fancied security," studying the laws of the evolution of their world and making wise predictions in regard to its future. But the production of a single spark of fire would ignite their atmosphere, and wrap them in utter destruction. "We know not at what moment immense, and to us, wholly unexpected energies may be called into action. For all that our knowledge can tell, the volume of human history may be finished during the next hour. A great explosion on the sun may scorch us into cinders in a second. The earth may be dashed to pieces and dissipated into gas, by collision with some immense meteorite. We may become involved in a nebulous atmosphere of combustible gas, which would ignite a moment later; in fact, as was so eloquently pointed out by Mr. Babbage, there is no catastrophe too great, or too sudden, to be consistent with the reign of law, and the continuity of action."

* See Jevon's Principles of Science, 1877. pp. 742-748.

In the discussion of physical phenomena, we always ignore the greater part of the discussion, by neglecting those elements which are, or are supposed to be, unimportant. In so simple an operation as the weighing of a quantity of matter on a steelyard, we can discuss only the merest elements of the case. The student of Physics would tell you, that the weights are inversely as the lever arms, but this is far from being the whole story. During the weighing, certain parts of the steel bar are heated; other parts are cooled; still other parts retain their temperature unchanged; electrical currents are set up within its mass; its magnetism is changed; its torsion and elasticity become different—in fact, to discuss all the changes occurring within the bar during so simple an operation, would infinitely transcend the power of the most gifted men.

If we could discuss completely the laws which govern phenomena, we should find them represented, in many cases, not by the comparatively simple formulæ, which have been found sufficient for practical purposes, but by infinite series, the first terms only of which our mathematicians have been able to deduce, and our physicists to experimentally detect.

What is here said of physical problems, is also true of problems of pure mathematics. It is stated by mathematicians, “that those problems which have been solved, are but an infinitely small part of those which can be proposed, that they are all special cases, (although sometimes called general) and that if a problem were selected, at random, out of the whole number that might be proposed, the probability would be infinitely slight—that any human being could solve it.”

Even those problems that have been satisfactorily solved, involve ideas that we cannot comprehend. Let us take a simple problem in Geometry. Imagine two wooden rods, or finite lines intersecting each other, and let us revolve one of them until they become parallel. Consider these lines infinitely prolonged, and let us see what becomes of these prolongations. As one line is revolved the point of intersection travels outwards. Finally the lines might seem to be parallel, but perhaps if we were to travel along the lines for a million of miles, we might come to the point of intersection. The mathematicians say, that when the lines have become parallel, the point of intersection will be removed to an infinite distance, which is, they say, equivalent to saying that the lines will not intersect. Where in space will these lines part company? Have they ends, which the point of intersection finally reaches, and which then separate from each other? No! The lines are supposed to be without end. *However far* the point of intersection may have travelled, we may straightway regard this distance, as represented by the first term of a divergent series of an infinite number of terms, each term of which is infinitely greater than the one which preceded it. We can form an independent conception of two infinite and absolutely parallel lines, but we cannot imagine how the infinite prolongations of intersecting lines can ever separate; nevertheless, we can continue the rotation of our finite line, until it passes through parallelism, and the point or at least a point of intersection comes travelling towards us from the opposite direction.

Prof. Jevons appears to think that our difficulty in such cases, is due to an imperfect idea of infinite space.*

In the study of Physics, our most certain experimental results force us to ideas equally beyond our power of realization. It is shown beyond question, that light moves over a distance of about seven times the circumference of our earth in a single second. We must look for something marvelous in any theory which can account for so marvelous a fact. According to Newton's theory, we should have particles of light, shooting off from a distant luminous body with this immense velocity, and, falling upon a mirror, their motion would not merely be checked, but the elasticity of these light particles must be assumed to be so perfect, that they rebound with an equal velocity.

According to the undulatory theory, the light consists of vibrations of a medium which fills all space. Since the velocity of transmission of these vibrations is so great, it follows that the elasticity of this medium must be 10,000,000,000 times as great as that of the hardest steel. Space is not now regarded as a void, but as filled with a medium which, as Thomas Young remarked, "is not only highly elastic, but absolutely solid." And yet, as we walk through space, the solid atoms which compose our bodies, experience not the slightest resistance. Such ideas, although they can be conceived, cannot be realized. We have had no previous experience with materials possessing such properties, and such ideas must necessarily appear strange to us; but they are no more strange than the phenomena of light which we directly observe, and which force us to this, or to some other theory, equally marvelous. Only those who have carefully examined the subject, can realize how weighty is the evidence in favor of the undulatory theory of light; but where such stupenduous conceptions are involved, a slavish acceptance of any theory, even by them, would be in the highest degree objectionable. We are not the friends of theories, but of truth.

So in all departments of thought, we come sooner or later to depths which the human sounding line cannot pierce; we reach ideas, about which it becomes hazardous to talk, unless one courts the position of a babbler of nonsense; we learn that all our "final" formulæ contain unknown quantities. As we are not infallible, we must therefore be cautious and modest.

It is not surprising then, that in the progress of our sciences, many errors of reasoning and in the interpretation of facts have been committed. You are all familiar with the ideas of Newton, in regard to the nature of light, ideas which were not in themselves absurd, which were firmly believed in by this man of such transcendent power, but which were clearly negated by results of subsequent experiment.

It was known long ago, that rain-gauges placed above the surface of the ground, caught less rain than those placed at the surface, and it is still taught in many of our text-books, that this is due to a condensation of moisture in the lower strata of the atmosphere. This idea is not absurd, but it has been shown* that this cause produces no appreciable effect, and that the observed effect is due

* Principles of Science, p. 767.

the action of the wind, "which sweeps some rain out of all gauges, and most, at of those which are highest, and therefore most exposed."

Lavoisier's idea that all acids were compounds of oxygen, received a complete refutation when the constitution of prussic and muriatic acids became known. In fact, the errors of scientific men are well nigh innumerable, not because they are men of science, but because they are *men*, and we are probably justified in saying quite in general, that if the man who never committed a mental blunder be found, we shall also find a man who never conceived a vigorous thought. The fact that the results of scientific men can usually be checked by observation and experiment, perhaps diminishes their liability to err and enables them to discover multitudes of errors that would otherwise escape their attention. This does not tend to make the results of their investigations less weighty than results which have been reached by other processes, more purely mental. If men of science, with their severe methods of research, their habits of testing their conclusions by observation and experiment, are nevertheless led into wrong conclusions, what does it prove? Simply that the human mind, even under the most favorable circumstances, is fallible! Is there a class of men less liable to make mistakes? It is precisely this experience which causes many to place a small value upon the unsupported assertions and speculations of any man, however honest, earnest, or able he may be.

On this point, one of the most admirable of experimenters, Faraday, has beautifully said: "The world little knows how many of the thoughts and theories which have passed through the mind of the scientific investigator, have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances, not a tenth of the suggestions, he hopes, the wishes, the preliminary conclusions, have been realized."

In the 24th series of his "Experimental Researches," Faraday describes many tedious and intricate experiments, in which he tried to connect gravitation and electricity. "He labored with characteristic energy for days, on the clock tower of the Houses of Parliament and in the shot-tower of Southwark, raising and lowering heavy weights, connected with wire coils. Many times his great skill as an experimenter prevented him from being deceived by results which others would have regarded as conclusive proofs of his idea, and when the whole was done, there remained absolutely no result." For although the results were wholly negative, Faraday could never accept them as conclusive against his idea, to which he had been led by his experiments on the relations between electricity and magnetism. His mental condition after this work was done, is best described in his own words. "Occasionally, and frequently, the exercise of the judgment ought to end in *absolute reservation*. It may be very distasteful, and great fatigue to suspend a conclusion; but as we are not infallible, so we ought to be cautious."

It is a matter of common observation, that men who, like Faraday, have done much to widen the boundaries of our knowledge, are precisely the ones who are most frequently in a state of doubt, while those who have received all their

* Jevons, in *Phil. Mag.* Dec. 1861.

knowledge at second hand are generally more ready with a positive decision and a reason for it, not necessarily because their intellectual integrity is less, but because they *cannot* realize how vain a thing the human reason is. To imagination and reason, controlled and checked by experiment and observation, are we to look as the source of the greatest advancement in science; but we are not to look for infallibility, and in cases where the reason alone is allowed to decide, where observation and experiment are impossible, the uncertainty must necessarily be greater. In many cases the fact that the subject is so intrinsically difficult that no experimental check is possible, appears to inspire the investigator with a confidence in his conclusions, that could hardly be reinforced by absolute certainty.

But we have not yet exhausted the list of errors to which scientific men are liable, in arriving at what we provisionally call correct conceptions of physical law. A few of them have carried their investigations into a domain in which certain hypothetical beings called "spirits" are said to be the main actors. It is exceedingly probable that a few trained investigators have been deceived in regard to the evidence of their own senses. This is not an unlooked for result, as it can be readily reproduced in the performances of any expert juggler.

I have confined myself to the errors which scientific men have committed, and to which they are liable in their search for truth, not because they alone are liable to err, but because a discussion of the multitude of errors into which intellectual men of other professions have fallen, would be sure to give offense. But it is not the scientific mind which stands impeached—it is the *human* mind!

To what end have we then come? It appears that all scientific results are attended with some uncertainty. Sometimes the uncertainty is very small, and we are able to obtain a numerical estimate of it. In other cases it may be possible that a fundamental misconception of the truth may have been formed. As an instance illustrating what I mean, we may cite the case of the measurement of the Atlanta base-line by the engineers of the United States Coast Survey. The whole length of the base-line was nearly six miles, and three determinations of its length showed differences of about $\frac{3}{10}$ of an inch—about a millionth of the entire length. It is safe to say that if these re-measurements had shown differences of ten feet, there would have been no quarreling in regard to which measurement was right, but all would have been rejected, and if the engineers were not dismissed as incompetent, they would, with feelings of mortification, have begun their work over again. It is curious to observe that in many cases where less skillful men attack problems infinitely more complex, reaching conclusions differing as widely as the poles, we have, instead of conscientious re-investigation or a modest reservation of judgment, dogmatic discussions, empty words.

In the other case, where the error is likely to be a fundamental one, the probability of the truth or error of a conclusion cannot always be determined numerically, and will vary greatly in different minds. For instance, A may think he saw a ball dropped into a box, and may feel certain that it is yet there; B is certain that it was a juggler's trick, and that the box is empty; C did not see

the act, and has no opinion in the matter. About the *fact* there is no uncertainty: the ball is either in the box or not. No discussion can affect the matter in the least. The uncertainty is purely a mental affair, its degree depending upon the ability of the observers, their opportunities for investigation, and their previous training. Their differences on this subject will be wholly obliterated by an exposure of the interior of the box, and without the necessity for any discussion whatever. If the box *cannot* be opened, the matter will remain a legitimate subject for dispute. The fact that competent men think a subject worthy of dispute seems to me a good indication that the matter is, humanly speaking, uncertain. That unpleasant thing called intolerance, in those cases in which it is accompanied with sincerity, arises from an inability to see these points, and hence we have A making strenuous efforts to convert B and C to his own opinion, failing in which, he proceeds to burn them, to imprison them, to lampoon them in the newspapers, or to do some of the more quiet, but scarcely less effective things, characteristic of our own times, that the spirit of the age will permit. Perhaps no blame is to be attached to such acts. If they are failings, they are simply to be counted in with the other failings to which well meaning men are liable, and when the evil effects fall heavily upon us, it is perhaps wise to endure them with philosophic calmness, along with the other misfortunes which for some reason or other seem incident to human life.

In conclusion, allow me to say, that it seems quite probable that human welfare does not require us to sit in judgment on the ideas of others. Thoughtful men are becoming more and more impressed with the vastness of the unknown, and the comparative insignificance of human achievement, while the demonstrated fallibility of human reason leads them to temperance and modesty of thought and expression; to *appreciation*, as well as toleration, of opposition and doubt. Certain it is, that if we preserve our intellectual integrity, we shall be unable to settle many of the problems that interest us most. If we decide upon some of them, and other persons still reserve their judgment or decide differently, we need not lose our tempers; they have not only decided differently from us, but we have also decided differently from them. It is important to notice that neither of these decisions has affected the *truth* in the least. If we feel called upon to defend the truth, we are, after all, only defending what we *believe* to be truth, and possibly against men as honest and as able as ourselves. But why should we defend the truth? So long as the heart of humanity shall pulsate, will not truth be cherished there? Why would it not be far better for each one to put himself in the attitude of a reverent *searcher* for truth? remembering always, that the little decisions that we may reach are possibly wrong, that all of the honesty and ability in the world is not concentrated within ourselves, and the comparatively few who think as we do, and that one can do nothing nobler, than to make himself as intelligent and humane as possible, resolutely following out his highest convictions, and living at peace with himself, and with all men.



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