ARTICLE VII.

RECENT BOOKS BEARING UPON THE RELATION OF SCIENCE TO RELIGION.

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No. I. — THE NATURE AND DEGREE OF SCIENTIFIC PROOF.

THE book[1] to whose guidance we willingly commit ourselves in this Article, is of exceptional value in this time so marked by fertile speculation and heated controversy. It covers a field which has been neglected entirely too much, by the interpreters both of nature and of the Bible. It may be of advantage to both parties, to be reminded that no facts are altogether foreign, either to science or religion, and that there is but one method by which to arrive at the truth, whether one call himself a scientist or a theologian. Logic is one; and holds alike all interpreters of facts to its rigorous postulates.

The authority of Christianity is not established by direct intuition; but as a conclusion of a syllogism, of which the objective facts contained in the Bible, and the circumstances attending its transmission to us, form the minor premise, and of which certain intuitions, which we will not here specify, compose the major premise.

The belief in the truths of physical science rests likewise on the conclusion of a similar syllogism, whose major premise is the same, and whose minor is a set of observations differing in many particulars from those in the other, but still similar to the others in this, that they are not proof, but only the basis of proof.

[1] The Principles of Science. A Treatise on Logic and Scientific Method. By W. Stanley Jevons, M.A., F.R.S., Fellow of University College, London, Professor of Logic and Political Economy in the Owens College, Manchester, England. 2 vols. 8vo. pp. 463, 480. London and New York: Macmillan and Co. 1874.

The central question of all reasoning is this: How do we join together the major and minor premise in a conclusion? Whence comes that new thought that is born neither of intuition alone, nor of observation? Has it the certainty of either? The defender of the Bible must answer, that he is not absolutely certain of its credibility and authority; for, from the nature of the case, one cannot be expected to establish these beyond a high degree of probability. But, on the other hand, is the physical philosopher able to do any better in his field? Is he able to eliminate all uncertainty from his conclusions regarding what are called the laws of nature? The author under review, who has made the physical sciences and their methods of proof a life-long study, answers, no; but expresses it as his "strong conviction that before a rigorous logical scrutiny, the 'reign of law' will prove to be an unverified hypothesis, the uniformity of nature an ambiguous expression, the certainty of our scientific inferences to a great extent a delusion." [1]

The distinguished reputation of Professor Jevons makes it worth while to notice his able and elaborate work upon the Principles of Science at some length. We can do this no better than by furnishing a connected series of extracts from its leading chapters, adding upon some allied topics, a few remarks of our own.

I. Nature of Scientific Inference.

"Science arises from the discovery of identity amid diversity. The process may be described in many different words, but our language must always imply the presence of one common and necessary element. In every act of inference or scientific method we are engaged about a certain identity, sameness, similarity, likeness, resemblance, analogy, equivalence, or equality apparent between two objects." [2] "It must be the ground of all reasoning and inference, that *what is true of one thing will be true of its equivalent*, and that under carefully ascertained conditions *nature repeats herself*." [3] "The fundamental action of our reasoning faculties consists in inferring, or carrying to a new instance of a phenomenon whatever we have previously known of its like, analogue, equivalent, or equal. Sameness or identity presents itself in all degrees, and is known under various names;

[1] Vol. i. Preface, p. ix. [2] Vol. i. p. 1. [3] p. 2.

but the great rule of inference embraces all degrees, and affirms that *so far as there exists sameness, identity, or likeness, what is true of one thing will be true of the other.* The great difficulty of reasoning doubtless consists in ascertaining that there does exist a sufficient degree of likeness or sameness to warrant an intended inference."[1]

In contrast to J. S. Mill, who held that all reasoning was really inductive, our author maintains the exact reverse.

"In a certain sense all knowledge is inductive. We can only learn the laws and relations of things in nature by observing those things. But the knowledge gained from the senses is knowledge only of particular facts, and we require some process of reasoning by which we may construct out of the facts the laws obeyed by them. Experience gives us the materials of knowledge; induction digests those materials, and yields us general knowledge." "In its ultimate origin or foundation, then, all knowledge is inductive, in the sense that it is derived by a certain inductive reasoning from the facts of experience. But it is nevertheless true — and this is a point to which insufficient attention has been paid — that all reasoning is founded on the principles of deduction. I call in question the existence of any method of reasoning which can be carried on without a knowledge of deductive processes. I shall endeavor to show that *induction* is really *the inverse process of deduction.* There is no mode of ascertaining the laws which are obeyed in certain phenomena, except we previously have the power of determining what results would follow from a given law..... An inverse process is the undoing of the direct process. A person who enters a maze must either trust to chance to lead him out again, or he must carefully notice the road by which he entered. The facts furnished to us by experience are a maze of particular results; we might by chance observe in them the fulfilment of a law, but this is scarcely possible, unless we thoroughly learn the effects which would attach to any particular law. Accordingly the importance of deductive reasoning is doubly supreme."[2]

II. Twofold Meaning of General Names.

"A name is said to *denote* the distinct object of thought to which it may be applied; it *implies*, at the same time, the possession of certain qualities or circumstances. The number of objects denoted, forms the *extent* of meaning of the term; the number of qualities implied forms the *intent* of meaning. ..... We increase the intent of meaning of a term by joining adjectives to it, and the removal of such adjectives, of course, decreases the intensive meaning. Now, concerning such changes of meaning the following all-important law holds universally true: *When the intent of meaning of a term is increased, the extent is decreased, and vice versa.* ..... Singular terms, which denote a single individual only, come under the

[1] Vol. i. p. 11. [2] pp. 14, 15.

same law of meaning as general names. They may be regarded as general names of which the meaning in extension is reduced to a minimum. Logicians have erroneously asserted, as it seems to me, that singular terms are devoid of meaning in intension, the fact being that they exceed all other terms in that kind of meaning."[1]

"There is no distinction but that of degree between what is known as reasoning by *generalization* and reasoning by *analogy*. In both cases from certain observed resemblances we infer, with more or less probability, the existence of other resemblances. In generalization the resemblances have great extension and usually little intension, whereas in analogy we rely upon the great intension, the extension being of small amount."[2]

An important observation is made upon the indifference of logic to the order in which the adjectives which add intensive meaning to a term occur.

"A little reflection will show that knowledge in the highest perfection would consist in the *simultaneous* possession of a multitude of facts. To comprehend a science perfectly we should have every fact present with every other fact. We must write a book, and we must read it, successively, word by word; but how infinitely higher would be our powers of thought if we could grasp the whole in one collective act of consciousness Compared with the brutes, we do possess some slight approximation to such power; and it is just conceivable that, in the indefinite future, mind may acquire a vast increase of capacity, and be less restricted to the piecemeal examination of a subject. But I wish to make plain that there is no logical foundation for the successive character of thought and reasoning, unavoidable under our present mental conditions. The fact that we must think of one thing first, and another second, is a logical weakness and imperfection. We must describe metal as 'hard and opaque,' or 'opaque and hard,' but in the metal itself there is no difference of order; the properties are simultaneous and co-extensive in existence."[3]

These remarks connect themselves, in a later portion of the work, with others of much significance to metaphysicians, to the effect that the independence of space and time, appearing in logical relations, and in the algebraical formulae which represent in their variations certain curved lines in space, gives us a hint that space and time are not necessary conditions of every form of being.[4]

In our author's view, all logic rests on the principle of identity, and reasoning is the process of following the thread of identity through its multifarious transformations and

[1] Vol. i. pp. 81, 82. [2] Vol. ii. p. 244. [3] Vol. i. p. 41. [4] See below, p. 555.

combinations with other things and in other statements. Deductive reasoning, like going into a labyrinth, is comparatively easy; but the inductive process is beset with the perplexities of getting out of a maze without any clew. It is proposed, with some approach to success, to simplify the process by the application of mathematical formulae. Hamilton and some others have endeavored to accomplish this object by the use of geometrical figures, exhibiting the mutual inclusion or exclusion of propositions by the relations of circles to one another; the spaces intercepted in common by them representing the identity, and hence the limitations of the conclusion. But in logic, as in mathematics, figures in space are cumbrous, and must yield to the symbols of algebra. For the proposition All A is B, or, transposed, B includes A, substitute the formula A = B, meaning that A is identical with a portion of B. Now, if also B = C, then a portion of C must be identical with A. And you have the formula A = ABC, which means, when read in extension, A is an A which is a B, which is a C; each letter adding to the fold a more general term; or, read in intension, it means A is an A which possesses the additional meaning B plus the meaning of C.[1]

By introducing appropriate signs for negation, variation, and alternative propositions, and following simple rules of substitution, the whole mass of syllogisms, in all their moods and figures, is brought within the management of a few algebraical symbols. This enables our author to accomplish the same thing for logic which Mr. Babbage did in mathematics, namely, invent a machine which shall, when once the terms and propositions have been reduced to appropriate forms, dispense with the drudgery of the routine work, and lead to the conclusions which are involved in the premises.

We have not room here to give any adequate idea of this process, which is carefully elaborated by the author. We are not sure that we see all its advantages. It incorporates, however Hamilton's idea of quantifying the predicate, and

[1] See Jevons, Vol. i. pp. 15–194.

also that of inference being a mere explication of the concept of the subject of the minor premise. He does not, however, like De Morgan and others, make logic a branch of mathematics; but, on the contrary, calls mathematics a branch of logic, and places the law of identity at the foundation of the ordinary axioms of number and space.

III. The Process of Induction.

We come now to the vital point of interest: What degree of certainty can the inferences of induction have? According to our author,

"Inference never does more than explicate, unfold, or develop the information contained in certain premises or facts. Neither in deductive nor inductive reasoning can we add a tittle to our implicit knowledge, which is like that contained in an unread book or a sealed letter."[1] The question regarding this explication is, "Where does novelty of form begin?"[2]

The difficulties of explication increase in geometrical ratio with every ascending step of induction. The discovery of a new cause, or the appearance of a new connected phenomenon makes a fresh knot in the snarl we are disentangling. It is well to weigh the following sentences.

"Induction is the inverse operation to deduction."[3] "Induction is the decyphering of the hidden meaning of natural phenomena."[4] "We seldom observe any great law in uninterrupted and undisguised operation."[5] "It is now plain that induction consists in passing back from a series of combinations to the laws by which such combinations are governed."[6]

"The following table shows the extraordinary manner in which the number of possible logical relations increases with the number of terms involved.[7]

No. of Terms.	No. of possible Combinations.	No. of possible selections of combinations corresponding to consistent or inconsistent logical relations.
2	4	16
3	8	256
4	16	65,536
5	32	4,294,967,296
6	64	18,446,744,073,709,551,616"

The uncertainties regarding induction arise from the fact that, except in a few unimportant cases, it can never be perfect.

[1] Vol. i. p. 136, see also, pp. 171, 250. [2] p. 137. [3] p. 139.
[4] p. 143. [5] p. 145 [6] p. 154. [7] p. 163.

An unknown, but most important, factor in our calculations concerning the permanence of the laws of nature, by which we prognosticate the future, or form judgments regarding the past, is the purpose of the Creator. Or rather we should say that this is the thing which, in our processes of induction, we are always, with very imperfect data, attempting to determine. Thus our author:

"There is no fact which I shall more constantly keep before the reader's mind in the following pages, than that the results of imperfect induction however well authenticated and verified, are never more than probable. We never can be sure that the future will be as the present. We hang ever upon the will of the Creator; and it is only so far as he has created two things alike, or maintains the framework of the world unchanged from moment to moment, that our most careful inferences can be fulfilled. ..... No experience of finite duration can be expected to give an exhaustive knowledge of all the forces which are in operation. There is thus a double uncertainty; even supposing the universe as a whole to proceed unchanged, we do not really know the universe as a whole. ..... We cannot be sure, then, that our observations have not escaped some fact which will cause the future to be apparently different from the past; nor can we be sure that the future really will be the outcome of the past."

"As the creation of the universe is necessarily an act passing all experience and all conception, so any change in that creation, or, it may be, a termination of it, must likewise be infinitely beyond the bounds of our mental faculties. No science, no reasoning upon the subject, can have any validity; for without experience we are without the basis and materials of knowledge. It is the fundamental postulate, accordingly, of all inference concerning the future, that there shall be no arbitrary change in the subject of inference. Of the probability or improbability of such a change I conceive that our faculties can give no estimate."

"No net addition is ever made to our knowledge by reasoning; what we know of future events or unexamined objects, is only the unfolded contents of our previous knowledge, and it becomes less and less probable as it is more boldly extended to remote cases." [1]

It will thus be seen that doctors of science as well as of theology walk by faith, and not by sight. Physical science cannot divest itself of a metaphysical and theological basis. The scientist is searching after the ideas of God which are involved in both the past and the future of the material creation. At the very threshold he encounters the metaphysical

[1] Vol. i. pp. 168, 169, 170, 171. See also, pp. 250, 251.

questions concerning the wisdom, goodness, and veracity of God, and the data for interpreting the marks of these are obtained from his own mental experiences.

IV. Doctrine of Probabilities.

Professor Jevons rightly gives to the doctrine of probabilities a high place in inductive reasoning.

"As Butler truly said, 'Probability is the very guide of life.' ..... All our inferences concerning the future are merely probable; and a due appreciation of the degree of probability depends entirely upon a due comprehension of the principles of the subject. I conceive that it is impossible even to expound the principles and methods of induction as applied to natural phenomena, in a sound manner, without resting them upon the theory of probability. Perfect knowledge alone can give certainty; and in nature, perfect knowledge would be infinite knowledge, which is clearly beyond our capacities. We have therefore to content ourselves with partial knowledge — knowledge mingled with ignorance, producing doubt."[1]

By probability is not meant random casualty. Our author is far enough from taking the position that we are simply observers of hap-hazard evolutions of blind forces. The dice we use in induction are all loaded, and we have some idea which side is heavier. He squarely asserts that there is no such thing as chance in the phenomena of nature. The "probability belongs wholly to the mind."[2]

"The theory of probability deals with *quantity of knowledge*. ..... The theory consists in putting similar cases upon a par, and distributing equally among them whatever knowledge we may possess..... The theory comes into play when ignorance begins, and the knowledge we possess requires to be distributed over many cases."[3]

"It is just possible that some regular coincidences which we attribute to fixed laws of nature, are due to the accidental conjunction of phenomena in the cases to which our attention is directed. All that we can learn from finite experience is capable, according to the theory of probabilities, of misleading us, and it is only infinite experience that could assure us of any inductive truths. At the same time the probability that any extreme runs of luck will occur is so excessively slight, that it would be absurd seriously to expect their occurrence."[4]

"Certainty belongs only to the deductive process, and to the teachings

[1] Vol. i. p. 224. [2] See p. 225. [3] pp. 227, 228. p. 236. See also, pp. 247, 248.

of direct intuitions; and as the conditions of nature are not given by intuition, we can only be certain that we have got a correct hypothesis, when, out of a limited number conceivably possible, we select that one which alone agrees with the facts to be explained."[1]

"Inductive inference might attain to certainty if our knowledge of the agents, existing throughout the universe, were complete; and if we were at the same time certain that the same power which created the universe would allow it to proceed without arbitrary change."[2]

"We, with our finite minds and short experience, can never penetrate the mystery of those existences which embody the will of the Creator, and evolve it throughout time..... The word 'cause' covers just as much untold meaning as any of the words, *substance*, *matter*, *thought*, *existence*."[3]

"Much has been said about the peculiar certainty of mathematical reasoning; but it is only certainty of deductive reasoning, and equally attaches to all correct logical deduction."[4]

It should be noted, at this point, that probability may approach so near to certainty as to be indistinguishable from it. And there is danger of under-estimating an argument because it is called "probable." For instance, Laplace estimated that the probability that the forty-three independent motions of the bodies in the solar system known in his day should coincide in direction by chance would be one half raised to the forty-second power: or "about 4,400,000,000,000 to 1 in favor of some common cause for the uniformity of direction." We have further to combine with this by multiplication the independent "probability that the sum of the inclinations of the planetary orbits would not exceed by accident the actual amount ([about one tenth] of a right angle for the ten planets known in 1801)" which is one tenth raised to the tenth power, or one ten billionth, i.e. the probability in favor of some common cause for these two sets of phenomena would be expressed by 44,000,000,000,000,000,000,000 to 1.[5] We may, or may not, agree with Laplace in adopting the nebular hypothesis; for we can plausibly reason that some idea of final cause has disturbed the orderly action of secondary causes. But when (not to pause here) we advance a step farther, and consider the uniformities resulting from the action of the geological, the molecular, the chemical, and

[1] Vol. i. p. 309. [2] pp. 274, 275. [3] p. 255. [4] p. 270. [5] See pp. 288, 289.

the vital forces we can affirm, from the doctrine of probabilities as applied to the material creation, that bald atheism is as near an absurdity as any supposition can well be. For we have sixty-four chemical elements. What is the probability that these should combine in an orderly manner by chance? The following calculations will give a faint idea of the problem. There are fifty-two cards in a pack. The number of hands of thirteen cards each which can be produced is 635,013,559,600.

"But in whist four hands are simultaneously held, and the number of distinct deals becomes so vast that it would require twenty-eight figures to express it. If the whole population of the world — say, one hundred thousand million persons — were to deal cards, day and night, for a hundred million of years, they would not in that time have exhausted one hundred-thousandth part of the possible deals. Now, even with the same hands, the play may be almost infinitely varied, so that the complete variety of games which may exist is almost incalculably great. It is in the highest degree improbable that any one game of whist was ever exactly like another, except by intention."[1]

When, furthermore, we think of the variety which might be produced from the original elements if combined in different numbers and proportions, and in higher orders of complexity, the conclusions are startling. We have, for example, twenty-six letters in our alphabet. From these we can by combination form several trillions of pronounceable words. From these words we can construct an indefinitely larger number of sentences. With these sentences we can fill an indefinitely larger number of books. Verily, of "making many books there is no end." And the variety of libraries that can be selected is indefinitely more numerous than that of the books that can be made. This last is what is called a combination of the fifth order. By combining two marks in all possible groups in similar ascending orders, the values would increase as follows:

First step, 2; next step, 4; third step, 16; fourth step, 65,536; fifth step, 65,536 *twos* multiplied together — a number "so great that we could not possibly compute it; the mere expression of the result requiring

[1] Vol. i. p. 217.

19,729 places of figures. But go one step more, and we pass the bounds of all reason. The sixth order of the powers of two becomes so great that we could not even express the number of figures required in writing it down, without using about 19,729 figures for the purpose."[1]

The fifth order of the powers of two is indefinitely greater than the number of molecules required to fill a globe extending to the stars of the sixteenth magnitude (hence with a radius of 33,900,000,000,000,000 miles), supposing the number of molecules in each cubic inch of solid or liquid substance to be 3×10^{26}.[2] The problem which undisguised atheism has on hand is to get the uniformities by which we live and move and have our being, from generation to generation, out of chance combinations when increased to infinite orders of the powers of infinity.[3] If a person denies design in the order and uniformity that reigns about him, and which he makes the basis of all his action, it is hardly worth while to reason with him, as Paley condescends to do, about the design manifest in a watch. Such condescension well merits the charge of being a leap from the sublime to the ridiculous. The uncertainties in science do not pertain to the question whether there is a design in nature, but to the very different question, How far is that design capable of interpretation by us, as to its ultimate and practical ends? A pure atheist is a rare product; and it is not strange that some — the Psalmist among them — question whether any who suppose themselves such are of a sound mind.

V. Hypothesis as an Organ of Induction.

Nothing is more interesting, and few things more startling, in these volumes, than the remarks which contrast the Baconian philosophy with that exemplified in the investigations of Newton. Our author — and we think with much reason — rates the Baconian method as very low, when compared with the Newtonian. The interpretation of nature is beset with difficulties analogous to those which attend the understanding of the verbal revelation of the Bible. Mere grammarians

[1] Vol. i. p. 221. [2] See p. 222. [3] See below p. 552.

and compilers of texts are not safe guides in the exposition of scripture, as the absurdities of many millennarians demonstrate. A true exegete must have, with his grammatical knowledge, a philosophical mind, which unifies and weighs the disconnected passages. The concordance and the multiplication table are not the only outfit which a student of the inspired record needs. Much that is said, in the following extracts, concerning the methods of the representatives of modern scientific thought applies also to the methods which are in vogue regarding the study of the Bible.

The question in exegesis is: How far shall the systematic theologian introduce what he knows from other sources of the general nature of the subject treated of, to modify and explain the particular passage under consideration? The present tendency in scientific investigation is exactly the reverse of that in biblical interpretation. Newton, Faraday, and Darwin, who represent the present predominant scientific tendency, insist on the right of rising above the mere enumeration of phenomena, and of giving superior weight to analogy, and of allowing — often without knowing it — enlarged views concerning questions of final causes to direct their investigations. That is, scientists are really turning themselves into metaphysicians and theologians, for what is called the positive philosophy has had its day; while there is a strange disinclination to the introduction of metaphysics into the pulpit, and a jealousy of the prominence which systematic theology has had in our methods of theological instruction. But to our extracts:

"Francis Bacon contributed to spread abroad the hurtful notion that to advance science we must begin by accumulating facts, and then draw from them, by a process of patient digestion, successive laws of higher and higher generality. In protesting against the false method of the scholastic logicians, he exaggerated a partially true philosophy until it became almost as false as that which preceded it. His notion of scientific method was that of a kind of scientific book-keeping. Facts were to be indiscriminately gathered from every source, and posted in a kind of ledger, from which would emerge, in time, a clear balance of truth. It is difficult to imagine a less likely way of arriving at great discoveries."[1]

[1] Vol. ii. p. 220.

"Newton did not less [than Bacon] found his method on experience; but he seized the true method of treating it, and applied it with a power and success never since equalled. It is wholly a mistake to say that modern science is the result of the Baconian philosophy; it is the Newtonian philosophy and the Newtonian method which have led to all the great triumphs of physical science; and I repeat that the 'Principia' forms the true 'Novum Organum.'"[1]

The importance of having a clew or a hypothesis to direct our observations, and at the same time a body of facts to correct our speculations, is illustrated in the experience of our leading investigators.

"As Faraday himself said, 'The world little knows how many of the thoughts and theories which have passed through the mind of a 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, the hopes, the wishes, the preliminary conclusions have been realized."[2]

Experiments at St. Helena showed that there was a tide in the atmosphere affecting the barometer, on the average, .00365, and even varying, according as the moon was farther or nearer from the earth, to the extent of .00056. Our author remarks upon this:

"It is quite evident that such minute effects could never be discovered in a purely empirical manner. Having no information but the series of observations before us, we could have no clew as to the mode of grouping them which would give so small a difference. In applying this method of means in an extensive manner, we must generally, then, have *a priori* knowledge as to the periods at which a cause will act in one direction or the other."[3]

It will be well to recall, in this connection, the famous but somewhat inconsistent passage from Sir William Hamilton upon the same general subject:

"This parital or one-sided cultivation is exemplified in three different phases. The first of these is shown in the exclusive cultivation of the powers of observation, to the neglect of the higher faculties of the understanding. Of this type are your men of physical science. In this department of knowledge there is chiefly demanded a patient habit of attention to details in order to detect phenomena; and, these discovered, their

[1] Vol. ii. pp. 228, 229. [2] p. 223. [3] Vol. i. p. 427.

generalization is usually so easy that there is little exercise afforded to the higher energies of judgment and reasoning. [?] It was Bacon's boast that induction, as applied to nature, would equalize all talents, level the aristocracy of genius, accomplish marvels by co-operation and method, and leave little to be done by the force of individual intellects. This boast has been fulfilled. [?] Science has by the inductive process been brought down to minds who previously would have been incompetent for its cultivation, and physical knowledge now usefully occupies many who would otherwise have been without any rational pursuit."[1]

More recently, Professor J. W. Dawson sounds the alarm with reference to his chosen field of study.

"Geology as a science is at present in a peculiar and somewhat exceptional state. Under the influence of a few men of commanding genius belonging to the generation now passing away, it has made so gigantic conquests that its armies have broken up into bands of specialists, little better than scientific banditti, liable to be beaten in detail, and prone to commit outrages on common sense and good taste, which bring their otherwise good cause into disrepute. The leaders of these bands are many of them good soldiers, but few of them fitted to be general officers, and none of them able to reunite our scattered detachments. We need larger minds, of broader culture and wider sympathies, to organize and rule the lands which we have subdued, and to lead on to further conquests."[2]

VI. Mysteries of Science.

It is not theology alone which imposes mysteries upon our belief.

"There is nothing intrinsically absurd, except that which proves contrary to logic and experience. The truest theories involve suppositions which are most inconceivable, and no limit can really be placed to the freedom of framing hypotheses. Kepler is an extraordinary instance to this effect."[3] "The smallness of the quantities which we can now observe, is often very astonishing. A balance will weigh to one millionth part of the load or less. Sir Joseph Whitworth can measure to the one millionth part of an inch. A rise in temperature of the 8800th part of a degree centigrade has been observed by Dr. Joule. The spectroscope can reveal the presence of the 180,000,000th part of a grain of soda, and the sense of smell can probably feel the presence of a far less quantity of odorous matter."[4]

"Provided there be no clear and absolute conflict with known laws of nature, there is nothing so improbable, or apparently inconceivable, that

[1] Hamilton's Logic, Lecture xxx., conclusion.
[2] Dawson's Story of the Earth and Man, p. 312.
[3] Vol. ii. p. 222.
[4] Vol. ii. p. 47.

it may not be rendered highly probable, or even approximately certain, by a sufficient number of concordances. In fact the two best founded and most conspicuously successful theories in the whole range of physical science involve the most absurd suppositions. Gravity is a force which appears to act between bodies through vacuous space: it is in positive contradiction to the old dictum that nothing could act but through some intervening medium or substance. It is even more puzzling that the force acts in perfect indifference to all intervening obstacles..... The undulatory theory of light presents almost equal difficulties of conception. We are asked by physical philosophers to give up all our ordinary prepossessions, and believe that the interstellar space which seemed so empty, is not empty at all, but filled with *something* immensely more solid and elastic than steel. As Dr. Young, himself, remarked: 'The luminiferous ether, pervading all space, and penetrating almost all substances, is not only highly elastic, but absolutely solid!!!' Sir John Herschel has calculated the amount of force which may be supposed, according to the undulatory theory of light, to be exerted at each point in space, and finds it to be 1,148,000,000,000 times the elastic force of ordinary air at the earth's surface, so that the pressure of the ether upon a square mile of surface, must be about 17,000,000,000,000 pounds. Yet we live and move without appreciable resistance through this medium indefinitely harder and more elastic than adamant. All our ordinary notions must be laid aside in contemplating such an hypothesis; yet they are no more than the observed phenomena of light and heat force us to accept."[1]

VII. No Necessary Antagonism between Science and Theology.

"There are scientific men who assert that the interposition of providence is impossible, and prayer an absurdity, because the laws of nature are proved to be invariable. Inferences are drawn not so much from particular sciences as from the logical foundations of science itself, to negative the impulses and hopes of men. Now I may properly venture to state that my own studies in logic lead me to call in question all such negative inferences. Those so-called laws of nature are uniformities, observed to exist in the action of certain material agents, but it is logically impossible to show that all other agents must behave as these do. The too exclusive study of particular branches of physical science seems, in some cases, to generate an over-confident and dogmatic spirit. Rejoicing in the success with which a few groups of facts are brought beneath the apparent sway of laws, the investigator hastily assumes that he is close upon the ultimate springs of being. A particle of gelatinous matter is found to obey the ordinary laws of chemistry; yet it moves and lives. The world is therefore asked to believe that chemistry can resolve the mysteries of existence."[2]

[1] Vol. ii. pp. 144, 145.

[2] Vol. ii. p. 429.

"A law of nature, as I regard the meaning of the expression, is not a uniformity which must be obeyed by all objects, but merely a uniformity which is, as a matter of fact, obeyed by those objects which have come beneath our observation. There is nothing whatever incompatible with logic in the discovery of objects which should prove exceptions to any law of nature."[1] "I demur to the assumption that there is any necessary truth even in such fundamental laws of nature as the indestructibility of matter, the conservation of force, or the laws of motion."[2]

"Let us assume, for a time at least, as a highly probable hypothesis, that whatever is to happen must be the outcome of what is; there then arises the question, What is? Now our knowledge of what exists must ever remain imperfect and fallible in two respects: First, we do not know all the matter that has been created, nor the exact manner in which it has been distributed through space. Secondly, assuming that we had that knowledge, we should still be wanting in a perfect knowledge of the way in which the particles of matter will act upon each other..... To assume, then, that scientific method can take everything within its cold embrace of uniformity, is to imply that the Creator cannot outstrip the intelligence of his creatures, and that the existing universe is not infinite in extent and complexity,—an assumption for which I can see no logical basis whatever."[3]

"The original conformation of the material universe, was, so far as we can possibly tell, free from all restriction. There was unlimited space in which to frame it, and an unlimited number of material particles, each of which could be placed in any one of an infinite number of different positions..... The problem of creation was, then, what mathematicians would call an indeterminate problem, and it was indeterminate in an infinitely infinite number of ways..... Out of infinitely infinite choices, which were open to the Creator, that one choice must have been made which has yielded the universe as it now exists."[4]

"Life altogether is an exception to the simple phenomena of mineral substances, not in the sense of disproving those laws, but in that of superadding forces of new and inexplicable character. Doubtless no law of chemistry is broken by the action of the nervous cells, and no law of physics by the pulses of the nervous fibres, but something requires to be added to our sciences in order that we even explain these subtile phenomena."[5]

"It is a mere assumption that the uniformity of nature involves the unaltered existence of our own globe. There is no kind of catastrophe which is too great or too sudden to be theoretically consistent with the reign of law. For all that our sciences can tell, human history may be closed in the next instant of time. The world may be dashed to pieces against some intruding body; it may be involved in a nebulous atmosphere

[1] Vol. ii. p. 430. [2] p. 431. [3] p. 432. [4] pp. 434, 435. [5] p. 436.

of hydrogen to be exploded a few seconds afterwards; it may be scorched up or dissipated into vapor by some great explosion in the sun; there might even be within the globe itself some secret cause of disruption, which only needs time for its manifestation."[1]

"I am inclined to find fault with mathematical writers, because they often exult in what they can accomplish, but omit to point out that what they do is but an indefinitely, nay, an infinitely, small part of what might be done..... This may be excusable so far as the immediate practical result of their researches is in question; but the custom has the effect of misleading the general public into the fallacious notion that mathematics is a perfect science, which accomplishes what it undertakes in a complete manner. On the contrary, it may be said that if a mathematical problem were selected by pure chance out of the whole variety which might be proposed, the probability is infinitely slight that a human mathematician could solve it."[2]

"After two centuries of continuous labor, the most gifted men have succeeded in calculating the mutual effects of three bodies each upon the other, under the simple hypothesis of the law of gravity. Concerning these calculations we must farther remember that they are purely approximate, and that the methods would not apply where four or more bodies are acting, and all produce considerable effects each upon the other. There is every reason to believe that each constituent of a chemical atom must go through an orbit in the millionth part of the twinkling of an eye, in which it successively or simultaneously is under the influence of many other constituents, or possibly comes into collision with them. It is, I apprehend, no exaggeration to say that mathematicians have scarcely a notion of the way in which they could successfully attack so difficult a problem of forces and motions."[3]

"If we are to apply scientific method to morals, we must have a calculus of moral effects, a kind of physical astronomy, investigating the mutual perturbations of individuals. But as astronomers have not yet fully solved the problem of three gravitating bodies, when shall we have a solution of three moral bodies?"[4]

"A science of history, in the true sense of the term, is an absurd notion. A nation is not a mere sum of individuals whom we can treat by the method of averages; it is an organic whole, held together by ties of infinite complexity. Each individual acts and reacts upon his own smaller or greater circle of friends; and those who acquire a public position, exert an influence on much larger sections of the nation. There will always be a few great leaders of exceptional genius or opportunities, the unaccountable phases of whose opinions and inclinations sway the whole body, even when they are least aware of it. From time to time arise critical positions, battles,

[1] Vol. ii. p. 443. [2] p. 451. [3] p. 453. [4] p. 458.

delicate negotiations, internal disturbances, in which the slightest incidents may profoundly change the course of history. A rainy day may hinder a forced march, and change the course of a campaign; a few injudicious words in a despatch may irritate the national pride; the accidental discharge of a gun may precipitate a collision, the effects of which will last for centuries."[1]

"Theologians have dreaded the establishment of the theories of Darwin and Spencer, as if they thought that those theories could explain everything upon the purest mechanical and material principles, and exclude all notions of design. They do not see that those theories have opened up more questions than they have closed. The doctrine of evolution gives a complete explanation of no single living form. While showing the general principles which prevail in the variation of living creatures, it only points out the infinite complexity of the causes and circumstances which have led to the present state of things. Any one of Mr. Darwin's books, admirable though they all are, consists but in the setting forth of a multitude of indeterminate problems. He proves, in the most beautiful manner, that each flower of an orchid is adapted to some insect which frequents and fertilizes it; and these adaptations are but a few cases of those immensely numerous ones which have occurred throughout the life of plants and animals. But why orchids should have been formed so differently from other plants; why anything, indeed, should be as it is, rather than in some of the other infinitely numerous possible modes of existence, he can never show. The origin of everything that exists is wrapped up in the past history of the universe. At some one or more points in past time there must have been arbitrary determinations which led to the production of things as they are."[2]

"My purpose [in this concluding chapter] is the purely negative one of showing that atheism and materialism are no necessary results of scientific method. ..... I draw one distinct conclusion that we cannot disprove the possibility of Divine interference in the course of nature."[3]

"The same power which created material nature, might, so far as I can see, create additions to it, or annihilate portions which do exist. Such events are doubtless inconceivable to us in a certain sense; yet they are no more inconceivable than the existence of the world as it is. The indestructibility of matter, and the conservation of energy, are very probable scientific hypotheses; ..... but it would be a gross misconception of scientific inference to suppose that they are certain in the sense that a proposition in geometry is certain, or that any fact of direct consciousness is certain in itself. Philosophers, no doubt, hold that *de nihilo nihil fit;* that is to say, their senses give them no means of imaging to the mind how creation can take place. But we are on the horns of a trilemma; we must either deny that anything exists, or we must allow that it was created out of nothing, at

[1] Vol. ii. p. 459. [2] p. 463. [3] p. 465.

some determinate date, or that it existed from past eternity. The first alternative is absurd; the other two seem to me equally conceivable."[1]

"Go on as far as we will in the sub-division of continuous quantity, yet we never get down to the absolute point. Thus scientific method leads us to the inevitable conception of an infinite series of successive orders of infinitely small quantities. If so, there is nothing impossible in the existence of a myriad universes within the compass of a needle's point, each with its stellar systems, and its suns and planets, in number and variety unlimited. Science does nothing to reduce the number of strange things that we may believe. When fairly pursued it makes large drafts upon our powers of comprehension and belief."[2]

"Science will not deny the existence of things because they cannot be weighed and measured. It will rather lead us to believe that the wonders and subtilties of possible existence surpass all that our mental powers allow us clearly to perceive. The study of abstract logical and mathematical forms has seemed to convince me that even space itself, is no requisite condition of conceivable existence. Everything, we are told by materialists, must be here or there, nearer or farther, before or after. I deny this — and point to logical relations as my proof..... So far am I from accepting Kant's doctrine, that space is a necessary form of thought, that I regard it as an accident, and an impediment to pure logical reasoning. Material existences must exist in space, no doubt; but intellectual existences may be neither in space nor out of space; they may have no relation to space at all, just as space itself has no relation to time. For all that I can see, then, there may be intellectual existences to which both time and space are nullities."

"Now among the most unquestionable rules of scientific method is that first law, that whatever phenomenon is, is. We must ignore no existence whatever; we may variously interpret or explain its meaning and origin; but if a phenomenon does exist, it demands some kind of explanation. If, then, there is to be a competition for scientific recognition, the world without us must yield to the undoubted existence of the spirit within. Our own hopes and wishes and determinations are the most undoubted phenomena within the sphere of consciousness. If men do act, feel, and live as if they were not merely the brief products of a casual conjunction of atoms, but the instruments of a far-reaching purpose, are we to record all other phenomena and pass over these? We investigate the instincts of the ant and the bee and the beaver, and discover that they are led by an inscrutable agency to work towards a distant purpose. Let us be faithful to our scientific method and investigate, also, those instincts of the human mind, by which man is led to work as if the approval of a Higher Being were the aim of life."[3]

[1] Vol. ii. p. 466. [2] p. 467. [3] pp. 468–470.