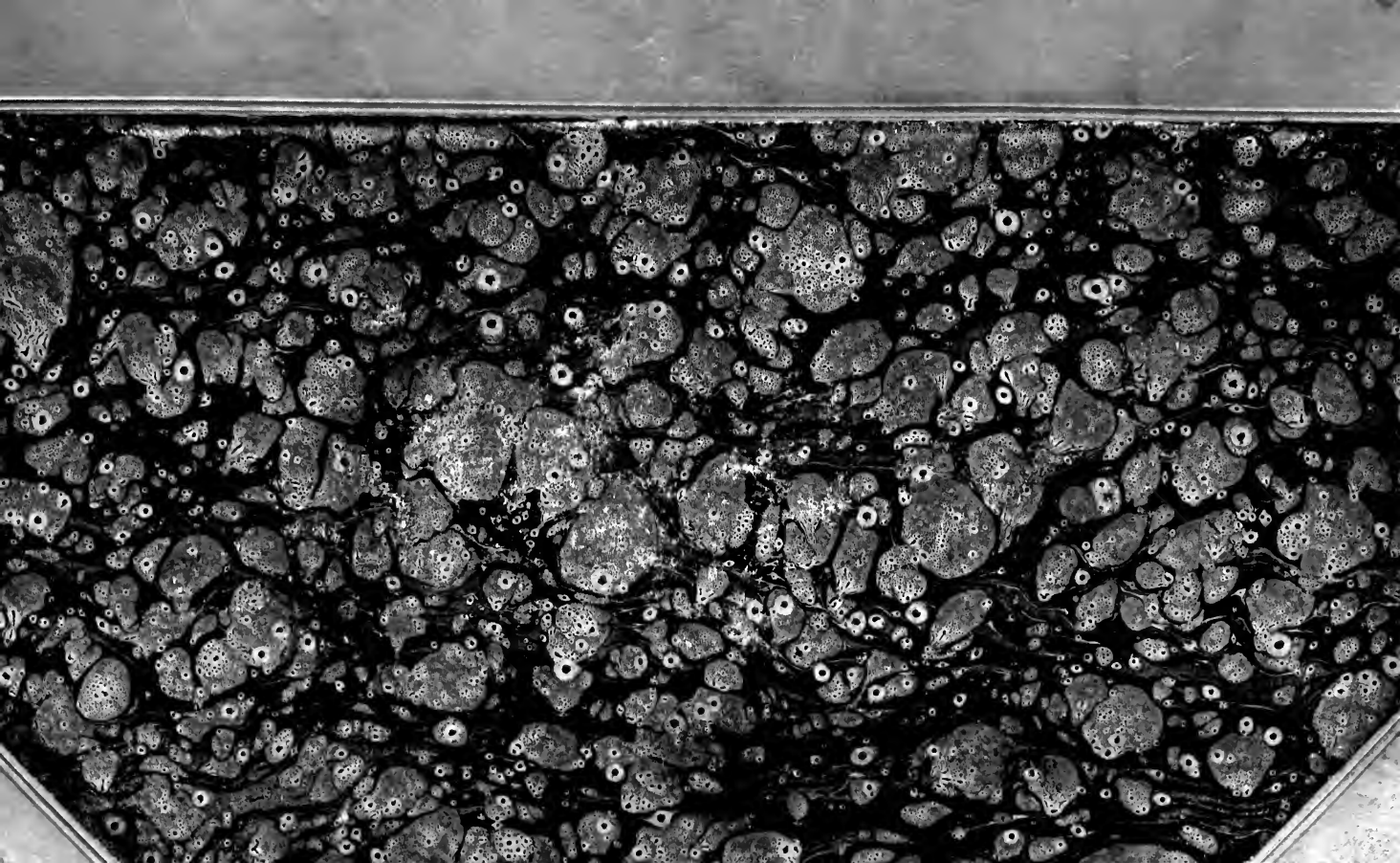

TWO PAPERS.

I.

On the Relation between Science and Religion, through the principles of Unity, Order, and Causation.

By the Right Reverend BISHOP COTTERILL, D.D., F.R.S.E., *Edinburgh.*

II.

On the Bearings of the Study of Natural Science, and of the Contemplation of the Discoveries to which that study leads, on our Religious Ideas.

By G. G. STOKES, Esq., M.A., D.C.L., F.R.S., *Lucasian Professor of Mathematics at Cambridge University.*

READ IN 1880

BEFORE THE VICTORIA INSTITUTE, OR PHILOSOPHICAL SOCIETY OF GREAT BRITAIN.

WITH SPECIAL APPENDIX.

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PREFACE.

Owing to the increasingly wide circulation given to certain writings of Herbert Spencer, Matthew Arnold, and others whose works have an analogous tendency, including the publications of the Secularists,* the Institute has decided to issue a People's Edition of the following Papers.

As all are aware,

The author of the first Paper is known as being one of the most powerful, deep thinkers upon Philosophical questions, and with Metaphysicians he takes his place in the first rank.

The author of the other Paper is a leader in the Scientific world and second to none among English Physical Science Men.

F. PETRIE, *Hon. Sec.*

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* At a recent Council meeting communications were read from members in India and the Colonies showing that Mr. Bradlaugh and the London secularist societies are actively supplying those places with pseudo-philosophical and quasi-scientific literature intended to promote scepticism in regard to the Christian Religion (Translations of such papers into the dialects of India are also circulated now), and that the Colonial press is being used with a similar purpose (The writers allude to the effects being already apparent.) Letters were also read showing that, with the view of meeting the evil, many greatly desired that the People's Editions of the Institute papers should be as widely circulated, lists of colonial booksellers being forwarded by some correspondents with a view to aiding the Council in placing the People's Edition within reach of colonists. (English, American, and Colonial correspondents assign as a reason for this, that they find in the papers of the Institute a careful examination of those questions or theories of Philosophy and Science which are said to militate against the truth of Revelation, and which questions are used against it by its active and unscrupulous enemies.)

New People's Editions.

On the Nature of Life. By H. A. Nicholson, M D., F.R.S.E., Professor of Natural History at St. Andrew's University. 6*d.*

On the Data of Ethics A Reply to Herbert Spencer's new Work). By Professor Wace, M.A. 6*d.*

(*The cordial welcome given to Professor Lias' Paper on "Matthew Arnold and Modern Culture" seems to warrant a further issue thereof.*)

Victoria Institute,
7, Adelphi Terrace,
W.C.

ON THE RELATION BETWEEN SCIENCE AND RELIGION THROUGH THE PRINCIPLES OF UNITY, ORDER, AND CAUSATION. By the Right Rev. Bishop Cotterill, D.D., F.R.S.E.

My Lords and Gentlemen,*

I WILL not venture to question the judgment of the Council of your Society when from time to time they invite others of its members, besides those whose time is largely devoted to scientific pursuits, to deliver its annual address. Yet when they claim, as they justly may, the co-operation of those of us who cannot presume to speak with authority on any special

* Delivered as an Annual Address.

branch of science, you will not expect from us the kind of aid which is so effectually rendered by the eminent scientific men who take a large part in the work of your Institute; you will allow us to speak from our own point of view, and of those aspects of the question of the Relations between Religion and Science with which our minds are most familiar.

In addressing you, therefore, on the present occasion I do not propose to undertake that, which perhaps is the proper duty of one selected to deliver this address, *i.e.* to bring before you the present state of the great question, commenting on the latest discoveries or speculations which directly or indirectly may seem to affect it. I will assume that I shall be allowed to take a somewhat different, and in one sense a wider scope, and to discuss some fundamental principles, which have in my judgment a very important bearing on the purposes for which this Institute is founded.

1. In a paper which I had the honour of reading before your Society two years ago, I examined the Relations between Scientific Thought and Religious Belief in one particular direction. It appeared to me, that in pursuing one of the primary objects of this Institute,—I mean, investigating scientific questions "with the view of reconciling any apparent discrepancies between Christianity and Science,"—a preliminary question ought never to be overlooked; viz., what ground there is for the "popular notions as to the authority of scientific thought, and its right to control and dictate to the intellect." For, in discussing these apparent discrepancies, whatever they may be, there is some danger, if not of ourselves supposing, yet of allowing others to suppose, that if we fail in discovering the true solutions, we have to choose between Faith and Reason, and balance, one against the other, the realities of a spiritual world, and those of the world of Nature which is no less truly God's. I therefore thought it necessary to point out, that the claim, too often tacitly implied, if not expressly asserted, that Science is a tribunal before which Religion is on its trial, whether it is or is not in accordance with Reason, is wholly untenable; and that neither on the plea of being the teacher of necessary truth, nor on that of establishing any principle contradictory of the Divine Will in the Universe, is Science at all competent to interfere with Religious Belief. Since that time a work has appeared,* in which the author has investigated, with singular acuteness

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* "A Defence of Philosophic Doubt: being an Essay on the Foundations of Belief." By Arthur James Balfour, M.A., M.P. London. 1879.

and power, those claims on the part of Science which I then challenged. Although his line of argument is different from mine,—for he has discussed fully and with much skill the philosophical aspects of the question,—and though on some points his reasoning seems to me not conclusive, yet the practical results of Mr. Balfour's argument so entirely coincide with those which I urged as essential to truth, that, as my subject to-day is cognate to that which I then discussed, I will first confirm the conclusions of that paper by a brief quotation from this work of an original and independent thinker.

2. Having observed that many believers in Religion, however widely they differ practically from unbelievers, yet agree with them "in thinking that no more certain warrant for a creed can be found than the fact that Science supports it; no more fatal objection to one than the fact that science contradicts it"; the result being "that it seems to be assumed that the logical relation which subsists between the doctrines of actual Science and of actual Religion is a fact of transcendent theological importance," he continues * (pp. 302, 303) :—

"I might insist on the evil done by such a state of things, both to religion and to science, but at this moment I wish rather to enter my protest against the principle from which the evil itself ultimately springs. Has Science any claim to be thus set up as the standard of belief? Is there any ground whatever for regarding conformity with scientific teaching as an essential condition of truth, and nonconformity with it as an unanswerable proof of error? If there is, it cannot be drawn from the nature of the scientific system itself. We have seen in the preceding pages how a close examination of its philosophic structure reveals the existence of every possible philosophical defect. We have seen that whether Science be regarded from the point of view of its premises, its inferences, or the general relation of its parts, it is found defective; and we have seen that the ordinary proofs which philosophers and men of science have thought fit to give of its doctrines are not only inconsistent, but are such as would convince nobody who did not start (as, however, we all do start) with an implicit and indestructible confidence in the truth of that which had to be proved. I am far from complaining of the confidence. I share it. My complaint rather is that of two creeds [the religious and the scientific] which *from a philosophical point of view*† stand, so far as I can judge, upon a perfect equality, one should be set up as a standard to which the other must necessarily conform."

3. That until the principles here asserted are recognised as the basis of the mutual relations of Religion and Science, the work of reconciling their apparent discrepancies will be both endless and unprofitable, I have no doubt whatever. We, on the Christian side, not only admit, but earnestly maintain, that while the creed of Religion is consistent with Reason, yet

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* "A Defence of Philosophic Doubt," &c. † The italics are mine.

it could not be constructed by Reason, and it requires in us a higher faculty, viz., that faith which is "the substance of things hoped for, the evidence of things not seen," to supplement human reason and make the foundations of Religion in our own minds secure. We contend that, on the other hand, Science is in a similar position; that to construct its creed Reason needs to be supplemented by much that is not strictly logical, by a scientific "instinct," an unreasoning and certainly not infallible intuition, which some men possess in a far higher degree than others, and the necessity for which leaves the world in general much more dependent on authority for their scientific belief than men ever are, or have been, in Religion, wherever they have access to Holy Scripture. For there neither is, nor can be, any standard and guide for the scientific intuition, such as the Bible supplies for faith.

4. It is not my purpose, however, to-day to discuss further this aspect of the Relations between Religion and Science. I have referred to it only to clear the way for another view of these Relations. The objects of this Society have indeed a wider scope than any in which Science and Christianity are regarded as at variance or even divergent. Both are God's gifts, and are intended to be, in different spheres of man's being, means for raising him above the region of mere sense, and educating him for this life and that which is to come. To prove that there is no conflict between them is doubtless necessary; for God is One, and all that proceeds from Him must be in harmony. But for the same reason that assures us that true Science and true Religion cannot be at variance, it also follows that they must have some correlation or correspondency. So far as their various creeds are sustained by Reason, they have more or less common ground, and we might naturally expect that they would be found to sustain each other. It will, I trust, be neither uninteresting nor unprofitable for the purposes of our Institute to examine with some care—so far as my limits will allow—the fundamental principles of this correlation.

5. I shall, perhaps, best explain the question before us by referring to that classification of the several spheres of human thought which in my previous paper I adopted from Fichte, and which is, at all events, sufficiently distinct and comprehensive for our present purpose. In this analysis, the first and lowest mode of regarding the universe is that of *sense;* we may consider (on some accounts at least) the *scientific* view as next in order; in that which we called the *poetic* or *spiritual* mode, the mind looks through nature to unseen ideals of goodness and beauty; the *religious* view sees God in all, and

regards the whole universe as of God, and in God, and for God, while the highest of all, which we called the *theosophic*, can only be attained through Revelation, and is the completion and fulfilment of the *religious*, through the knowledge of the true relations of the universe to God, and of God to the universe in the Incarnate Word Jesus Christ. When I speak to-day of Religion, I include in this the latter sphere of thought, for the one is not complete without the other.

In regard to all these distinctions, I pointed out that, "although each higher sphere of thought contains nothing contradictory to those which precede it in order, yet the ideas of the lower do not of themselves direct us to the higher, but they may, in some cases, even seem to be opposed to it;" "some new power is required in order to pass from one phase or sphere of thought to the higher." But it is equally important to observe that, although the lower mode of thought seems at times a hindrance rather than a help to attaining the conceptions required for the higher, yet it may be, nevertheless, essential to those conceptions, and of great value in their development. Although the acutest perception of the objects of sense is consistent with the absence of all conception of law in nature, and, indeed, what has been called the "crude realism" of the *sense* view of nature often seems at variance with the scientific, and creates prejudices which Science only gradually dispels, yet not only is physical science itself dependent on the trustworthiness of the senses, so far as their powers extend, but it is largely aided by them throughout its whole extent, its conclusions being either derived from, or verified by, the accurate observation of sensible objects. On the other hand, although the conclusions which Science draws from the evidence of the senses may differ widely from those conceptions which belong to the *sense* mode of thought, which confounds subjective perceptions with objective realities, yet it is the very trustworthiness of the evidence which the senses afford that enables Science to correct the conclusions which the senses suggest.* The relation again which exists between the scientific view and the poetic is sufficiently obvious, though it indicates, as indeed the history of man proves, that in order of development the poetic precedes the scientific. For while it does not require Science or law for its own ideas, it seems doubtful if any scientific conception could be formed without the aid of the imagination, which is the active faculty

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* Mr. Balfour, in his chapter on "Science as a Logical System," appears to me to have discussed the question to which I here refer somewhat illogically.

in the poetic mode. Indeed, the subject of the use and abuse of the imagination in Science is one which might be discussed with almost as much profit as that of its use and abuse in Religion. For the substitution of the imagination for the scientific intuition has been the cause of almost as many superstitions in Science as ever have obscured Religion. And it might be easily shown that it is to scientific superstitions on the one side, or to religious superstitions on the other, that the apparent discrepancies between Science and Religion are mainly due. For example, materialism in all its forms is nothing else than a superstition, due to the imagination attributing to matter properties and qualities which Science itself contradicts.

6. Enough, however, has been said to explain the question at issue; that is, what connection there is between the scientific and the religious view of the universe. My argument to-day must be limited to one aspect of this very large question, which, perhaps, has not received sufficient consideration. It may be thus stated. *The principles which Science is compelled to postulate, without which it could have no existence, which it therefore seeks to trace in Nature, and which, though it never can prove them to be universally true, yet so far as its powers extend it does verify, are common to Science and Religion. Of these principles Religion supplies the only rational and adequate basis; indeed, the only basis that is not contradictory of Science.*

It is obvious that for this argument it will be necessary to consider carefully, and somewhat in detail, what the scientific view of the universe actually is; and, rapid and imperfect as our survey must be, it must be comprehensive in its range.

7. Science, as distinguished from such knowledge as we receive either from the immediate perceptions of the senses, or from intuitive cognitions, may be defined as the knowledge of the relations of natural existences or phenomena. Without admitting that all human knowledge is relative, we must allow that scientific knowledge is by its very nature so limited. It has been formed by observing the common elements in the different phenomena of the universe, and so tracing unity in the diversity of Nature, the One in the Many. And practically, as the actual outcome of such investigations, the scientific mode of regarding the universe means a view of its existences and phenomena, not as isolated objects, but as belonging to a universal order; that order being twofold,—first, the *contemporaneous*, or that in which time is not a factor; and, secondly, the *consecutive*, or the order of succession in time of natural phenomena. We cannot always treat of these two forms of

order separately, for they are intimately connected; yet it is important to observe the distinction. It is in the consecutive order, in which time is a factor, that Science attains its highest sphere, viz., that knowledge of phenomena as sequences of cause and effect which enables us to infer, by the process of deduction, particular results from general laws. But throughout the whole range of Science the three following principles will be found to be always postulated,—Unity, Order, and Causation; and these, not as separate principles independent of each other, but the order is assumed to be the expression and manifestation of unity by means of causation, which itself proceeds from the unity, and, so far as it is the subject of exact Science, is identical with continuity.

8. (I.) The simplest form of Science, it is evident, consists in that recognition of common elements in diverse objects which enables us to classify these objects. And we must observe that even in this very first step in Science, in which law means nothing more than the order of contemporaneous existences, unity must be assumed, before we can assure ourselves that Science is possible. For without unity all knowledge is fragmentary, and order, which is the expression of the relations of the different existences to one another and to the whole, could never be investigated. The order also, which is required to be available for scientific knowledge, must be fixed and determinate in such a sense that its variations will be according to order, and not irregular or promiscuous.

But it is important to observe what is implied in the order which Science recognises in the universe. It involves the idea implied in the Greek word κόσμος, that is, the suitable arrangement and adaptation of the different parts of the whole. Without discussing the somewhat difficult question of scientific classification, it is sufficient to say that the order demanded by Science implies a whole so divided and subdivided, with relations between the several parts, that in a complete scientific scheme the exact position of any particular object may be determined with certainty; and any such scheme is truly scientific in proportion as the order is not artificial and technical, but conformable with that which Nature itself indicates. For it must be observed that the order of Nature does not consist of a series of existences differing from one another by imperceptible degrees. Such a universe is quite conceivable, but in it Science would have no place, because natural classification would be impossible. In the universe as it is, while the number of those existences, the differences between which are accidental to the individual, is indefinite, yet the number of different classes of such identities is finite, and the

differences between these classes, instead of being infinitesimal, are sufficient distinctly to separate one class from another. To apply the terms of Evolution to the contemporaneous order of Nature, Science proceeds on the assumption that there is a limited number of integrations in Nature; and the office of Science is to determine these integrations with exactness. For example, while the material constituents of this earth and its surroundings are readily recognised even by the senses as different from one another; yet this order, as observed unscientifically, is more or less confused. It belongs to Science to classify them as distinct integrations, and to exhibit each of them as possessing its distinctive character and properties. Chemistry, which investigates the composition of these several constituents, throws further light on the order in the unity of the visible universe, by proving that everything material is composed of a small number out of some sixty or seventy elements, of which many are of rare occurrence, while some may be traced in other worlds than our own; and not only is each of these elements itself a definite existence, distinct from every other,—a separate integration,—but the substances which are chemical combinations of these elements have the same character, being not uncertain or irregular mixtures, but combinations in definite and fixed proportions. There is no confusion, such as must have been the result of chance, nor yet is there, except in the case of crystallization, that symmetrical or geometrical regularity, which might seem to indicate that mechanical law could have determined the arrangements. Scientific thought, indeed, which in all directions seeks for unity in Nature, its own sphere, suggests that under different conditions from those that exist at present on this earth all these distinct elements might be reduced to one primary element. It seems not impossible that the progress of spectroscopy may lead to some discoveries as to the relation of the molecules of the different elements that might be sufficient evidence of this. Yet this would not bring us in the least nearer the cause of these integrations in the order of Nature, much less would it enable us to explain the properties of the different elements and their combinations. It is hopelessly beyond the power of Science to determine how the unity, which Science is compelled to postulate and endeavours to trace, can be consistent with an order in which the existences are so very different in their properties from one another. Science demands unity, and demands also causes for the differences; but it finds in this part of Nature nothing to satisfy the two principles. Where (we ask) must we look for a rational basis for both principles? Science cannot help

us here; it leaves a void which clearly compels us to look for a profounder basis for the unity of Nature than any which Nature can itself provide.

9. The view which Science exhibits in inorganic nature of distinct integrations in its order is illustrated also in living existences; and first of all in the distinctness of these from all other existences. The phenomena which are characteristic of living matter (I use the words of Professor Huxley) are strongly marked off from all other phenomena.* Certain properties distinguish it *absolutely* from all other kinds of matter; "our present stock of knowledge furnishing no kind of link between that which is living and that which is not." These properties are,—first, the chemical constitution of living matter, as it invariably contains a particular compound of carbon, water, and nitrogen, only found in organic matter, which is the chief constituent of the "protoplasm" of which the organism is constructed. The second distinctive property of living matter is its universal disintegration and waste by oxidation, and its re-integration, not by external accretion, as a crystal increases in size, but by introsusception of fresh and suitable material. The third property is its tendency to undergo cyclical changes; each individual form, when it has passed through these changes, ceasing to possess the properties of living matter, though continuing and multiplying its existence by its seed or other portions of itself, which, in their turn, all undergo the same cycle of changes. No other form of matter whatever (I still quote from Professor Huxley) exhibits these properties, or any approach to the remarkable phenomena of the two last properties. Living matter has indeed other properties peculiar to itself, though not so distinctly marked. Its activities depend more or less on moisture and heat. Complete desiccation is fatal to living matter, as are also extremes of temperature. Besides these, organisation, or the possession of special instruments for special purposes, is usually characteristic of these existences, and is often, even in what we might consider a simple form, exceedingly complicated. And, we may add, in living matter a new idea is introduced into Nature, that of an existence composed of many very different molecules of matter, which yet is one individual.

10. We have, then, here, in the order of the Universe, a class of existences definitely marked off from the rest by the possession of properties, different not only in degree but in

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* *Encyclopædia Britannica.* Ninth edition. *Biology.*—T. H. H.

kind, from those of other material existences. Science, intent as it is on tracing unity, confesses that it can find "no kind of link" between them. Is there, then, a real break in unity because we cannot find continuity in Nature? If we believe in that rational basis of unity beyond Nature which Religion supplies, we shall not wonder that Science cannot trace the continuity here, when continuity cannot be traced even among the constituents of dead matter. The same remark applies to the distinctions between the main divisions in this general class of living existences. The tendency of the scientific mind, whenever it shrinks from recognizing a deeper foundation of the unity and order of the universe than any that Nature can supply, is, in disregard of distinctions which unprejudiced reason recognizes as fundamental, to assume that the vegetable, animal, and human types, are all connected together in a continuous order, and that the apparent gulf between the animal and the vegetable, and the far greater abyss that separates man and the brutes, do not exist. Yet to establish this, it is necessary to neglect indications of a break of continuity which Nature itself suggests,—such as the fact that the animal in all its forms requires nutrition which living organisms alone produce, while the vegetable in all its forms can supply its waste from inorganic matter,—and, further, to argue illogically that because we cannot always distinguish the primary forms of each, therefore distinctions do not exist,—which evolution from a structureless germ contradicts. While the distinctions between the two classes which are more fundamental than those that are merely physical must be neglected for this purpose. The most highly-developed vegetable has no consciousness of its own existence, much less anything resembling intelligence. And if the physical characteristics of man differ less widely from those of the most highly-developed animal than the animal differs from the vegetable; yet reason, with its godlike powers of speech and abstract thought, its apprehension of the beautiful, and its conscience of good and evil, constitutes an essential distinction between the man and the mere animal, to which all the rest of Nature can supply no parallel. Why is Science to be searching for a unity in which these essential differences must be neglected, and violence done to the dictates of reason by denying them? Surely, to the unprejudiced mind, they are in themselves sufficient to prove that the true basis of the unity of that universe in which differences so essential are found, must be sought in Him in whom all things, dead and living, rational or irrational, subsist. A belief in one

living and true God supplies a rational basis: nothing else can.

11. The character of that order of Nature which Science desiderates in the inorganic world is very clearly exhibited in the world of organic existences. Indeed, the classification of these existences in the natural histories of the vegetable and animal kingdoms, if arranged according to the relations and connections of the organization of the several forms beginning from the lowest, illustrates, far more precisely than any definitions could explain, what is the meaning both of the order and of the unity of Nature. Without inquiring at present into the causes of the order, it is obvious that from the simplest forms both of vegetable and of animal life to the highest, Nature exhibits an ascending scale,—not that of an inclined plane, but in distinct steps, and these not running upwards all in one series in the same direction, but branching off in many different directions. The integrations both in vegetable and in animal life are, indeed, by no means so definite as those of the chemical elements and combinations which seem positively to contradict the idea of continuity in Nature itself. Yet that there is not in organic matter a continuous series of intermediate existences connecting the species and genera and higher divisions one with another, and that wide *lacunæ* often are found, are facts which cannot be questioned, however they may be explained.

12. In the contemporaneous order of Nature, animate and inanimate, viewed as a whole, the harmony of the several parts and the adaptation of one to another, have been often noticed as evidences of design; in other words, as proofs of the unity and order of Nature having its basis in one Supernatural and Infinite Reason. As it would be absurd to attribute this harmony and adaptation to chance, the only kind of explanation that can be given of it by those who deny the necessity for a supernatural foundation for the order of Nature, is that one part of Nature has the power of adapting its forms and existences to the conditions of the other. This, of course, still leaves the question untouched, whence this strange power of self-adaptation is derived, for science and self-causation in Nature are contradictory. To this question I must again refer under the head of the consecutive order of the universe. But this theory of self-adaptation, at all events, can only be true within certain limits, and does not touch the general argument from the harmony of the inorganic world with the vegetable, the animal, and the human existences; and of all these one with the other. For example, to all living existences,—at least, so far as we know anything of them, and to reason from ignorance

instead of knowledge is not Science,—it is essential, first, that there should exist in the universe certain chemical elements, and these in particular combinations; secondly, that the temperature should be confined within certain definite limits. "Habit," to use the words of Professor Huxley, "may modify subsidiary, but cannot affect fundamental, conditions." And what cause in Nature itself can Science assign, or imagine with any probability, either for the necessary existence of these particular elements in the universe, or for the extremes of temperature, in any part of the universe, being confined within the limits which make life a possibility? In this earth, though the average temperature were to continue exactly the same, yet, if the maximum and minimum temperatures were altered, the whole world would be a desert.

13. Before proceeding to examine the question of the consecutive order of the universe, it will be necessary to consider a little the meaning of that word *cause*, which I have used more than once with reference to its contemporaneous order. For there is no part of Nature, as regarded by Science, from which the idea of causation can be excluded, although, strictly, it implies a succession of events. And as much confusion of thought is often introduced into this subject of causation, through ambiguity in the use of the word, it will be well to call attention to certain facts in this part of our general subject which may assist in guiding us. The word *cause*, in reference to the phenomena of Nature, for example, is popularly used in more than one sense. Some of these phenomena are, we know, in a greater or less degree, subjective. An image in a looking-glass, and the rainbow as an arch in the sky, are purely subjective forms. They are effects produced on the eye of the beholder in a certain position by light,—in one instance proceeding from a certain object and reflected in the mirror; in the other, proceeding from the sun and reflected in drops of water. In these cases, Science examines and determines the causes of the phenomena; that is, the reasons why they are to us such as they are. The explanation is a geometrical one, and may be represented by a figure. Colour, again, is subjective in a different sense. There is that in Nature (viz., the different lengths of the light undulations) which is the external cause of the sensations of colour, although the sensation itself is purely subjective. Science proceeds a step further in the succession of physical causes by the explanation now generally accepted, viz., that in the retina there are three kinds of nerve-fibres, the excitations of which give respectively the sensations of red, green, and violet; the combinations of these in different proportions pro-

ducing the sensations of every shade of colour. But the cause of the colour sensations being produced by these nerves, or of the union of sensations of red and green (for example) being yellow, science cannot explain. It must be observed that, in every process of causation, there are really three elements,—the antecedent, the consequent, and the *reason of the sequence*. And the causation is completely known only when all three are known. When, as we shall find is the case with physical energies, the consequent is the continuance of the antecedent in another form, the whole causation is explained. But this Science cannot prove to be the case in the transition from a physical impression to a sensation.*

Such considerations lead us to look for some basis of the general idea of causation more comprehensive and more profound than any of the various meanings of the word. We may, I think, confidently assert that there is no idea that can satisfy the mind, or that is sufficient to connect together the various modes of causation, and to underly them all, and give meaning and reality to them all, except that which is implied in *reason*. Science, just so far as it is the exponent of reason, compels us to look to this as the basis of all sequences of cause and effect; and certainly no reason can be an adequate basis for all that there is in Nature, except that which is infinite.

14. Thus far, then, we have traced in the contemporaneous order of the universe the three principles, Unity, Order, and Causation, all of which it is necessary for Science to postulate in its investigations into Nature. There can be no doubt that

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* When we pass from the objective to the subjective, from the *non ego* to the *ego*, sometimes, as in the case of colour, there is no congruity whatever that our minds can discover between the antecedent and the consequent. In the case of form, of which the mind receives knowledge by touch as well as by sight, the case is different. And our reason rebelled, when we were told, as we were told in some unphilosophical books on Optics, that the inverted image on the retina was set on its feet again by the mind correcting the mistake! If that were so, undoubtedly Idealism would be the only possible philosophy. But it is absurd to suppose that there need be such complicated mechanical apparatus to produce an impression of the form corresponding to the object, if the sensation represented something totally different. Again, in regard to sound, we could not conceive it possible that the sensation of a treble note could be produced by a long wave, or that of bass by a rapid vibration. Yet here, again, why a particular form of wave should produce the sensation which recognises what we call the tone or *timbre* of a voice or instrument is only partially explained by saying it is due to the harmonics. In light there seems nothing whatever, in the present state of our knowledge, that would indicate any correspondence between the different colours of the spectrum and the comparative lengths of the light undulations.

these principles are common to Science and Religion; for all Religion begins in the belief in the existence of One almighty, infinitely wise, and omnipresent God, above all, through all, and in all. That the Being of God is an adequate basis for these principles is self-evident, and we have found sufficient proofs that such a basis cannot be discovered in Nature itself; in fact, a basis in Nature would be a contradiction of the very principles which are supposed to be based on it; for Science assumes the order in the unity to be the result of causation. But if anything in Nature could be the basis of causation, it must be itself uncaused. Yet Science assumes, as a principle necessary to itself, that every existence and phenomenon in Nature has a cause. To suppose, for example, that the atoms are self-caused is not only unprovable, but is a contradiction of Science; for if those things of which all Nature is composed have the source of causation in themselves, it cannot be assumed that anything whatever in Nature is the subject of causation.

15. (II.) But all these conclusions will be more clearly illustrated in the examination of the scientific view of the consecutive order of the universe. In this we have to deal with those laws of Nature, as they are called, which represent the order in which certain phenomena or existences follow one another in succession. Here, again, Science is compelled to postulate that there is an order, that events or phenomena do not follow one another promiscuously; and further, that there is a unity in the order, and that both this orderly succession and the variations in it are the result of sequences of cause and effect. Science also assumes a unity in all the apparent diversity of these sequences, and continually searches after a connection between the various causes, the effects of which are subjects of its observation.

The confidence that there is an established order in the universe is the only ground on which empirical laws, which cannot be determined as sequences of cause and effect, can ever have the slightest value in Science. In fact, it is the profound conviction in the human mind of order and unity being fundamental principles in the universe, that produces, in those who have not sufficiently considered or apprehended the equally fundamental principle of causation, too much confidence in empirical laws. Indeed, so deeply rooted is this confidence in the order of the universe, that it is a very common belief in the unscientific mind that a law of Nature, instead of being an order due to causes which, under other conditions, might produce another order, is an independent entity, possessing some power of causation in itself. Of all

the *idola* which have imposed on the understanding of man none is more irrational than this false notion of law. But it is not sufficiently realised, I think, that even in regard to dynamical laws, which rise far above the category of those that are merely empirical, it is necessary for Science to make assumptions which require some basis outside Nature itself. To exhibit this we must briefly examine the history of the development of Science in this direction.

16. The most familiar instance of the progress of Science from empirical laws to dynamical—I mean that which we have in the Science of Astronomy—is also the most instructive. How the unsystematic order of the heavenly bodies observed by ancient Astronomers was by the genius of Copernicus expounded in the true system of the universe; how this system received further exposition by the three phenomenal laws discovered by Kepler; and how these empirical laws were exhibited by Newton as necessary results of a universal law of gravitation, are facts too well known to require more than the briefest notice. The assumption of the very simple law that the force of gravity is proportional to the product of the gravitating masses directly and inversely to the square of the distance between them, enables Science, by a mathematical process, not only to determine the order of the motions of the heavenly bodies, but also the perturbations of that order, and by accurate observations to verify the conclusions; and it has enabled mathematicians not only to explain phenomena already observed, but even to discover the existence, and determine the conditions, of others not yet observed. It is obvious that a general law of this kind has an authority which no merely phenomenal law can possess. Its discovery—or rather, I should say, its application—is a far higher act of human reason; its accuracy may be tested to an almost unlimited extent by the aid of mathematics; and we cannot but accept the law as a part of the established order of the universe which governs a very large class of secondary and phenomenal laws, and the determination of which is thus a long step in the direction of the interpretation of that order. But, observe, one step and nothing more. If gravitation is the cause of many effects in the order of the universe, what is the cause of gravitation? We cannot be surprised that the natural feeling in the scientific mind is that some cause must exist in Nature itself. Newton himself considered that it was impossible for any one "who has in philosophic matters a competent faculty of thinking," to allow the possibility of action at a distance, such as gravity seems to imply. Yet none of the hypotheses, as yet suggested to account for

gravity, except that of Le Sage, has any claim whatever to be a scientific exposition.* However, this only leaves us with a still more difficult question, viz., what can be the cause in Nature of *ultra mundane* corpuscles flying about in all possible directions, in infinite numbers, and with enormous velocity? Sooner or later, it seems, we must get beyond Nature. A hypothesis of all this *ultra mundane* energy, of which only an infinitesimal part affects Nature at all, looks very like a confession of this truth.

17. However, there is a more fundamental question still, to which I must briefly refer. It is well known that all the mathematical investigations, by which from Newton's time the results of the law of gravitation have been determined, are founded on three Laws of Motion, as they are called. What are these? Are they self-evident axioms which reason cannot question without self-contradiction? or are they assumptions necessary to Science, which it verifies, so far as it is able, within the limited range of our experience, from the agreement with observation of the conclusions made on that assumption? The fact that the truth of these laws was so long questioned and so slowly apprehended by the human mind, sufficiently indicates that they are not self-evident identities. Let us take the first and simplest of these laws. A body at rest will continue at rest, and a body in motion will continue to move with the same velocity in the same direction, unless acted on by some extraneous force or cause of motion. In other words, it continues in the same state as regards motion, unless there is some cause of change of state. Now the principle of continuity, which is assumed here, to those of us who are familiar with it in the dynamical problems of the universe, and with the necessity of it to all scientific investigation, may appear almost self-evident. But if we should be asked on what grounds we have this conviction, independent of the very incomplete evidence that Nature supplies, we certainly could not answer, as we must with regard to a mathematical axiom, that it expresses an identity. The existence of a state and its continuance are two totally different ideas. We must look further for the reason why we assume continuity. Religion points us to a sufficient and rational basis, viz., that Nature subsists in One Who is eternal and unchangeable, and both its continuity and its changes have their adequate cause in Him. Is there any other?

18. This principle, in fact, involves a second, viz., that in Nature there is no self-causation. The second law of motion, which has sometimes been called "the law of independence,"

* *Unseen Universe*, Article, 140-141.

affirming that the effects of forces, or causes of motion, are under all circumstances equivalent to those causes, enlarges this view. The result of the various causes acting together can be neither more nor less than if they acted separately. Whether the particle on which they act is at rest or in motion does not affect this. Neither the state of the body, nor the combination of the causes, alter the law of causation. In other words, matter is merely inert or passive. There is no power in it either to generate motion or to change motion. We are driven, therefore, to look for an original cause of motion out of the material universe. And if of motion, how much more of life, sensation, consciousness, intelligence? For it is absurd to suppose that matter cannot generate motion in itself, and yet that it can generate these, which reason recognises as much higher and further removed from the category of material substance.

Thus Science is compelled to assume the negative principle that in Nature itself there is no initial source of causation: a principle which is common to religion also, pointing as it does to one primal source of all causes in the Being of God.

19. There is no doubt, however, that this question of causation, and with it also the relation between Science and Religion in regard to causation, has till our own time been somewhat obscured by the unscientific use of the word force, as if it were a reality in itself like motion its effect. Force is no doubt a very convenient word to use when we understand its meaning. But that force has an objective existence can never be proved, and it is not only an "unfruitful" idea, but one apt to lead into error. Dr. Carpenter, I observe, in a late Essay on "The Force behind Nature," challenges this view, and protests against force being treated as a mere creature of the imagination. He grounds his protest on the fact that our senses give us an idea of force in pressure and resistance. But this is to confound the idea which the sense view of nature suggests with that which Science concludes. Our senses suggest that the yellow colour of the primrose is an objective existence in the flower; but Science concludes that the objective reality is something quite different from colour. The sensation of pressure is quite familiar to us; so is that of colour. But what in each case is the physical antecedent of the sensation?*

* One danger attending the popular use of the word "Force" is, that some not only consider force as a real entity, but almost deify it. They invest it with mysterious attributes, and when they speak of the First Cause, conceive of some primal force which is the source of all the various forces in Nature. Dr. Carpenter does not mean this; for in his essay (which originally appeared as an article in the first number of the *Modern Review*)

20. The history of the modern discoveries which have led to the present use in scientific researches of the idea of energy which is measured by the work done, instead of that of force which is measured by quantity of motion, I assume to be sufficiently known. The theory of the correlation of all physical forces, followed by the discovery of the mechanical equivalent of heat by Dr. Joule, and by the molecular and atomic theories, has opened to Science even a wider field than was opened by Newton's use of the law of gravitation. In this new development of Science a principle is accepted which was recognised by Newton as an interpretation of his Third Law of Motion, but which it remained for modern Science to propound in the present form of *conservation of energy*; viz., "that in any system of bodies whatever to which no energy is communicated by external bodies, and which parts with no energy to external bodies, the sum of the various potential and kinetic energies remains for ever unaltered." This is really only another form of that principle of continuity which we found in the First Law of Motion, though in this modern form it is more than ever apparent that the continuity cannot be accepted as a self-evident axiom. Indeed, this law of the conservation of energy is as luminous an instance as could be found anywhere, of Science being compelled to assume a principle which it can never absolutely prove, but which it verifies as far as it can by observation of the results obtained on the assumption. It cannot be proved as a proposition in Euclid is proved.* The difficulty of proving it experimentally is even greater than that of proving the First Law of Motion by direct experiment. Strong indirect confirmation of its truth can be obtained, and whenever the law can be brought to the test of experiment it is found true. But what is it (we may ask) that in the absence of anything approaching complete proof satisfies the scientific mind as to the universal truth of the law? Undoubtedly the conviction that permanence or continuity is a fundamental principle of the universe; or, as Religion would express it, that the universe subsists in God.

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he quotes with approbation language of Sir John Herschel, who speaks of force as "indisputably connected with volition, and by inevitable consequence with motive, with intellect, and with all those attributes of mind in which personality consists." And he himself deems it "absurd and illogical to affirm that there is no place for a God in Nature, originating, directing, and controlling its force by His will." Yet the very title of the essay, "The Force behind Nature," illustrated as it is by a steam-engine working the machinery of a cotton factory, appears to me calculated to mislead, and to obscure the true idea of the relation of God to His universe.

* See *Conservation of Energy*, by Balfour Stewart.

21. But this law of the conservation of energy, which is the result of further insight by science into the consecutive order of the universe, is followed by another law which, to the unscientific mind, appears like a contradiction of the former, viz., the *dissipation of available energy*. While the conservation of energy points to permanence, this indicates a process of dissolution; that is, unless it should be checked (as Clerk Maxwell has shown to be possible) by the interposition of intelligence. I notice this because, though not directly bearing on my present argument, it both strengthens it and nearly affects the general question of the relation between Science and Religion. Were it not for this second law, which indicates that the present visible universe has had a beginning and must have an end, the scientific principle of continuity might seem to mean that the universe is eternal, and subsists in God, in the Pantheistic sense, as belonging to His Infinite and Eternal Being. But we learn, not only that the permanence which it has in its Creator is consistent with its being subject to cyclical changes, but that its order and its causations, if left to themselves, must terminate; which is the strongest conceivable proof that the origin of these is not in Nature itself. In fact, this law of dissipation is the very interpretation of the law of conservation that Religion as a whole requires. The first religious view of the existences of the universe is, "He hath made them fast for ever and ever, He hath given them a law which shall not be broken":* which is also the first scientific view. The profounder religious view, the theosophic, is, "They shall perish, but Thou shalt endure: as a vesture shalt Thou change them, and they shall be changed: but Thou art the same, and Thy years shall have no end."† Or, to use the singularly exact language of the Apostle Paul,‡ "The Creation was made subject to vanity"; that is, to instability and liability to change and decay; and this (he adds) for some special purpose on the part of Him who made it subject; as if Divine intelligence (as Science itself indicates) might have prevented this, if some higher purpose had not intervened.

22. But it is especially in reference to *causation* that this new scientific development illustrates my present argument. It was impossible, until the transformation and conservation of energy were discovered, to explain clearly the strict and proper meaning of causation in the physical universe. Modern Science, however, enables us to interpret this very definitely

* Ps. cxlviii. 6 (*Prayer Book version*).
† Ps. cii. 26, 27. ‡ Rom. viii. 20.

indeed. If the cause is the energy A, the effect proper is the sum of the energies a_1 a_2 a_3 &c., into which, by impact or any other action, the original energy is transformed. For example, if one body impinges on another, the original energy is changed,—partly into those of the resulting motions, partly into heat. And the sum of these resulting energies is exactly equal to the original energies, and is its only proper effect. But suppose that the body struck is on the edge of a table or a precipice, and the two bodies fall on the ground, then their kinetic energies, when they strike the ground, are greatly increased; but this is merely because the effect of the collision has been to convert potential energy into kinetic. Or suppose that the body struck contains some explosive substance, the effect of the percussion is then vastly greater than the initial energy; but this is because the blow has disturbed the unstable equilibrium of the molecules of the chemical mixture, and the proper effect of the initial cause, though it remains unaltered, is quite lost in the incidental effects. In this case also, what we may consider as potential energies are suddenly changed into the kinetic energies of elastic gases. Another well-known case of a small initial cause resulting, from a similar reason, in effects far beyond those properly due to it, is seen in the spread of fire. A lighted match falls on a curtain, and a whole city is burned to the ground. This instance is sufficient to prove that in the case, not only of those substances (such as explosive mixtures) the chemical stability of which is very small, but of those also the chemical stability of which is considerable, the complete results of the initial cause often consists of two totally different kinds of effects;—first, of the effects proper, which are equivalent to the cause; and, secondly, of effects due to energies transformed or set free from their potential form, which bear no definable proportion to the original cause.

23. Such instances are sufficient to prove how much ambiguity there is in this subject, and how necessary it would be, in any Science of causation in Nature, to distinguish between the sequences of cause and effects when the latter are nothing more than a continuity of the transformed cause, and are exactly equivalent to it; and when the effects are those which result from the transformation of potential into kinetic energies. The transformation of itself does not necessarily imply any expenditure of energy to produce it; but, whether this be the case or not, it is evident that, as there is no determinable relation between the initial cause and the ultimate result, the effects of causation in Nature, so far as sequences of this sort occur, are absolutely incalculable; and that, however the

whole system of animate and inanimate existences may be limited by the law of the conservation of energy, it is, nevertheless, unscientific and indeed absurd to regard the universe as a piece of mechanism, the consecutive order of which could be determined as a problem in dynamics.

24. For it must be observed that into terrestrial phenomena (at least) this kind of indeterminate causation enters very largely, because the physical changes amongst these phenomena are in a great measure due to the changes of chemical combinations which are acted on by the various energies of heat, electricity, magnetism, actinism, and such like. The question of chemical equilibrium and the comparative stability of chemical combinations has attracted some attention in recent times, but the question, as a whole, is not within the range of exact science.* Clerk Maxwell succeeded in tracing a connection between some of the empirical generalisations of chemistry and the laws of the conservation and dissipation of energy. But it is evident that nothing short of the absolute stability of chemical structures, which would be fatal not only to all life, but to all the variety of Nature, could make sequences of cause and effect in physical phenomena on this globe, in all cases or even generally, determinable. And this consideration leads to the remarkable conclusion that, whilst Science is compelled to postulate both order and causation for its investigations, it never can possess the power, in many of the phenomena of Nature, to prove that the order is due to the causation; for the results of the causation, instead of being definite and orderly, are, so far as we can understand them, and to an extent apparently undefinable, quite indeterminate. And yet Science would contradict itself, and, in fact, could have no foundation, if the order and the causation had not some common basis. One Divine Reason, underlying at the same time the order and the causations, can alone supply a sufficient basis for both.

25. I would call attention, in passing, to the confirmation of this truth, of Reason being the basis of the whole system of the universe, that is afforded by the view of causation which we have been considering. Science, at all events at present, can give no explanation of the comparative stability and instability of the different constituents of the material universe; and yet on this the order of Nature very largely depends. If the arrangements of the energies in the chemical combination of hydrogen and oxygen in water, for example, or in

* See paper on "Chemical Equilibrium," by M. M. Pattison Muir, *Nature*, April 1, 1880).

carbonic acid gas, which supplies food to plants, were less or more stable than they are, or if the atmosphere were a chemical combination at all, stable or unstable, the present system of organic life would be impossible. It is, indeed, with reference to organic life that the considerations I have suggested are of most importance. The relation of living matter to physical energies is one, all must allow, of insuperable difficulty. Living matter has powers of adopting, transforming, directing, and applying, those energies which are not only quite unintelligible to us, but which have no parallel in dead matter. Our knowledge of this fact is, however, not scientific knowledge. It is a fact of which it is impossible for Science to find the cause in Nature; for even if the functions of life were proved to be connected with magnetism or any other physical energy, that would simply indicate, as in the case of sensation, the antecedent to the effect, not the reason of the sequence. And that life is an ultimate fact in Nature is confirmed by the researches of Science, which can discover no origin of life except living matter itself. And all we can say as to the relation of cause and effect in this sphere of Nature is that the phenomena of life are the results of continuity, but since it is the very characteristic of living matter to call physical energies into active operation, and to spread as a fire spreads from the smallest initial cause to an extent unlimited, this whole sphere is one which lies entirely beyond the range of exact Science.

26. But though Science in its highest form, as determining exact sequences of cause and effect, can have no place here, yet in its lower office of investigating by observation the consecutive order of phenomena, it has more trustworthy guidance here than in inorganic Nature. As one characteristic of living matter is that it is the subject of cyclical changes, the question of consecutive order necessarily belongs, to some extent, to all scientific researches into organic existences. And in the cyclical changes of all these existences there is a phenomenal law of order, originally observed by the poet Goethe, and in modern times more distinctly defined in what is known as the Law of Evolution, the truth of which may be tested almost without limit, and which holds, in the organic world, nearly the same position as the law of gravitation holds in the inorganic. And this law is so entirely in accordance with the principles of the contemporaneous order observed in Nature, that though no doubt it is impossible to prove its universal truth, or even to verify it as a dynamical law may be verified, yet it commends itself with almost irresistible force to the scientific mind as a general expression of the order of Nature, and to the religious

mind also (as it seems to me) as having its basis in Him Who is everywhere the Author of the same order. I am convinced that the more the law itself is carefully studied and clearly understood (and its study, apart from the obscure and repulsive terminology which has been introduced into this branch of Science, is as interesting as it is instructive), the less liable will the mind be to be carried away by those premature and unscientific conclusions which, by the world in general, are often confounded with the law itself.

27. The law, as it is observed in individual organisms, where we can trace it throughout the whole process, is (we must remember) simply the order of the changes through which every such organism passes from its initial structureless germ to its complete development. It is the same law in the vegetable and the animal, in the apple-tree and the elephant, in the sparrow and the human body. It does not in the least account for the differences between these existences, or give any explanation of them, much less is it a *cause*, in any proper sense of the word, of their being what they are. It only affirms that the operation of the different causes, to which the development of the organism is due, must follow a certain order. The causes themselves, if we consider the case of an individual existence, are obviously twofold.

First, the antecedent life, or lives, of which its own life is the continuity.

Secondly, in a subordinate and very limited degree, the environments or conditions of the organism during its development.

The first of these is undoubtedly in all cases the dominant cause. It is not only contrary to all experience that the derived existence should not be identical in kind with its antecedent or antecedents, but it would be inconsistent with the principle of continuity. But for this cause to produce its effect, certain environments or conditions are essential to the normal development. The absence of these, or any defect, or even excess in them, may render the development imperfect or abnormal, or even prevent it altogether. The limits of the effects that can be produced on the development of an individual organism by the alteration of its environments is a subject on which little is known with accuracy; indeed, these effects are generally so small,* that it is only by observing the

* The instance that at first sight seems the most startling is that which is afforded in the natural history of bees,—of the queen bee being developed by additional food and heat (especially the former) from the larva of a working bee. But as the working bee is an undeveloped female, this is merely the case of a complete normal development requiring a certain amount of food and heat. There is a similar instance, I am informed, in the natural history of the *termites*, or white ants.

accumulation of the effects, after many successive generations, that any approximation can be made to a scientific treatment of the subject. This, as is well known, has an important bearing on a much larger question than that of the consecutive order of the cyclical changes of an individual existence: viz., whether it is possible that, through the accumulated effects of environments, there may have been an evolution of the different types of organic life somewhat analogous to that of the different stages of development in the individual. This generalization assumes that, besides the law of continuity, which determines that each succeeding generation shall resemble that which preceded it, another class of causes, from generation to generation, may gradually modify this resemblance, and, it must be observed (for this is absolutely necessary to the theory), modify it continuously in the direction of evolution, and also in such a manner that the new types produced through these modifications shall be each of them a distinct integration. For the theory is, that the result of the process is the present highly-developed and accurately-defined contemporaneous order of the organic world.

28. The question at issue, we must remember, is not whether the process through which this order has been established followed the law of evolution,—as much as this might, I think, be inferred from the characteristics of Divine and Reasonable order, and is, indeed, indicated by Revelation itself in the Scriptural account of creation;—but whether the causes of the process can be traced in Nature itself. And even if there should be reason to suppose that the order of Nature has been determined, to a large extent, by conditions such as those which Mr. Darwin and his school consider sufficient, the question would still remain,—Whence does living matter derive the extraordinary power of adapting its forms to these several conditions, and especially of so directing all the successive infinitesimal modifications produced by environments, that by these modifications alone the whole of the order could be evolved. The evolution of the Ascidian from the Moner is, in fact, more unintelligible, than that changes should be produced in the higher orders of animals, unless some unknown power, such as that by which the embryo grows in the womb, should have been the cause of the development. For, however environments may aid development, and the law of evolution may limit it, they can effect nothing whatever of themselves. I have elsewhere *

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* *Church Quarterly Review*, July, 1878, on *Evolution*.

suggested that the analogy of embryology itself points to the probability of a period of genesis of Nature, during which other powers were in operation than those which we can trace in Nature in the present condition of the earth. But, indeed, notwithstanding Professor Huxley's late very positive assertion * that it is impossible for the scientific mind any longer to question the sufficiency of known causes for the evolution of organic forms, the evidences of continuous progress *in the direction of evolution* (which certainly the hoof of the horse and other cases to which he refers are not), are at present so defective that they can only derive any weight at all in the question from the supposed necessity of Science tracing at the same time both the order and the causation.

29. However, I am not now discussing, nor do I intend to discuss, the subject of any discrepancies between science and religion: both affirm the same fundamental principles, and must also hold that these principles have a common root. Science assumes them, and must do so as necessary to itself; and it endeavours to prove its assumptions to be true by the agreement of their results with its own observations. Religion derives the same principles from its belief in one Infinite and Almighty Intelligence, in Whom they all subsist, and Who is the basis of them all. And it confirms its belief by the evidences of order and design which Nature exhibits. Often, indeed, as we have found alike in the Unity, the Order, and Causation of the universe, it is absolutely impossible for Science to discover the connecting links or prove the principles from Nature. As the wise man said, — "It is the glory of God to conceal a thing."† But it is no part of Religion to question the evidences which Nature gives of these principles so far as Science is able to interpret it; nor is it any part of Science to imagine that it has discovered all the causes at work in God's universe, as if there might not be many far more powerful and active than any which our very limited experience and faculties apprehend. Meanwhile, Science itself teaches us quite enough of the infinite complexity of the causes at work in Nature, and of the indeterminate character of their effects, to prove that their operation not only cannot preclude, but even demands the action of supreme and infinite intelligence for the ultimate result. This (to use the words of Professor Jevons) "must have been contained

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* In a lecture delivered at the Royal Institution last March, entitled "The Coming of Age of the Origin of Species."

† Prov. xxv. 2

in the aggregate of the causes, and these causes, so far as we can see, were subject to the arbitrary choice" (I should say, are subject to the Will and Reason) "of the Creator."*

30. And this leads us to another truth, in which all these principles, whether regarded from the scientific or the religious point of view, meet and coincide. It is a common notion that the effect of the scientific view of the universe, as compared with those which our senses give us, is to get rid of its mysteries, and make the whole intelligible. Religion, on the contrary, is imagined to be full of unintelligible mysteries, and its condemnation, with superficial minds, is, that it cannot be understood. It is accepted by those who are ignorant of Science, its adversaries maintain, because they are not familiar with the solutions of the difficulties of Nature which Science supplies. But so far is this from being true that the effect of Science is to lead us to more serious difficulties and more incomprehensible mysteries than any of those which it solves. The proof of this I must assume here; but I will use the words of one who will not be suspected of any prejudice in favour of Religion. Speaking of ultimate scientific ideas, Mr. H. Spencer† says:—

"The explication of that which is explicable does but bring out into greater clearness the inexplicableness of that which remains behind. . . . . Objective and subjective things" the man of science "ascertains to be alike inscrutable in their substance and genesis. In all directions his investigations eventually bring him face to face with an insoluble enigma; and he evermore clearly perceives it to be an insoluble enigma. He realises with a special vividness the utter incomprehensibleness of the simplest fact considered in itself."

The complete result then of our argument is, that as the principles of Unity, Order, and Causation, which Science assumes, have no adequate and rational basis in those things which Science can investigate, and as in all cases in which Science traces the principles to the utmost range of its own powers, it is brought to that which to the human understanding is incomprehensible‡; therefore we must conclude, from the

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* *Principles of Science*, ii., 462.

† *First Principles*, second edition, p. 66.

‡ The universe is infinitely wide;
And conquering Reason, if self-glorified,
Can nowhere move uncrossed by some new wall
Or gulf of mystery; which thou alone,
Imaginative Faith! canst overleap
In progress towards the fount of Love,—the throne
Of Power, whose ministers the records keep
Of periods fixed and laws established, less
Flesh to exalt than prove its nothingness.
WORDSWORTH.

teachings of Science itself, that the ultimate basis of all cannot be other than an existence incomprehensible to the human mind.

31. This, however, as our previous investigations have shown, by no means lands us in agnosticism, any more than Science itself does. Science has been found to point continuously in the direction of One infinite and almighty Intelligence as the only explanation of the principles it requires. That which these principles demand is what we know as reason. Indeed, apart from all other evidence of this, since reason is manifested in man, the highest existence known to us in the universe, this at least must be found in the ultimate cause of the universe. And if we ask still, why in One Who must, it seems, from the very teachings of Science, be incomprehensible, we venture to speak of the human attribute of reason,—the voice of Religion answers (and we are now outside the sphere of scientific thought, and must have Religion for our guide, if we would have any at all), "God created man in His own image, in the image of God created He him."

32. It is not, of course, possible for me now to follow out the argument which I have indicated as to the relations between Science and Religion, or it would not be difficult to prove that it would lead to results of great religious value, and illustrate some of the profoundest mysteries of Faith. But, though I have already trespassed too long on your patience, I must in conclusion call attention very briefly to one application of the argument—of overwhelming practical importance in the present day—which, I confess, most weighed with me in choosing for my address to-day this investigation of some very intimate relations between Science and Religion. It is impossible to doubt that just now the tide of unbelief is setting with almost unprecedented force against the very foundation of all Religion, the Being of God. In itself there is nothing in this either surprising or discouraging. Atheism is the logical conclusion of all forms of infidelity, and it is well that the infinitely momentous question should be brought to its real issue. Men, indeed, vastly deceive themselves when they imagine that if they deny the existence of God they are at the bottom of the pit. There are already symptoms more than enough that there is a depth below this, and that those who are taunting rationalists and deists with not having carried their principles to their logical conclusions, will soon find out that of all systems the most illogical is one that demands morality, truth, and justice without God.

But cannot Science give us some aid in our attempts, by God's help, to stay the plague? Of late years there has been,

largely owing, I believe, to the efforts of this Society, a greatly improved understanding on both sides of the relations between Science and Religion. The present outbreak of Atheism assumes a flimsy disguise of Science; but, in reality, it has no scientific basis. It assumes that scientific conclusions can be proved, and are therefore to be believed; that the existence of God cannot be proved, and therefore is not to be believed. Such fallacies deceive those who are willing to be deceived; but they must disappear if once exposed to the light. But meanwhile I know that the feelings of many of those who are endeavouring to stem the tide of evil is that a literature, specially directed against the present phase of unbelief, and adapted for the classes who are most in danger from its sophistries, is still much needed. I would venture to suggest that in a matter of such vital importance as the best method of dealing with Atheism, there is nothing that we may with so much advantage study for our guidance as the example of the first inspired preachers of Christianity to the world. The heathen world, with which St. Paul, for example, had to deal, was, at heart, Atheistic, even more than it was idolatrous. Æsthetic feelings, national prejudices, and traditional usages were in favour of the old heathen system; but at the root of much both of the sentiment and of the philosophy of heathenism there was unbelief in any true and living God. We find, however, that in addressing the heathens, the Apostle argues *from* the existence of God, and he asserts confidently that men know not only that there is a God, but also sufficient of God to recognise that idolatry is a contradiction of His being. But when we examine his language closely we find that there was always present to his own mind as the ground of this assumption, one particular evidence of the being of God, to which he expressly refers as absolutely and completely sufficient. Whether he addresses uncultivated Lycaonians or Athenian philosophers, or is writing to Romans of their heathen fellow-countrymen, he always appeals to the visible universe as affording proofs of the eternal power and divine attributes of God, quite sufficient for reasonable man. It is not to be supposed that this great Apostle, who, to use the vulgar phrase, was certainly "abreast of the questions of the day," knew nothing of the Atheistic speculations of the Epicurean philosophers whom he addressed at Athens, or of those of the Epicurean Roman poet, which are the very type, if not the origin, of the Atheistic theories of certain modern physicists. But he evidently considered that such speculations did not touch the question at all. Atoms or no atoms, the universe

could only be the result of Divine Power and Divine Reason. We cannot but conclude from St. Paul's language that he considered this witness to God absolutely unassailable. He speaks of God's Being, not as something that may be discovered, but as a manifest truth, known to all, though they may suppress and keep down their knowledge so that it fails to produce in them its proper effects. He does not say that it requires some special gift of faith in order that God's eternal power and divinity may be traced in His works; he asserts that men are without excuse if they do not clearly recognise these. We must not infer from this that there is not also in man an intuitive cognition of God by conscience and by faith; but that of which he speaks as in itself sufficient is, undoubtedly, a logical process. From the principle that there can be nothing in Nature without an adequate cause,—a principle necessary to all scientific investigation,—Reason concludes that the cause of the phenomena and order of Nature must be the eternal power and infinite wisdom of God. However immediate the inference may appear, it is the result of a process, the several parts of which the logical faculty can discuss. And since, according to the Apostle's teaching, the inference is not only legitimate, but one that man's reason cannot reject without self-contradiction, the result of such discussion ought to be to make the conclusion more apparently and obviously certain.

There can be no doubt that Science has a most direct bearing on the several parts of this logical process. We have found in our brief survey that Science pours a flood of light, not only on the order of natural phenomena and existences, but also on questions of causation. All the principles assumed by Science in Nature require that which is supernatural. And if the conclusion from Nature was recognised by the heathen world then, may it not now be made even more apparent to the minds of men in the far clearer light of modern Science? It appears to me, I confess, that we shall not faithfully fulfil the trust committed to us in God's gift of Science, unless we so use it as, at all events, to expose the folly of those who say, "*There is no God*," and thus, by God's help, save those who are being deceived by the sophistries of such men from sinking into the horrible pit of darkness and despair which Atheism has opened.

ON THE BEARINGS OF THE STUDY OF NATURAL SCIENCE, AND OF THE CONTEMPLATION OF THE DISCOVERIES TO WHICH THAT STUDY LEADS, ON OUR RELIGIOUS IDEAS. By G. G. Stokes, Esq., M.A., D.C.L. LL.D. Dub. F.R.S., Lucasian Professor of Mathematics at Cambridge University, &c.

IT is the constant aim of the student of science, who not only follows the labours of others, but seeks to extend his own researches into the region of the unknown, to refer observed phenomena to natural causes. Thus, the ocean is seen to

exhibit strange periodic movements, which have an evidently beneficial effect as tending to prevent stagnation. A study of the period of these movements shows that they have some mysterious connexion with the moon. Presently, Newton arises and shows that these movements are necessary mathematical consequences of the same law by which a stone, held in the hand and let go, falls to the earth.

As regards this particular phenomenon, it may be that the immediate effect of the discovery is rather to turn aside the mind from the contemplation of the useful results of the movement, and involve it in the intricacies of a very complicated hydrodynamical problem. The particular phenomenon is shown to be part and parcel of a vast system, and it may well be that the beneficial results of this system are not at first apparent; from its very vastness the mind's eye fails to take it in.

Yet surely the study of truth of one kind, rightly pursued, cannot conflict with our reception of truth of another kind, though from the imperfection of our knowledge and of our faculties temporary difficulties may arise. Doubtless, in the end our views will be enlarged, and in some respects, it may be, corrected.

To illustrate my meaning, permit me for a few moments to indulge in fiction. I will suppose then, that in some unfrequented part of the Pacific Ocean there existed an undiscovered island, which, for the sake of a name, I will call Irene. The Irenians were men of cultivated minds, intelligent, and deeply religious, but for centuries they had been cut off from all connexion with the rest of the world, and they were ignorant of the very rudiments of natural science. They delighted in poetry, and in the cultivation of the feelings; and being devout they contemplated the phenomena of nature in immediate relation to a supreme Being. That most wonderful of our senses, the sense of sight, buried to them in mystery in all that belonged to it, was a special object of admiration, and they loved to dwell on it as evidence of the beneficence of the Creator.

At last the island was discovered by the captain of a scientific circumnavigating expedition. The Irenians and their visitors were greatly pleased with each other; and the scientific men of the expedition, finding them apt pupils, took great interest in teaching them so much of the elements of physics as the length of their stay permitted. They taught them among other things something of optics, the existence of rays, the laws of reflection and refraction, the formation of images by lenses, the use of telescopes. They then dissected an eye,

and showed how an eye acts just as an optical instrument in forming images of external objects on the retina. At this the Irenians were taken aback. They had been used to regard the sense of sight as an immediate gift from the Creator, depending on no second causes, and now they saw part of their organs of vision acting like so much dead matter. They received a shock, at which some of them were staggered, and asked themselves the question, Is it possible that, after all, this beautiful scene around us, these trees and flowers and painted butterflies, are merely a casual result of the blind interaction of a few simple laws?

But when the expedition had sailed from their shores, and the Irenians were left to themselves, and the novelty of their new ideas had a little worn off, a more sober judgment was formed of what they had learned. It is true that human reason had broken in on what they had been in the habit of regarding as holy ground; and they had learned that up to the formation of images on the retina the eye behaves like a mere optical instrument. But how came it to pass that its parts were so strangely well-adapted to fulfil this end? the cornea smooth and transparent, and nearly spherical, yet somewhat prolate, which as we know would tend to destroy spherical aberration; the crystalline lens shaped much like the lens of an optician, yet becoming gradually denser towards the centre, in a manner that the optician cannot imitate; the iris regulating the quantity of light admitted just as the astronomer regulates the aperture of his telescope, but self-acting in a manner which the optician cannot imitate? Reflecting on these things they became overwhelmingly impressed with the evidence of design, and design must have had a designer. But they had learned to think of him differently in some respects from what they did before; to regard it as no derogation of his character to suppose that he accomplishes his ends in conformity with, rather than in supersession of, such natural laws as they can themselves investigate, and doubtless of many others which are beyond their ken.

Now the progress of science is continually placing us more or less in the condition of our imaginary islanders, by reducing to a result of the straightforward operation of natural laws processes, perhaps evidently beneficial in their effect, but which were at one time shrouded in mystery as to their nature. And it behoves us to keep our minds in a condition of sober impartiality, neither on the one hand being so carried away by the achievements of science as to forget how much there is which science holds out no prospect of ever being able to explain, nor on the other refusing to admit conclusions fairly

deducible from scientific evidence, on the ground that we had associated something contrary to those conclusions with truths which we hold it most important to maintain.

The alarm at one time felt at the conclusions of geologists that the antiquity of the earth itself, and even of plants and animals, was to be reckoned by something considerably exceeding a few thousand years may pretty well be looked upon as a thing of the past. But instances in which scientific discoveries, or conclusions based on good evidence, run counter to our preconceived ideas occur from time to time, and are likely to occur in the future. In this connexion I would refer for a minute or two to a scientific doctrine which is now beginning to be pretty generally received, and which has, I think, given needless alarm to some who have the cause of religion at heart; I mean the doctrine of the conservation of force. I am not going to enter on any lengthy explanation of what the doctrine means; suffice it to say that for every development of *work* there must be a corresponding *expenditure of something*; and conversely, when work is apparently lost, its full equivalent must appear in some other shape, in quantity corresponding to the work apparently lost, and very commonly in the shape of heat. We have reason to believe that this law is no less applicable to living beings than to dead matter, and that, for instance, the work exerted by a labouring man is the equivalent of a part of the energy due to chemical combinations between the constituents of his food and the air he breathes. It is this last application of the law which seems to give rise, in the minds of religious men, to apprehensions which to me appear wholly groundless. We have long been familiar with the idea that living beings, no less than dead matter, are subject to the three laws of motion; and if we have now reason to believe that they are no less subject to the law of the conservation of force, I cannot imagine what religion has to fear from that. To aid our ideas let us adopt a rude analogy, and compare a living being to a railway train in motion. If we have now reason to regard the will, considered in relation to the exertion of muscular work, as something more nearly analogous to the intelligence of the engine-driver than to the coals under the boiler, that surely is not in any way derogatory to our idea of a living being, or of the wisdom and power involved in its first creation. Rather, as it seems to me, our ideas of what constitutes a living being tend to be refined and exalted.

If we allow the existence of,—say even if we adopt for trial the hypothesis of the existence of,—an intelligent Being above ourselves to whose Will the arrangement of Nature is due,

there are two ways in which we may draw a picture in our minds (however imperfect that picture may be) of the mode of exercise of that Will, namely (1), by a series of independent *fiats*; or (2) by adapting means to an end, and working according to established laws. Now, the ordinary course of Nature shows that such is at any rate an ordinary mode of operation of that Will; as, for example, where we see an apparatus adapted to the laws of reflection and refraction of light in such a manner as to produce images on the retina. What, then, should we expect *a priori* to find in our examination of Nature? Surely, as we must picture to our minds a skill of contrivance far beyond our own, we might expect that the greatest human intellect would be able to follow but a small portion of the contrivances actually existing; consequently, that at the boundary of what we have been able to make out there should be dim indications of something of the same kind stretching out into the unknown; but yet, at the same time, that there should be no indication that such a chain of causation would of itself alone suffice for the explanation of the system of Nature.

And this, it seems to me, is precisely what we find. To revert to our illustration of the eye: we have seen that as regards the formation of images on the retina it acts as an ordinary optical instrument in a way which we can fully follow; but when the images *are* formed, what then? We find the retina to contain an exquisitely delicate network of nerves collected into the optic nerve, and thence running into the brain. These nerve-fibres seem as evidently adapted to fulfil an end as the telegraph wires which run along a road or railway, though how they act in conveying an impression into the brain is as yet unknown; and how the impression so conveyed into the brain is capable of affecting our minds is shrouded in the deepest mystery. Again, the form and character of the cornea, crystalline lens, &c., are such as admirably fit them for their office of refracting the rays of light; but how came they to have this form and character? We perceive that there are vessels evidently subservient to their growth and nutrition, and that is pretty nearly all we can explain about it.

There is thus, as it seems to me, no inconsistency in accepting the theory of evolution as a guide in our researches, and yet rejecting it as sufficient of itself alone to explain the whole order of nature. The rejection of it as a guide, and the acceptance of it as an axiom of universal application, seem to me to be founded alike, though in different ways, upon an exaggerated estimate of the extent of human knowledge. To

say that what we cannot explain by the operation of natural causes must be directly referred to the *fiat* of the Author of Nature, and that it is presumptuous to attempt to explain it, is to measure His mind by our own, and to assert that where *we* are no longer able to recognize the adaptation of means to an end there contrivance ceases. To assume that because the doctrine of evolution is a useful guide in our researches therefore nothing more is required, is to perform a gigantic "extra-polation" (to borrow a term sometimes employed in mathematics); to conclude the form of a complete curve from the mere infinitesimal arc which alone is open to our observation.

The progress of science is continually bringing phenomena under the category of deductions from established laws, but at the same time it leaves barriers which it gives no indication that science will ever be able to get over; nay, sometimes it makes the existence of such barriers more apparent. This, I think, is the case with the principle of the dissipation of energy. I will endeavour to give some idea of what this principle means. Imagine a condensing steam-engine at work. For simplicity's sake, suppose the fire removed when the boiler has been well heated; make abstraction of all the surroundings; and suppose the work done by the engine to be that of turning round a paddle between fixed paddles, the fixed and the movable paddles being alike immersed in water belonging to the condenser. The engine would go on working for a time by virtue of the heat which it got from the coals before the fire was removed. The heat belonging to the steam which comes from the water in the boiler is in part conveyed into the condenser. I say in part, not entirely, even if we make abstraction of the solid materials of the engine; for a part is in appearance lost, and in lieu of it we have an exact equivalent in the shape of work done. But in the arrangement supposed this work is converted again into heat, through the friction in the water in the condenser. The upshot is, that while in different parts of the system there is a mutual exchange between energy of one kind and energy of another, the total energy of the system remains unchanged. But though this be so, the system is in a very different condition in its initial state from what it is in its final state, when the temperature has become uniform throughout. At first some parts were hot and some were cold; and it was in consequence of this unequal distribution of temperature that it was possible to convert energy in the shape of heat into energy in the shape of work, work which, though in the arrangement supposed it was expended, wasted we may say, within the system itself, might have been conveyed outside by a shaft, and turned to

useful account. But in the final state the whole system is in a condition of dead uniformity, lukewarm throughout, and no useful effect can be obtained from it.

Now this principle blocks out a supposition in which it is possible that a certain class of minds might rest content—the supposition, namely, that the present order of things has existed as it is, saving merely certain periodic fluctuations, from a past eternity. There is something so mysterious in the idea of *past* time, when considered as the seat of past events, and not merely as a mathematical abstraction, that if the uniformitarian doctrine could be scientifically maintained many minds might be content to take refuge in the mystery and inquire no further. But we are bound to face the problem of the existence of the state of things we see around us as something that had a beginning, or, at any rate, something that was preceded by a state entirely different.

There are some, indeed, who are content to take things as we find them, without recognising anything beyond the operation of natural causes such as those which we investigate, and who boldly accept the conclusion to which the principle of the dissipation of energy considered by itself leads us, that the present order of things is slowly tending towards a goal of universal death.

But if this conclusion is true as to the future, the present order of things ought to be capable of being deduced in like manner from what existed at any anterior time, however remote. If our formula were general, the variable expressing the time ought to be capable of being made negative as well as positive, and as large as we please. The question therefore arises, Can we account for the existence of what we see by mere evolution from a state the most remote that science enables us to conceive, understanding by evolution the result of the operation of natural causes, such as those that we can investigate, and excluding the operation of will, unless it be with reference merely to men and animals?

There are several reasons for thinking that our earth was at one time in a molten state. There are not wanting indications of a condition more remote from the present than even this. Associated with the stars, which the telescope reveals to us in such overwhelming numbers, are those remarkable objects, the nebulæ, which have long excited the curiosity of astronomers. Laplace regarded them as remaining indications of a primæval condition of matter which he supposed to have existed in a state of diffusion, and to have given rise to the stars by concentration under the influence of the attraction of gravitation. These luminous films were supposed to be portions of that

diffused matter that had not yet condensed. But as telescopes were improved in power and definition many of these objects which had formerly appeared diffuse were seen to be resolved into clusters of stars, and a presumption seemed to be raised that if several still resisted all attempts to resolve them it was only because the stars of which they were composed were so numerous within a given angular space, and individually so minute, as to baffle—hitherto at least—all attempts of opticians to construct telescopes powerful enough to resolve them. The magnificent speculations of Sir John Herschel are perhaps known to most of those here present. He regarded a nebula as something like the system composed of our own sun, and all the stars we can see with the naked eye, and even those more minute, placed at such an almost inconceivable distance that the whole subtends only a minute angle; and that the individual stars, of which the system consists, can no longer be seen individually, even with telescopes, and we merely perceive a faint gleam of light emitted by the system as a whole. But a remarkable discovery made in recent years by Dr. Huggins rather leads us back towards the ideas of Laplace. Huggins found that, quite unlike the spectra of the sun and of the stars, the spectra of most of the irresolvable nebulæ consisted of a very few *bright* lines, a character which laboratory experiments show to belong to the spectra of incandescent gases and vapours. This leaves little doubt that such must be the character of the matter of which these nebulæ are formed. It would seem, *à priori*, that the matter of such masses must in time condense, and thus conceivably stars might be formed. And what strengthens this conclusion is, that many of these diffuse nebulæ exhibit within them stellar points, so related to them that the chances are enormously against their being merely fixed stars casually situated in the same direction, and that these stellar points exhibit spectra of the same character as those of stars in general.

Science, then, seems dimly to point to a fiery nebula as a condition of matter the most remote that we can go back to. Can we then deduce the existence of all that we see around us by the mere operation of self-acting laws from such a condition? Or to take a starting-point not quite so far back, imagine our own earth to have cooled down to a temperature at which it would be possible for plants or animals, as we know them, to have existed; can we imagine such springing into existence, so to speak, of their own accord? Or to take a still later stage, supposing such forms of a low order once to exist, have we any scientific grounds for supposing that all that is required for the gradual formation of the higher forms, including man himself, is a slow process of natural evolution?

No attempt worth mentioning has ever been made to adduce evidence of the spontaneous production of living from dead matter, unless it be with reference to low organisms whose minuteness almost baffles our means of investigation. Putrefying organic solutions are found to swarm with microscopic creatures, whose presence at first sight, and even after a great amount of careful investigation, is very difficult to account for on the supposition that they came from germs. But if the germs, if germs there be, of such creatures bear anything like the same proportion in size to the adults that they do in the higher animals, one can foresee that a full examination of the question must be beset with enormous difficulties. I think the immensely preponderating weight of evidence obtained by those who have most carefully investigated the question is, that if germs are excluded no life is found.

With respect to the answer to the second question the weight of authority at the present day seems more divided. It would ill become me to criticise the labours of those who have worked in fields which I have not explored. Yet, looking at the thing from the point of view of an outsider, I cannot refrain from saying, that it seems to me that speculation as to the transmutation of forms has run utterly rampant. A certain amount of change yielding sub-permanent varieties no doubt presents itself to our observation, as in breeds of cattle and races of men, and it is likely enough that the same causes of variation operate beyond what we can actually prove. But, with all due allowance for such changes, is it conceivable that they could bridge over the enormous interval which separates the higher animals and man himself from some low organism?

I am no biologist, my own studies in natural science having lain in the domain of physics. But accustomed as I am to the severe demands for demonstration which in the physical sciences are made a condition of the acceptance of a theory, I confess that it is not without astonishment I have come across what seems to me the coolness of assumption with which mere speculations are spoken of as if they were established truths by many who, following in some respects in the wake of the great leaders of biological science, have not had time to acquire that vast store of knowledge which puts the mind in a condition properly to judge of the weight of evidence by which a particular hypothesis may be supported.

On the whole, while freely acknowledging the operation of natural causes, and thinking it probable that they extend far beyond the boundaries of our knowledge, and that accordingly we may seek to include the latest well-established scientific theory in some yet higher generalization, I see no

prospect of accounting for all we see around us by any such process as this. I see evidence of the operation of will and design, which cannot be eliminated even if we would wish to eliminate it; and that which we are obliged to admit as having operated in the past may yet operate in the future, may be operating in the present.

I have said that the principles of the conservation of force and of the dissipation of energy lead to the conclusion that the present order of things is leading towards a goal of universal death. Of course, this is only on condition that everything beyond the operation of the ordinary natural laws such as we can investigate is excluded. It becomes a curious question, is there any process which we can even picture to our minds, by which, without any violation of the principle of the conservation of energy, we can conceive the distribution of energy so altered as to make it again available for useful purposes, instead of having everything in a condition of dead uniformity? The only satisfactory affirmative answer that I am acquainted with to this question is contained in a suggestion made by the late Professor Clerk Maxwell.

Let us imagine a closed vessel, the sides of which we will for simplicity's sake suppose impervious to heat, filled with a gas in a uniform condition, and consequently at a constant temperature throughout. In the first place, what must we picture to ourselves as the state of things within the vessel? How must we think of the gas itself? The laws of chemical combination, embraced as they are in the atomic theory of Dalton, give us strong ground for supposing that a mass of ponderable matter is not a continuous plenum, but consists of ultimate molecules alike to one another in matter of the same kind. The laws of crystallography again seem hard to account for if we refuse to admit the supposition of ultimate minute molecules. If these exist, a gas like a solid of liquid must be thought of as a congeries of molecules. But what conception are we to form of it in relation to heat? What is the physical picture of a higher or lower temperature as measured by the thermometer? There is the strongest reason now to believe that heat is in fact a mode of motion; that radiant heat consists in a vibratory movement of that medium pervading space, at least to the distance of the furthest visible star, which we call the luminiferous ether, and whose existence we are obliged to assume in order to account for, as most marvellously well it does account for, the phenomena of light. When radiant heat is absorbed by ponderable matter, we have reason to believe that it is that the energy of the vibratory movement of the ether is transferred to the ponderable matter, of which

the ultimate molecules are thrown into a state of agitation, or rather of greater agitation than before, and that it is this state of agitation that constitutes thermometric heat. According to the molecular theory of gases, which is in great measure due to Maxwell himself, and which has now received such remarkable confirmations that it may be considered pretty well established, in a gas the molecules are for the most part free, provided at least the gas be not under a very high pressure, and are moving about with very high velocities, and occasionally coming in contact with one another, or, what comes to much the same, so close as powerfully to affect each other's motion. The velocity is not the same for the different molecules, and if it were it would not remain so, for as they came casually into collision some would be so struck as to be made to move faster, and others so as to be made to move more slowly; it is only a sort of average state of agitation that remains permanently unchanged so long as the condition of the gas remains the same.

Suppose now our imaginary vessel divided into two by a thin partition, and suppose this partition pierced with a vast number of very minute holes, each large enough to let through one molecule at a time, but not much larger than that. Imagine each little hole closed by a sliding shutter, and suppose each shutter presided over by a minute intelligent creature, that Maxwell called a demon. Suppose it were wished to have one, call it the right hand, compartment of the vessel filled with warmer and the left hand compartment filled with cooler gas. This might be effected by the demons by suitably opening or closing the shutters. When a demon saw a quickly-moving molecule approaching his hole from left to right, or a slowly-moving one approaching it from right to left, he would open the shutter to let it through. When he saw a slowly-moving molecule approaching the hole from left to right, or a quickly-moving one approaching it from right to left, he would shut the shutter to stop it. Thus after a time the right-hand compartment would be filled with molecules which on the whole were moving more rapidly, and the left-hand compartment with molecules which, on the whole, were moving less rapidly than the average. If the limits of speed which decided whether they should shut or open the shutters for the molecules moving to right or left were properly chosen by the demons, the pressure would be the same on both sides of the partition, and if the partition were then conceived to be away, no alteration would take place until the molecules had had time to diffuse among one another. Meanwhile, without any change in the total

energy, an unequal distribution of temperature would have been brought about, which is an imperative condition in order that the existing energy should be capable of being turned to useful account.

I have thought it worth while to mention this curious speculation because it presents a picture, however fanciful in its conditions, of how the natural tendency of a natural law may be averted without any disturbance of the law itself, provided, and only provided, we superadd the idea of will guided by design.

SPECIAL APPENDIX.

THE following extract from the notes to the Preface of vol. xii. of the Victoria Institute's *Journal* will be read with interest.

1. Age of the EARTH :—Chief Justice Daly, LL.D., President (1878-9) of the American Geographical Society, referring to this subject and a careful collocation thereon of the views of Astronomers, Geologists, and Physical Geographers, said, that there was found to be "a wide diversity of opinion between them upon the question of time—a diversity so irreconcilable as to show that our knowledge is not yet sufficiently advanced to admit of any reliable theory as to the age of the Earth." *Pref.* vol. x. and xiii.

2. With regard to the bearing of recent Geological discovery upon the statements of Scripture, more than one paper and discussion referring thereto appear in Volume xiii. of the Victoria Institute's *Journal*. The following recent opinions will not be without their interest to many :—

"We need not, in accepting the Bible narrative of man's creation, repudiate one fact accurately deduced from modern scientific research."—*The late Radcliffe Observer* (R. Main, 1878). *Relig. Hist. of Man*, p. 5. (See also Preface, *Trans.*, vol. xi.)

"Nothing can exceed in truth and grandeur these words (*Gen.* i.) of the inspired historian, * * the most keen-eyed hypercriticism could see nothing to object to."—*Ibid.*, in *Aids to Faith*. (*Trans.*, vol. xi. p. 431.) [Professor A. McCaul's paper on "The Mosaic Record of Creation," in the same work, will be found thoroughly satisfactory.]

"With regard to Physical Science, I think we have seen that its real advances are in favour of Religious Faith."—*Ibid.*, *Trans.*, vol. x., p. 174.

"The language of Scripture neither is, nor can be, * * contrary to the language of Science."—Professor Challis, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy at Cambridge. *Trans.*, vol. ix. p. 140.

"The Bible abounds in illustrative references to natural objects and phenomena, * * these are remarkable for their precise truth to nature."—Principal Dawson, LL.D., F.R.S. *Trans.*, vol. ix. p. 173.

"The great discoveries as to the physical constitution and probable origin of the universe, the doctrine of the correlation and conservation of forces, * * these, and many other aspects of the later progress of Science, must tend to bring it back into greater harmony with revealed Religion."—*Ibid.*, in *Origin of the World*. (See also Preface, *Trans.*, vol. xi.)

"There has never been produced in my own mind * * the slightest impression that we (he, and those who studied under him) were considering facts and laws in any way opposed to Christian Faith, to the inferences of Natural Theology, or the deductions from Scripture."—The late Professor Phillips, F.R.S., speaking of his duties as Professor of Geology at Oxford (1874). *Aids to Faith*. (See also *Trans.*, vol. xi. p. 432.)

"We all admit that the book of Nature and the book of Revelation come alike from God, and that, consequently, there can be no real discrepancy between the two, if rightly interpreted."—Professor G. G. Stokes, M.A., F.R.S., &c., Secretary of the Royal Society. (See Preface, *Trans.*, vol. v.)

3. The Descent of MAN :—Professor Virchow (1878), alluding to the Darwinian hypothesis, says :—"There is a complete absence of any fossil type of a lower stage in the development of man. * * Any positive advance in the province of prehistoric anthropology has actually removed us further from proofs of such connection—namely, with the rest of the Animal kingdom. (See *Preface*, vol xiii.)