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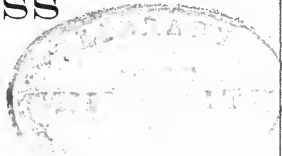
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THE

COURSE OF NATURE:

AN ADDRESS



DELIVERED BEFORE THE
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,
St. Louis, August 22, 1878.

BY

SIMON NEWCOMB,

Retiring President of the Association.

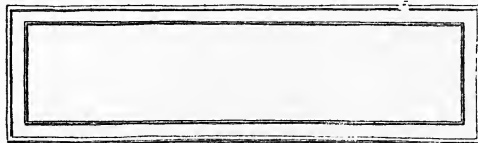
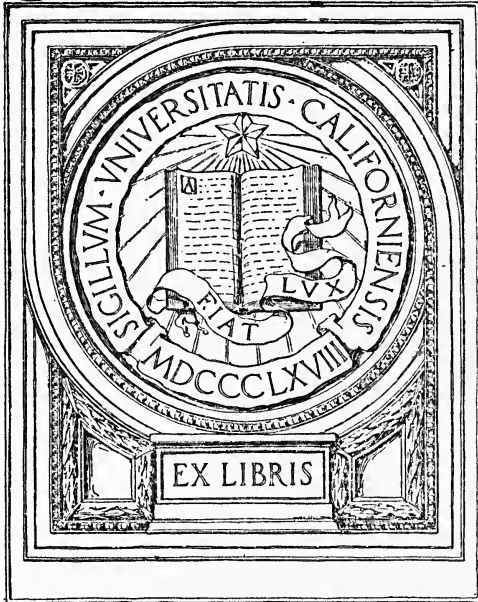
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UNIV. OF
CALIFORNIA

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ADDRESS

OF

PROFESSOR SIMON NEWCOMB,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

LADIES AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR
THE ADVANCEMENT OF SCIENCE:—

IN imposing on its retiring President the duty of delivering an address, the constitution of this society sets no limits to his choice of a theme. Both in these and in the corresponding addresses delivered before the sister society of Great Britain, it has not been uncommon for the speaker to choose for his subject the general progress of scientific research during the year. This course is now less common than formerly, because, owing to the immensity of the field of research, it has become impossible for any ordinary mind to follow its progress in all its branches. I have thought, therefore, that a higher interest would attach to a theme chosen from the field of modern scientific thought, and, by a process in which I have been the follower rather than the leader of my own contemplations, I have been led to present to you some thoughts on the Course of Nature as seen in the light of modern scientific and philosophic research. Though I have but a single central idea to present to you, namely, that of the simplicity and universality of the Laws of Nature, yet so great is the confusion of thought which prevails on the question, What are the Laws of

Nature, that it is necessary to approach my idea from more than one standpoint, and to illustrate it in more than one way.

We all know that the history of the Caucasian race, during the last three centuries, has been marked by a kind of intellectual development so entirely without precedent that some might call it miraculous; in fact, by such a development of the understanding of the course of nature as has revolutionized human society in many of its phases. You also know that this development has been marked by frequent collisions of opinion between the investigators of the material manifestations of nature on the one side (if I may be allowed to use the expression), and philosophers and theologians on the other, respecting the true theory of the course of nature. My desire in entering this field is to act the part of the peacemaker rather than that of a combatant, not sustaining any other propositions than those which are actually believed in by the large majority of educated men at the present time; but the confusion of thought on this subject, to which I have just alluded, is so great that, although I may combat no opinions actually held, it may be necessary to greatly modify their application, and to criticise the forms in which they have found expression.

The key-note of my discourse is found in a proposition which is fundamental in the history of modern science, and without a clear understanding of which everything I say may be entirely misunderstood. This proposition is, that science concerns itself only with phenomena and the relations which connect them, and does not take account of any questions which do not in some way admit of being brought to the test of observation. The only universe it knows is that made known by the telescope, the microscope, and other appliances of observation. That this is the whole universe we should all be very sorry to suppose, and none more so than he who has the honor to address you. But, should I pretend to a scientific knowledge of what lies behind this visible frame, I should be acting the part of the rash speculator rather than of the cautious thinker. Only into a single field of thought do I dare to venture. When we trace the efforts of men to penetrate the secrets of nature, we find them clearly divisible into two classes: philosophic speculation, and scientific investigation. We find the objects of thought equally divisible into two classes: phenomena and their hidden causes, those unknowable entities out of which

they proceed. The great progress which the last three centuries have witnessed has been wholly in the field of phenomena, and it is to this field, and to the results of scientific investigation in it, to which I ask your attention this evening. But, it is to be expected that, in this brief characterization of our field of thought, I have failed to convey to your minds any clear conception of its boundaries. The progress here alluded to has been rendered possible only by entirely rejecting the mode of thinking about nature which was prevalent in former ages, and into which the untrained mind is almost sure to fall at the present day. The distinction will be evident to one mind at a glance, while another may be unable to comprehend it after all the explanations which it is possible to give. As my whole discourse will be misleading unless all my hearers have a clear conception of it, I shall endeavor to present you with the materials of such a conception, rather in the form of concrete illustrations in familiar language, than in that of abstract general definitions.

As one mode of expression, we might say that modern science introduces into the higher modes of thought about nature that same kind of practical good sense which characterizes the successful man of business. Scientific investigation is, in a certain sense, purely practical in both its methods and its aims. There is a mental operation, with which all are well acquainted, under the familiar term "theorizing;" to this operation all scientific investigation is so much opposed that the mere theorizer and essayist can never make any real advance in the knowledge of nature. To speak with a little more precision, we may say, that as science only deals with phenomenon and the laws which connect them, so all the terms which it uses have exact literal meanings, and refer only to things which admit of being perceived by the senses, or, at least, of being conceived as thus perceptible. This purely literal meaning of all scientific language is in strong contrast to the metaphorical and poetical forms of expression into which we are apt to fall in discourse upon abstract subjects generally, where our ideas cannot be at once referred to sensuous impressions.

We might also say, that no question is a scientific one which does not in some way admit of being tested by experience. The single object of scientific research is to predict the course of nature, or the results of those artificial combinations of causes which we call experiments; and no question is a scientific one

unless its solution will in some way advance this object. I must not, however, be understood as saying that the test of experience can always be immediately applied, because then no disputed question could be a scientific one. For example, the question whether man existed on the earth 50,000 years ago is a scientific one, because it is one respecting actual historic occurrence of scenes evident to the senses. It could at once be settled by simple inspection, could we in any way form a picture of the earth as it then looked, and it may actually be settled in the future by the presence or absence of sensible traces of the existence of man at those times. Should we, however, go farther, and inquire whether such men had souls, our inquiry would not be a scientific one, nor one in which science could in any way concern itself with profit. The soul can neither be seen, nor in any way made evident to the senses of others. From the very nature of things, it could leave no material trace of itself to be unearthed by the geologist or antiquarian of a future age. So far are we from forming any conception even of our own souls, as sensible existences, that no question affecting them, even now, is a scientific one; much less can science consider those of past generations.

There is thus a quite well defined limit between questions which are scientific ones and those which are not scientific, and with which, in consequence, science has no concern whatever. You must not understand me as in any way claiming that questions of this last class are not worth thinking about. They include many which are of the most absorbing interest to the human race, and about which men will think the more as they become more thoughtful. But to mix them with scientific discussions will only introduce confusion of thought respecting sensible things, without in any manner advancing their solutions. The current desires that science shall consider man as something more than an animal are as unreasonable as if we wanted to make algebra a help to moral philosophy.

This limitation of all scientific research to a single specific field is something so little understood, that I may have occasion to call it to mind in other connections. But, there is another equally essential maxim of science which I must explain in order that you may understand the spirit which animates scientific investigation. It is, that the man of science, as such, has no preconceived theories to support, but simply goes to nature to find out and interpret

what she has to say according to her exact meaning. What he may desire to be true has no bearing at all on the question what really is true. Here arises the inability of men of science to view theological questions in a light which shall be satisfactory to the theologians, and the corresponding inability of the latter to appreciate the spirit in which men of science discuss the problems of life and being. We hear much at the present time of a supposed conflict between science and religion, but it is rather a conflict between two sets of men who view nature from opposite and irreconcilable standpoints. It is essential, to the understanding of our theme, that we should see in what this difference of view consists; I shall, therefore, endeavor briefly to explain it.

The theologian looks upon the doctrines he has been taught, as something the truth of which is essential to the welfare of humanity, and, we might almost say, to the supremacy of the Creator. He thus invests them with an attribute of moral excellence, implied rather than expressed in the term orthodoxy, and looks upon those who attack them, not simply as men who are mistaken, but as men who are seeking to do a great injury to the human race. Hence, the idea of weighing the arguments on both sides with entire indifference to the result, is one which he cannot be expected to receive with favor, or even to readily comprehend as received by others. His idea of truth is symbolized in the pure marble statue which must be protected from contact with profane hands, and whose value arises from its beauty of form and the excellence of the ideas which it embodies. He therefore looks upon those who attack it, with feelings not unlike those of the keeper of the statue upon a chemist, who refuses to see anything in the statue except a lump of carbonate of calcium of peculiar form, and who wants to handle it, weigh it, determine its specific gravity and its cohesive power, and test its substance with acids. The corresponding idea of the scientific investigator is symbolized by the iron-clad turret, which cannot be accepted until it has proved its invulnerability. Instead, therefore, of being protected from violence as if it were a product of the fine arts, violence is invited. Its weak points are sought out by eyes intent on discovering them, and are exposed to the fire of every logical weapon which can be brought to bear upon them. A scientific theory may thus be completely demolished; it may prove so far from perfect that its author is glad to withdraw it for repairs or reconstruction; or it

may be hammered into an entirely new shape. But however completely it may stand the fire, it maintains its position as a scientific theory only by being always in the field ready to challenge every new comer, and to meet the fire of every fact which seems to militate against it. A countless host of theories have thus been demolished and forgotten with the advance of knowledge, but those which remain, having stood the fire of generations, can show us a guarantee of their truthfulness which would not be possible under any other plan of dealing with them.

As a consequence of this way of viewing theories, the scientific man recognizes no such attribute as orthodoxy in his doctrines. There is nothing at all which he says you must believe to be true as a condition of scientific recognition. There may, indeed, be many propositions to doubt which would indicate extraordinary incredulity, or down-right folly, or even insanity, and he might, therefore, regard a skeptic as possessing a pitiful feebleness of intellect, and, in consequence, refuse to listen to him; but he would refuse, not because the man disbelieved something which was undoubtedly true, but because he was not worth listening to. Perhaps the point which I am striving to make clear may be most readily grasped by the reflection that science offers its highest rewards to him who will overthrow and supplant its best established and most widely received theories. Thus, the names of the men who disproved the theory of epicycles in astronomy, and the doctrine of phlogiston in chemistry, occupy the most honorable positions in the history of science. Of course, no such thing as authority in science has anything more than a provisional recognition. If a man of good repute says that he has investigated a certain subject and reached a certain result, the latter may be accepted on his authority, in the absence of other evidence. But this gives no reason at all why anyone else should not reach a different result, and it would be no argument at all to cite the mere authority of the first against the second. In case of a discrepancy of this kind, the whole question would have to be reinvestigated. The dictum, "It is written," has no terror whatever for the investigator of nature; he can recognize no authority for any feature in the course of nature, except nature herself as he sees her.

These principles are of so much importance in the philosophy of science, that I may be pardoned for viewing them in yet another

light. In reading those discussions with scientific men on certain theories recently advanced by the more advanced students of philosophic biology into which the representatives of theology sometimes enter, I have often noticed, that if the representative of science propounds, discovers, or brings forward any fact or principle which seems to tell against his side of the question, the other calls it an "admission," or "concession," just as if his opponent had first selected his side for the love of it, and was then unwilling to concede or admit anything which might militate against it. Now, to go into the philosophy of the subject a little deeper than heretofore, allow me to say that the man of science professes no ability to recognize truth on sight, as he would recognize a house or an animal. The question whether any given proposition is or is not true, is necessarily to be decided by the human judgment, co-ordinating all the facts which bear upon it. There is no such thing as a revelation of scientific truths, and even if one should claim that there was, the admission or rejection of the claim would be an act of the judgment, which thus becomes the ultimate arbiter in any case. Hence a proposition is to be proved probable or true, not by anything in itself, but by a more or less long and painful examination of the evidence for and against it. Everything that can be found to militate in favor of it is put into one scale, and everything that can be found to militate against it is put into the other. If the investigator is imbued with the true spirit of science, his search is equally vigorous for arguments to go into the two scales. When he says that the proposition is worthy of being received as true, he means, not that it bears any recognized seal of truth, but that the evidence in favor of it entirely preponderates over all that can be brought to bear against it.

You will not understand me as maintaining that every individual man of science constantly maintains this spirit of impartiality any more than that every Christian constantly lives up to the highest standard of his profession. Hot conflicts have sometimes raged, and there is no reason to suppose that they have entirely ceased, even now, in which each combatant could only see one scale. But the spirit I have described is that in which science exhorts her votaries to approach every question, and in which they will constantly endeavor to approach it if they are worthy of their profession.

Let us now approach our main theme, the course of visible nature. Let me again remind you that of the two universes, the seen and the unseen, I am only going to speak of the former. We find ourselves placed in this world in the midst of a vast theatre of activity. We see an atmosphere agitated by storms; great masses of water rising in the air to form clouds, and, after falling to the earth, flowing as mighty rivers to the ocean; countless forms of vegetation rising from the earth, and then returning to it; a sun supporting all life on our planet with its heat; an infinitude of chemical changes going on around us; countless stars moving through space with velocities which transcend all our conceptions. To all appearance these operations have been going on for millions of ages past, and may continue for millions of ages to come. As the thinking man contemplates them, he is led irresistably to the conclusion that they do not go on at random, but that they are joined by connecting links, or are in some way the product of knowable causes. From his earliest infancy he sees connections between them which enable him to foresee results. He finds that fire burns, that the sun warms, that food satisfies his hunger, and that heavy bodies fall with a certainty which shows the forces at play to be invariable in their action. To penetrate the mystery in which these forces are enshrouded, he has exerted the efforts of his intellect from its first dawn until the present time. What general conclusions has he reached?

From the earliest times at which man began to think, two modes of explaining the operations of nature have presented themselves to his attention. These modes are sometimes designated as the teleological, and the mechanical.

The teleological explanation of nature, presupposes that her operations are akin to human actions insomuch as they are under the control of, and directed by one or more intelligent beings having certain ends in view; that the events are so directed as to compass these ends; and, finally, that the relation of the events to the ends, admits of being discovered by observation and study. This last condition is a very important one, because, without it, the teleological explanation of the cause of nature would not be a scientific one. The doctrine that the Author of Nature has certain ends in view, and directs the whole course of events so as to bring them about, will not enable us to explain and predict the events unless we know what those ends are. But, as I have

already said, the test of scientific advance is the power of foresight—of foreseeing what result any combination of circumstances will lead to. If we always had to wait for the result, and could then only say, I know this is the result which was intended, because it has happened, no actual foresight would be possible; and however excellent the doctrine might be as a theological one, it would not admit of being tested by observation and experiment, and the question of its truth would, therefore, not admit of being settled by scientific investigation.

You may recall the remark of a satirical philosopher, when he saw the gifts which those who escaped the dangers of a certain treacherous and stormy sea offered up to the goddess who had this sea at her command: "I see no offerings from those who were lost," said he. It was not till the voyager had got safely to shore that he found himself under the protection of the goddess.

It must be well understood that the teleological theory of nature, or, as it is now familiarly called, the explanation of natural phenomena by design, has two distinct forms, the scientific, and the theological. These forms are not antagonistic ones; the one held by scientific men, and the other by theologians; for, as you may well know, the scientific form is the one in which scientific men almost universally reject the teleological theory, while they have nothing to say against the other forms. The forms refer only to the fields to which the theory may belong, the scientific and the theological. The distinction turns, on whether we suppose the ends which the Creator has in view to be discoverable by scientific investigation, or to be inscrutable. Only in the former case have we, as scientific investigators, anything to do with the question. The theory, as we have to consider it, is in brief this:—that the course of events in inanimate nature is from time to time modified by invisible intelligences just as it is modified by man when he changes the course of a river or plants a forest.

The other explanation of nature is the mechanical one. It assumes that her processes go on in accordance with certain laws which admit of being fully comprehended by the human mind so far as their effects are concerned. Each state of things is the effect of the state which immediately precedes it, and the cause of that which immediately follows it. The course of nature is thus considered as an endless chain, of which the work of science consists in making out the forms of the links, and the modes in which

they are connected. In this work we have to be concerned with two things; the general laws of nature, as they are familiarly called, and the facts or circumstances which determine the operation of these laws. This distinction is most clearly seen in human laws. Thou shalt not steal, is a law; that John has stolen, is a fact. The combined result of the law and the fact is that John is locked up in jail. So, that all bodies near the earth gravitate toward it with a force directly as their mass, and inversely as the square of their existence from its centre, is a universal law of nature. The Niagara river and the precipice are facts; and the cataract is the result.

But the general explanation of the course of nature, on the mechanical theory, is not of this simple kind, because the laws of nature do not act singly, but in combination; so that the result of each is modified by the action of all the others which come into play. The law of gravitation is not that all bodies must fall, but only that they tend to fall, and, therefore, will fall unless held up by some sufficient opposing force. So long as I support this weight in my hand it does not fall, because the force of gravitation and the resistance of my hand neutralize each other. But the instant I let go, the weight drops, according to a certain law known as that of uniformly accelerated velocity.

The doctrine I am endeavoring to elucidate is this: knowing a few simple laws of nature, of which gravitation is one; knowing also the arrangement of material things within the field of investigation; that is, knowing the facts, we can predict with unerring certainty what the result will be: or if we cannot predict it, it is not because of any quality of the thing itself, but only because of the insufficiency of our powers. Moreover, these results will be, as it were, another layer of facts, from which it is possible to predict new results to follow them, and so on without limit, unless some force from without intervene to change the course. If we include the whole of nature in our field, no outside facts can come in, and her course, therefore, admits of being predicted with entire certainty from beginning to end.

Now the point which I wish to bring to your attention is, the revolution which modern science has brought to pass, in the opinions of mankind, respecting the relations of the two classes of causes, or supposed causes, which I have described. That all events could be explained on teleological principles, it is not

likely that anyone ever supposed. That the falling of heavy bodies, the running of rivers, the changes of seasons and the revolutions of the heavens, were all in accordance with mechanical laws, at least so far as the phenomena are concerned, no one ever knowingly denied. But it was thought that the action of these causes was from time to time modified by the introduction of causes of the teleological class, just as a rock might be kept from falling by the force of cohesion. The general rule has been that the more ignorant the age, the more minute and immediate was supposed to be the action of those beings who were modifying the course of nature in order to compass their ends.

As illustrating this I might commence with the age of image worship, when the fate of the individual is supposed to be at the mercy of certain spiritual entities, symbolized by forms of wood, stone, or wax. But, leaving out of consideration ideas so different from those which prevail among us, let us come nearer home. It is not many generations since men, who knew that the regular course of nature went on in accordance with mechanical laws, believed, nevertheless, that occurrences of a terrific or extraordinary character were specially brought about to compass some end of Providence. Not only so, but, what is most essential to our theme, this end was supposed to be a scrutable one. The motions of stars and planets had gone on from age to age, until no new aspect of them inspired alarm. But a comet was looked upon as a messenger specially sent to give warning of a coming calamity. The scrutable end was, in this case, the warning of mankind. Ordinary cases of sickness and accident, whatever their result, always have been looked upon as a part of the regular course of events. But it is not many centuries since the pestilence was believed to be specially sent by Heaven to punish mankind for their wickedness. Punishment and terror were here the ends which Providence was supposed to have in view. The regular daily breezes and showers were supposed to be the result of natural laws. But these laws were not supposed to be entirely adequate to the production of the tornado, which was again a special messenger, and they were suspended, or their action was modified in times of extreme drought, threatening mankind with famine.

These special messengers of Heaven have, one by one, yoked themselves to the car of natural law, so that I think I can hardly be wrong in saying that the supremacy of mechanical law, and its

adequacy to account for the whole course of nature, as we see it going on before us, is now the almost universal opinion of educated men. This revolution in human thought is, perhaps, clearly brought out in the different view we now take of certain religious observances introduced by our ancestors, whose ideas would now be considered as approaching the irreverent. Take, for example, the prayers for the right kind of weather, which we find in our prayer-books. When they were first composed and inserted, their object was a purely practical one. As the farmers now sometimes fire off cannon to make the black cloud break and discharge its contents upon the parched field, so the prayers were to be offered up in order that the aqueous vapor in the air might be made to condense and fall. That a much more exalted view of prayer than this is now taken by the more enlightened portion of the religious world, I think we have every reason to believe.

Although we can hardly entertain a serious doubt that the mechanical theory of natural operations, or, as it is sometimes called, the doctrine of the uniformity of nature, is generally acquiesced in by the mature thought of intelligent Christendom, yet objections are frequently made to it because it seems to run counter to some of our most cherished ideas. If it were not paradoxical to make the assertion, it might be said that we hold, or at least express entirely inconsistent views on the subject. The fact is that we are pupils of two opposing schools, which are, in a certain degree, antagonistic, one of which we cannot, and the other of which we will not, give up. In one of these schools the chief teachers are observation and experience. All sentiment and emotion are banished from its curriculum, which admits only the hard realities of the outer world. The older we grow the more we see and hear of this school, and the more unreservedly we accept its teachings. It tells us that the whole course of nature takes place in accordance with certain laws capable of expression in mathematical language; that these laws act with more than an iron rigor, and without any regard to consequences; that they are deaf to prayer or entreaty, and know no such thing as sympathy or remorse; that if we would succeed we must study them, and so govern ourselves that their action shall enure to our benefit.

The other school is that of sympathy, emotion, and religious faith. In it, as children, we receive our first teachings. It shows us ourselves placed, as it were, in a forest of mystery, surrounded

by forms over which we have no control, and able to penetrate so little into the surrounding darkness, that we cannot tell what shall happen to us on the morrow. It has, in all ages, peopled the thickets with invisible beings having an interest in our welfare or our injury, or with providential interferences designed to compass ends of which we, in advance, have no conception. Its teachings are nearest and most welcome in times of affliction and fear. Its objections to the teachings of the other school, are heard far and wide through the land. Notwithstanding the number of forms which these objections take, their essence may be condensed into a very few sentences. The following will probably be accepted as a fair rendering of their substance.

You take a contracted and unphilosophical view of nature when you say that the world is governed by inexorable laws. These laws are not governors, but only the instruments of government by which the real governor executes his purposes. With them, but without subverting or violating them, he can reward or punish, bring on prosperity or call down disaster, according to the dictates of his sovereign will. The child and the peasant call the thunder the voice of God. The modern philosopher attempts to correct them by showing that it is the product of evaporation and of atmospheric electricity. But the view of the child is really the more correct of the two, because he ascends at once to the first cause, and thus sees further than the philosopher who corrects him because the latter stops short at the immediate or secondary cause without even trying to raise his eyes to the higher source of power. I think I am not far wrong in giving this as the substance of the most cogent objections which may be anticipated in any quarter against the mechanical theory of the course of nature.

Now, if these views referred only to inscrutable first causes of things, or to the intelligent but invisible substratum which underlies the whole cause of nature, we should have no occasion to discuss them, because they would lie outside the field I have assigned as that of our contemplation at the present time, and which I have sought to describe as the field of phenomena. The doctrines that all things go on in exact accordance with the will of the Creator; that he has certain ends which the laws of nature are designed to bring about; and that an intelligent cause lies behind the whole universe of phenomena, are of a class which science has no occasion whatever to dispute. If it were made clearly to appear

that the field of the teachings in question was thus limited, and was entirely distinct from that of phenomena, with which alone science is occupied, there would be no occasion for dispute between the two schools. I have no disposition to throw a single stone across what I consider the sacred boundary line, nor to enter a field which I am by natural and acquired habits of thought, unfitted to cultivate. As men of science let us by no means attempt to penetrate a region in which the eye of science can see nothing but darkness. If we thus subject ourselves to the imputation of being "of the earth, earthy," we may console ourselves that our edifice is firm and durable because it does not seek to rise into regions of serener air, nor to rear its dome above the clouds.

I can hardly be mistaken in saying that the objections to the mechanical theory of nature, which I have just tried to formulate, are not always confined to the field of inscrutable first causes. There is a part of the boundary line over which the stones are flying very thickly. While some of the combatants may profess to make no attack on the doctrine of the uniformity of natural law, I cannot but think that these professions often arise from a misapprehension of the scientific side of the question. Indeed, I must confess that I have met with a difficulty from my inability to form a clear idea of the views really entertained by the school now under consideration. I have made a somewhat careful study of some of the most elaborate works of the writers of the theological school, devoted to this very topic, and I have left them without being able to decide in my own mind, whether the writers do or do not hold unreservedly to the mechanical theory of the course of nature. That nearly all intelligent men really believe in this theory, at least so far as the present time and dispensation are concerned, we have abundant reason for believing. Nor is there even among advanced theologians any lack of profession of a belief in the uniformity and supremacy of the laws of nature. But, when thinkers of the other school maintain the doctrine, and trace it to its logical consequences, undisguised by sentimental language or figure of speech, they are met with criticism which I can account for only by supposing that the theologian understands by laws of nature something different from what is understood by the man of science.

Let us try to condense the questions at issue into the smallest possible space. The scientific philosopher maintains that the natu-

ral course of events goes on in invariable accordance with certain knowable laws. He asks the theologian in the words of Pope:

“Think'st thou like some weak Prince the eternal cause
 Prone for his favorites to reverse his laws?
 Shall burning *Ætna*, if a sage requires,
 Forget to thunder and recall her fires?
 On air or sea new motions be impress'd,
 O blameless *Bethel* to relieve thy breast?
 When the loose mountain trembles from on high
 Shall gravitation cease if you go by?
 Or some old temple, nodding to its fall,
 For *Chartres'* head reserve the hanging wall?”

To all these questions the other answers, no, and thus all occasion for dispute ought to end. But it does not end, by any means; for he proceeds to criticise the views of the questioner on the ground of their narrowness, and to inform him that the Creator can, (and, by implication, that he does) so arrange things that any result he may wish shall be brought about by the action of natural laws themselves. “We do not expect *Ætna* to recall her fires when a sage is near; or the air and ocean to acquire new motions to preserve a saint from danger.” * * * “Should these individuals not be rushing recklessly against the known laws of Heaven, or should it be the will of God to preserve them, it will be found that provision has been made for their escape, and that not through the powers of nature disobeying their own laws, but through other powers in nature opportunely interposing to stop, to turn aside, or otherwise to modify their operation.”

Now, always supposing that such remarks as these are intended to apply to the domain of sight, hearing and understanding, they differ fundamentally from the scientific theory in their view of what constitutes the laws of nature. The school seems to look upon causes and effects in nature as belonging to two different classes of things. They see an immense collection of causes, to each of which the appropriate effect is tied. So long as the cause is followed by its effect, the laws of nature are satisfied. So, if the Ruler wants to reward, punish, kill, or rescue, He has only to bring into operation the appropriate cause at the proper moment; the natural effect follows, and His will is executed without any violation of the laws of nature. I am not sure that this is an exact statement of the views to which I refer; but it is the best I can gather from the study of the forms in which they have found expression. Supposing this to be the view really entertained, it is

essentially different from that held by the scientific philosophy. The course of Nature as it presents itself to the eye of science is not a collection of isolated causes, each with its effect attached to it, but it is rather to be symbolized by a chain in which each link is connected with the link which precedes it and with the one which follows it. At each moment of time, the state of the universe is the effect of the state which immediately preceded it, and the cause of the state which immediately follows. There are no such things as distinct causes and effects, but only laws of progress which connect the successive links of the seemingly endless chain.

As an illustration of this, let us take the falling of the rock. To the mere observer there is no evident reason why it should fall at one time rather than another, he may, therefore, feel that there is room for speculation as to the cause which made it fall at the exact moment it did. But science teaches that it will fall at the very moment when the cohesive extraction which binds it to the mountain behind, becomes less than the weight of the rock. We might suppose a power to so adjust the causes which effect the cohesion that the rock shall fall at some desired moment. But any such adjustment would be as complete a change of the course of nature as if the power should hold the rock up after it had begun to fall. The natural processes by which the cohesion of the rock is slowly diminished, though largely hidden from our view, are governed by laws as precise in their action as those which regulate the motion of the planets. The water which falls from the clouds slowly percolates through the ground, and enters a crack in the supporting mass. It wears it away at a rate dependent on the solubility of the material and the quantity of water which falls. A constant, but certain molecular action goes on without ceasing between each molecule of water and each molecule of rock. The strength of the latter is thus weakened according to some law admitting of precise mathematical statement. Thus, a mind possessed of sufficient mathematical ability, knowing how much water runs over the rock from time to time, and knowing also the laws of molecular action between the rock and the water, could determine long in advance the very moment at which the rock would fall.

Going back another step, we see that the quantity of water which runs over the rock depends on antecedent circumstances in

the same way, namely, upon the quantity of the rainfall and the arrangement of the crevices in the ground. However the latter may have been produced, the cause is still another link in the endless chain which we can trace back to preceding links as far as we please. Equally is the rainfall a fixed element, determined by the course of the winds and the amount of moisture which they carry. Thus we have a network of causes, too complicated for the human mind to trace in detail, but which the philosophy of science teaches us act with mathematical certainty. No tempering, modifying, or adjusting action comes in at any stage of the process, so far as we can see; if we admit such action, we have to keep placing it farther back as our knowledge increases.

Now there is one feature of these causes, the admission or rejection of which constitutes the main point of difference between the two schools of thought which I have before indicated. All are agreed that the course of nature is determined by what we may call causes or laws, but all are not agreed as to the scope of action of these laws. The great and distinguishing feature which the school of sciences recognizes, and which the other school does not recognize, is that all the laws of nature act without any scrutable regard to consequences. I qualify my statement by the word scrutable, because it is entirely outside the pale of scientific research, to speculate upon possible inscrutable ends in nature. This being a subject of which the man of science, speaking as such, can affirm nothing, so he can deny nothing. Having found that no trace of regard for consequences can be seen in the mode of action of the laws which he investigates, but that the whole course of things, so far as his eye can penetrate, may be explained and predicted without supposing any such regard, the demands of science are satisfied, and he must there stop.

Let me illustrate this by going over the train of thought which has just occupied us in the opposite direction, starting from the rainfall, and tracing the succession of causes to the fall of the rock. The spot at which each drop of rain shall fall is determined by antecedent conditions entirely, by gravitation, and the winds. The drop neither seeks nor avoids the crevices, never asks in any way what shall be its destiny after it reaches the ground. It strikes the ground wherever gravity and the winds bring it, percolates through the soil according to the law of least resistance,

and dissolves the rock according to the laws of chemical affinity, without any respect to the consequences, immediate or remote. At length a moment arrives at which the cohesive force of the rock becomes less than the weight which urges it downward. This moment is fixed entirely by antecedent circumstances, such as the solubility of the rock and the amount of water which percolates over it. At this very moment the rock begins to fall. It falls sixteen feet the first second, three times that distance the next, and so on, according to the mathematical law of falling bodies, without any respect to the lovely character of the beings it may destroy, or the disasters with which it may crush the fondest hopes of men. The region may be the wilderness; the passer-by may be a babe in its nurse's arms, an angel of charity, fulfilling her mission of good will, or a murderer aiming the deadly blow at his victim; but under no circumstances can we see that these conditions in any way affect the chain of causes which lead to the falling of the rock, or cause it to wait a moment or swerve a hair's breadth from its inevitable course.

According to the theory of the course of nature, which I am trying to elucidate, the chain of causes which we have described, each cause acting according to antecedent conditions, but without any regard to consequences, is the type of the whole course of inanimate nature as far in space as the telescope can penetrate, and as far back in time as the geological record can be deciphered. An essential feature of the theory is, that the laws which connect the several links of the chain, and thus determine the progress of events, do not possess that character of inscrutability which belongs to the decrees of Providence, but are capable, so far as their sensible manifestations are concerned, of being completely grasped by the human intellect, and expressed in scientific language. Without this, the theory would have no practical bearing whatever, because to say that the course of events is fixed, but by laws which we can never grasp, would give us no clew at all to learning what that course shall be, and would be equivalent to telling us that it is enshrouded in the same impenetrable mystery with first causes. A very important feature of the progress of science is found in the constant resolution of the laws of nature into more simple and elementary ones, until we reach principles so simple that it is impossible to analyze them farther. Let us take

as an instance of this the laws of the celestial motions. When Kepler discovered that the planets moved round the sun in ellipses, having the sun in one focus, he found what were, for his time, simple and elementary laws. They were entirely comprehensible, admitting of being expressed in mathematical language. They enabled him to predict the motions of the planets, and, so far as the intellect of the time could penetrate, they could not be resolved into more simple expressions.

But when Newton appeared on the scene, he showed that these and other laws could be expressed in the simple and comprehensive form of gravitation of every particle of matter toward every other particle with a force inversely as the square of the distance which separates them. All the laws of planetary motion which had before been discovered were shown to be reducible to this one simple law, combined with certain facts respecting the directions and velocities of the planetary motions. The most essential of these facts is, that the velocities of the planets in their orbits are such that these orbits, under the influence of the sun's gravitation, are nearly circular.

By this grand generalization Newton reduced the laws of the celestial motions to a form so elementary, simple, and comprehensive, that no further reduction seems possible in our present state of knowledge. Attempts have been made to show that gravitation is itself the result of discoverable causes, but they appear to me entirely unphilosophical, since the causes into which they would resolve gravitation are more complex than gravitation itself. But for our present purpose it is not necessary to concern ourselves whether gravitation may arise from some more subtle principle, as yet undiscovered. The point which I wish you to grasp is the entire comprehensibility of the law, as it now stands. There is no mystery surrounding it. When I say that any body left unsupported will fall toward the centre of the earth until it meets with the earth itself, or some other obstacle to its farther fall, you know exactly what I mean, and what are the results of the law which I enunciate. In a certain sense we might say that the laws of nature are simply *general* facts, distinguished from *special* facts by their dependence upon certain antecedent conditions. Considered as such, there can never be any doubt as to their meaning or results. There is no profound philosophy involved in their action

or expression any more than there is in such statements as that all unsupported bodies fall toward the centre of the earth; that gunpowder, when touched by fire, suddenly changes to an incandescent gas; that water, at ordinary pressure, changes to steam at a temperature of 212° .

Now, scientific investigators are earnestly endeavoring, each in his own sphere, to do for the whole of nature what Newton did for the laws of planetary motion, to find and announce the elementary principles which connect all the links of the endless chain which symbolizes her course. The student of chemistry cannot doubt that the innumerable properties of the various compounds which he studies arise from the play of certain attractive and repulsive forces among the elementary molecules of the matter of which these compounds are formed. Could he only learn the law according to which these forces act, chemistry might become very largely a deductive science, and the properties of compounds might be predicted in advance, as the astronomer predicts the conjunctions of the planets. The idea now entertained by those who see farthest in this direction is that all the physical properties of matter depend upon and may be reduced to certain attractive and repulsive forces acting among the ultimate atoms of which matter is composed.

It may also be supposed that all the operations of the vital organism, both in men and animals, depend, in the same way, upon molecular forces among the atoms which make up the organism. The operation of forces unknown to chemistry must, indeed, be presupposed, but there is no reason to suppose that these forces are less simple than chemical ones. Some would even go so far as to explain the facts of consciousness in this way. The philosophy of this explanation belongs, however, to another department of thought—that of scientific materialism—into which we cannot at present enter.

The most startling attempts, in the direction I have indicated, are those which are designed to show that those wonderful adaptations which we see in the structure of living animals, and which in former times were attributed to design, are really the result of natural laws, acting with the same disregard to consequences which we see in the falling rock. The philosophy of Darwinism, and the theory of evolution, will be at once brought to your mind as form-

ing the modern system of explanation tending to this result. On these theories, the eye was not made in order to see, nor the ear in order to hear, nor are the numberless adaptations of animated beings to the conditions which surround them in any way the product of design. Absurd as this theory appears at the first glance, and great as is the anxiety to secure its rejection, the question of its truth is to be settled only by a careful scientific study of the facts of nature and the laws of hereditary descent. The principle which is to aid in its settlement is universally admitted in quarters where it is fully understood. We are not to call in a supernatural cause to account for a result which could have been produced by the action of the known laws of nature. The question then is whether these laws of hereditary descent and of natural selection are adequate to account for the gradual growth of such organs as the hand, the eye and the ear, and for all the adaptations which we see in nature. If they are, it would be idle to call in any other cause, except we place it behind the laws, and if we place it behind those laws we must equally place it behind all others. Of course, such a cause lies beyond the field of sight, and does not, therefore, belong to scientific observation. Granting the theory, then, so far as the eye of science can penetrate, the whole result is brought about by laws acting in seemingly blind disregard of consequences.

Let us now turn once more to the theory of scrutable design, which supposes at least the occasional action of causes which the human intellect can perceive to have been intended to produce certain effects, such as the salvation of the righteous, the punishment of the wicked, the warning of the indifferent, or the preservation of the race. Studying this theory from the purely scientific standpoint in all the varying forms in which history presents it, we see its distinguishing feature to be the idea of causes acting so as to bring about certain results.

When Pallas inspired Diomed with renewed strength, and gave superhuman accuracy to his aim, it was in order that he might be able to pierce his Trojan enemies. Ordinary investigation might fail to show that his hand trembled less than usual as he raised his javelin, but the goddess took care that the last tremulous motion of his hand, as the weapon left it, should be in the direction to send it into the breast of the foe. The utterances of the oracles

were determined, not by the past or the present, but by events still in the future. The blazing comet appeared, not in obedience to a chain of causes commencing with the creation, but in order that man might be warned of the coming calamity. When the prayers of the righteous averted the coming storm, the cloud moved aside in order that their fields and houses might be saved, and when they brought down the gentle rain upon the parched fields, the rain fell in order that famine might be averted.

These supposed causes differed from what enlightened minds now understand by the term Providence, in being amenable to scientific investigation, and in not being included in the regular chain of natural phenomena. The designs of Providence are inscrutable, but those of Pallas and Juno were not. Careful experimental investigation, such as might have been undertaken by a Helmholtz of that time, would have sufficed to show just how Pallas wanted the spear thrown, if the view of the Homeric age was the correct one. When the King died, or the enemy was victorious, men thought they knew exactly why the comet appeared when it did.

These views having so far vanished into thin air, I do not see how we can avoid recognizing the reality of the revolution which modern science claims to have made in the views of men respecting the course of nature. And yet, as I have already shown, there are many tendencies in our being which make us unwilling to admit the revolution, and lead many to look upon the old theory as correct, provided it were only considered as tracing causes to the will of the Creator. On what is this view founded at the present time? Entirely, it seems to me, in ignoring the distinction between the scrutable and the inscrutable, between the seen and the unseen, worlds. Science has, to a greater or less degree, banished final causes from the visible universe; but they act with undiminished vigor in the invisible one. Such a translation may not be a great revolution in thought from a theological point of view, but it certainly is from a scientific standpoint, which considers only visible things.

I can readily imagine your asking if teleological causes can be really considered as absolutely banished from the whole domain of visible nature, if, considering how limited our knowledge, and how vast that part even of the visible universe which we do not

know, it is not rash to assert that we know the true theory of nature, even in the field of phenomena. This question may lead us to look, a little more carefully than we have hitherto done upon the exact standing of the doctrine of the uniform course of nature according to antecedent causes, and the relation of this doctrine to modern scientific investigation. And this leads me to say that it would be entirely unphilosophical to regard the revolution I have described as a scientific discovery or induction. It may be doubted whether the scientific mind is really any less disposed to believe in final causes than the ordinary mind. Nor can the theory that the course of nature is symbolized by the chain of cause and effect, as I have described it, be considered as a product of modern investigation simply, or as belonging especially to the present age. It is a theory which has been, in a limited sphere, recognized by all men at all times. The reason why modern science has so greatly extended its scope is, that modern science has acquired a vastly more extended view of nature than has before been obtained. One of the most curious and suggestive features of the teleological theory has been that the action of teleological causes has always been ascribed to operations into which human investigation could not penetrate, although their ultimate effects might be plainly seen. Whenever the subject becomes so well understood that the chain of natural causes can be clearly followed, miracles and final causes cease, so far as the scientific explanation of things is concerned. That a ball or spear thrown in one direction would bend its course into an entirely different direction no one ever supposed. Homer never imagined Pallas as changing the course of the javelin after it had left the hand of Diomed. But those states of the nervous system which result in a certain and accurate aim, or in a tremulous or uncontrolled arm, lay beyond the pale of physiological knowledge in the time of Homer, so here it was that the goddess intervened. When nervous action became fully understood, the final cause receded and took refuge in some deeper arcanum of our ignorance. Jove was never expected to make thunder and rain without clouds, nor was the falling of the rain ever ascribed to his interference, because every one believed that if the drops were once formed they would fall at once to the ground without any action on his part. But the mixing currents of moist and cool air, and the processes of condensation which lead to the

formation of rain and electricity, were not understood, so here Jupiter had a chance to work unseen by man. When the mode in which clouds were formed was once understood, the god of thunder left his seat upon Mount Olympus for a more distant abode. From the earliest historic times the man who took a large dose of poison has died, as a matter of course; neither good nor evil spirit had anything to do with it. But if brain disease bereft him of reason, the malevolence of an evil spirit was called in to account for the result.

Now, I beg you to notice that in all these cases, the only distinction we can make between those effects which were supposed to be produced by natural causes, and those which were produced by the will of some higher power acting with a scrutable end in view, is this: in the first class of cases we can clearly see the effect to have been produced by the action of natural causes, and in the second we cannot. This distinction, depending as it does upon the extent of our knowledge, cannot be regarded as a logical one. Yet, in so far as a belief in that class of final causes which we have been considering exists at the present day, I see no other definition of the limits within which these causes are supposed to act. Let us take an illustration from the plague now desolating our southern cities. No one would believe that under any circumstances any superior power would build a yellow fever hospital, and supply it with the best medicines. If we should say that the prayers of the whole nation for the immediate erection of such buildings would have no effect whatever, we should not be accused of unbelief or irreverence in any quarter, for every one would fully agree with us. But there are great numbers of people who believe that, if the whole nation should pray for frost, frost might be sent in answer to the prayer when it would not have come otherwise. And to many who do not share this belief, the denial of any possibility of an influence of this kind would seem to savor much more strongly of unbelief, irreligion, or irreverence, than the denial that Providence would build a hospital without human hands.

And yet, if the scientific philosophy be correct, the providential production of frost would be as miraculous and as incredible as the providential erection of a hospital in a single night without human hands. The temperature of the air and the amount of

moisture it shall have in any given place, a day, a month or a year from the present time, is as completely fixed by the present state of things and by the laws of evaporation condensation and motion of gasses as are the position of the heavenly bodies. The first deposition of frost will be determined by forces now at play, and any deviation from the inevitable action would be a miracle of the same kind as pieces of timber hewing themselves into shape and putting themselves together untouched by man. Please notice that this similarity between the two states of things is entirely independent of any philosophical theory of natural causes. All we claim is that the laws which determine the motion of the air, the formation of clouds, the fall of rain and the deposition of frost, are, with respect to their certainty of action, of the same class with those which determine the position, the movements, and the cohesion of a stick of timber. If you claim that both classes of causes are the acts of the Creator, we have nothing to say against it. All we say is that you must interpret his acts in the same way in the two cases. You must not claim that He will produce heat or cold by a fiat of an arbitrary will, unless you also claim that He will build the hospital or leave it unbuilt, according to a similar fiat. Nor is it of any avail to say that you know it to be His will that the hospital shall remain unbuilt unless man undertakes it. We can in reply maintain that we know it to be His will that the course of nature shall go on unchanged, no matter how it may effect human interests.

It thus appears that the dividing line between mechanical and final causes, as drawn by the human mind in all ages, has not been fixed by any absolute criterion, but only near the limits of the knowledge possessed by each generation. Science has extended the line entirely beyond ordinary mental vision, not by introducing any new theory of nature, but by extending the boundaries of exact knowledge, and with them, of the field in which, by common consent, final causes do not admit of being traced. The telescope has revealed to us a universe compared with which that known to ancients is but an atom, and geology has opened up to our view a vista of ages in which the lifetime of our generation is hardly more than a moment. And thus final causes have taken their flight from a vast region in which they before lay hid in obscurity. You may now ask, have they simply taken refuge in

the more distant but vastly wider circumference which now marks the boundaries of our knowledge, or are we to suppose them entirely banished from nature? This is entirely a question of intuition, and not at all of scientific investigation. I have described the scientific theory of nature as not admitting scrutable final causes at all, but as claiming that the law of the falling rock is symbolic of all her operations. But I think this is a view towards which philosophers have always inclined. We must always expect that men will incline to this view in proportion to their familiarity with the material side of nature. At the same time it is evident to all that there must have been a beginning of things, and that nature could not have commenced herself. We have, therefore, a wide belt left between the origin of nature and the boundaries of our knowledge in which we may suppose the inscrutable cause to have acted. Here we reach questions of philosophy which lie outside of our field, and which, therefore, we cannot now stop to consider.

The exact bearing of the subject will be better understood by condensing what has already been said so as to present the whole in a brief space.

1. When men study the operations of the world around them, they find that certain of those operations are determined by knowable antecedent conditions, and go on with that blind disregard of consequences which they call law. The criterion for distinguishing these operations is that their results admit of being foreseen. They also find certain other operations which they are unable thus to trace to the operation of law.

2. Men attribute this latter class to invisible anthropomorphic intelligences, having the power to bring about changes in nature, and having certain objects, worthy or ignoble, in view, which they thus endeavor to compass. Men also believe themselves able to discern these objects, and thus to explain the operations which bring them about. The objects are worthy or ignoble according to the character of the intelligences, which again depend upon the state of society. In ancient times they were often the gratification of the silliest pride or the lowest lusts.

3. As knowledge advances, one after another of these operations are found to be really determined by law, the only difficulty being that the law was before unknown or not comprehended, or that the

circumstances which determined its action were too obscure or too complex to be fully comprehended.

4. Final causes having thus, one by one, disappeared from every thicket which has been fully explored, the question arises whether they now have or ever had any existence at all. On the one hand, it may be claimed that it is unphilosophical to believe in them when they have been sought in vain in every corner into which light can penetrate; on the other hand, we have the difficulty of accounting for these very laws by which we find the course of nature to be determined. Take, as a single example, the law of hereditary descent. How did such a law—or, rather, how did such a process, for it is a process—first commence? If this is not as legitimate a subject for inquiry as the question how came the hand and the eye into existence, it is only because it seems more difficult to investigate. If, as the most advanced scientific philosophy teaches, creation is itself but a growth, how did that growth originate? We here reach the limits of the scientific field, on ground where they are less well defined than in some other directions, but I shall take the liberty of concluding my remarks with a single suggestion respecting a matter which lies outside of them. When the doctrine of the universality of natural law is carried so far as to include the genesis of living beings, and the adaptations to external circumstances which we see in their structure, it is often pronounced to be atheistic. Whether this judgment is or is not correct, I cannot say, but it is very easy to propound the test question by which its correctness is to be determined. Is the general doctrine of causes acting in apparently blind obedience to invariable law in itself atheistic? If it is, then the whole progress of our knowledge of nature has been in this direction, for it has consisted in reducing the operations of nature to such blind obedience. Of course, when I say blind you understand that I mean blind so far as a scrutable regard to consequence is concerned—blind like justice, in fact. If the doctrine is not atheistic, then there is nothing atheistic in any phase of the theory of evolution, for this consists solely in accounting for certain processes by natural laws. I do not pretend to answer the question here involved, because it belongs entirely to the domain of theology. All we can ask is that each individual shall hold consistent views on the subject, and not maintain the affirmative of the

question on one topic, and the negative on another. My object in presenting the views I have has been, not so much to propound a new theory as to promote consistency, precision, and independence of thought among those who discuss the subject.











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