Extract from an unpublished essay on physical force / by Louis Mackall.

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UNPUBLISHED ESSAY

ON

PHYSICAL FORCE

BY

LOUIS MACKALL, M. D.

WASHINGTON:
H. POLKINHORN & SON, BOOK AND JOB PRINTERS,
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Every one who has given much attention to science is convinced, that the proposition relating to the occult properties of matter is fallacious, or devoid of truth. Sir Isaac Newton, in his writings, repeatedly gives expression to this conviction ; yet, in all his reasoning, he constantly uses the terms *attraction* and *repulsion*, and adverts to the ideas expressed by these terms as axioms of physical science. In order to cover up, or to conceal in some measure, this glaring inconsistency, he disclaims the use of these terms in their literal sense, or indeed, with any meaning other than merely to express the fact of the motion of bodies so and so. Since the period at which Sir Isaac Newton wrote, physicists, and indeed, all scientists, have used the same device to avoid the appearance of incongruity ; but the words attraction and repulsion, and those expressing other occult properties, as chemical affinity, &c., are everywhere to be found in their writings, *and still retain their original meaning, or are used in a literal sense, notwithstanding this disclaimer.*

The proposition in science embracing the occult properties, however obsurd in itself, *must* be retained, until one, more rational, is found, that may take its place ; for unless the idea of causation finds expression, science would be at a stand ; there could be no explanation of physical phenomena, which is the main object of science. In our present system of science, the occult properties are the sole *causes*—the idea of causation is wholly vested in them. Physicists have been compelled to resort to the idea of attraction, as an occult property, in explaining gravitation, for without this they could, in their present ignorance, refer the phenomena to no cause whatever.

The great defect that has existed in science from its birth up to the present time, is, the want of a proposition that may furnish a rational explanation of physical phenomena, and that may take the place of, or be substituted for, the present absurd proposition embracing the occult properties of matter.

This great defect or want in science, I have attempted to supply, as will be observed in this Extract, by suggesting a change in the meaning of the term, *laws of nature*, as used in science. Instead of having this term to mean, as it now does, the normæ or rules of relation as established by human intelligence, I have proposed that it should be used in science in a more literal sense, *as the laws or ordinances that have been decreed by the Author of Nature*, and that have been invested with the power or force necessary to their operation, or that is required for their execution. In this sense the laws of nature may be regarded as *the proximate or secondary causes* in all physical phenomena ; and the whole idea of causation may be transferred from the occult properties of matter, to these, the true laws of nature.

Thus, assuming that a law was decreed at the Beginning of the World, by virtue of which, or by the authority of which, all ponderable bodies were made to move, or *tended* to move in a direction towards the centre of the earth—and the final cause, or the design in such a law is obvious—then, ponderable bodies may be nnderstood to move in this direction *because* of the *law* that was made to this effect ; and when we invest this law with force or power derived from the acknowledged source of all power, the idea of causation connected with the law becomes complete.

A ponderable body gravitates towards the centre of the earth by virtue of, or by the force of, *the law of nature*, that we may still call the law of gravitation. The only question left then, is simply this : does the ponderable body *tend* to move, that is to say, is it *compelled to move* (for

this is the true meaning of the word *tend)* by the imaginary occult property of attraction, that is supposed to reside in the body moving, and in the earth receiving it; or *does it tend to move in this direction in accordance with the design of the Creator, and by virtue of a law made for the purpose of accomplishing this design?* I leave this question to be decided as he judgment of the reader may determine.

But some modern scientists have attempted to get rid of the absurdity of regarding the occult properties of matter as *causes*, simply by calling them forces, potentials, or dynamics, and have added to these the imponderable forms of matter; thus we have as forces in nature or as physical forces, the force of gravitation, the force of chemical affinity, heat, light, electricity, &c., and then, by regarding these forces as being convertible, the one into another, and further, by giving them together with matter, perpetual duration, they have formed a new theory, or generalization, as they say, that is to give an entirely new phase to science. This theory, called the dynamical theory, Correlation and Conservation of the physical forces, or simply the Persistence of force, is extremely visionary and, as I shall now attempt to show, is founded on sophistry or false reasoning.

To make good this charge I must beg leave to refer to the reasoning of Count Rumford from the facts presented in his celebrated experiment in boring a brass cylinder, which, as it gave origin, as I believe, to this theory, may be taken as a fair specimen of all the reasoning used in forming it. The Count, during the experiment, observing that a large amount of heat was formed, and being at a loss in accounting for its origin or for the mode in which it was formed, after casting about, conceived, that it must have originated in the motion of the borer; and then, by a happy thought jumped to the very illogical and wholly unwarranted conclusions, that "*heat cannot possibly be a material substance,*" and that therefore, that "*heat is motion.*" Convinced by this lucid reasoning, our modern scientists have concluded that the imponderables, as heat, light, odours, &c., are merely *modes of motion.*

Had the Count reflected sufficiently, he might have found that the heat was formed by the re-combinatton of some portion of the element of the metal, that had been decomposed by means of friction, as is explained by my hypothesis, to be found at page 13 of this Extract. The same hypothesis will be found to furnish a rational explanation of many phenomena that have been misconstrued, and thus made to support a false theory. If this hypothesis should be adopted—if it is admitted, that the imponderables or, as I should prefer to call them, the diffusibles, are formed by the re-combination of some of the elements, in every change of form of matter, a large number of phenomena may be readily explained that have not been satisfactorily explained heretofore; as, the heat and light in combustion, and in the decomposition of animal and vegetable substances; the heat that is formed in living animal and vegetable bodies that are constantly undergoing changes; the heat that is produced by friction, whether of solids, or of liquids, wherein there are always decompositions, and more or less changes of form; and so of the formation of the other imponderables; they may all be formed whenever the element of matter is free to enter into re-combinations. Thus, there may be a *correlation* of the forms of matter, as all forms have one element; and there may be a conservation of the *element* of matter, as it is indiscerptible and therefore indestructible; but, there can be no convertibility of the physical forces, as the laws of nature, whence these forces or this force is derived, are not convertible; neither can there be any conservation or persistence of physical force, when this force is only exhibited during the operation of the laws of nature, and ceases, or is lost when these laws cease to be in operation.

GEORGETOWN HEIGHTS, D. C., *December 20th*, 1865.

Extract from an Unpublished Essay

ON

PHYSICAL FORCE

BY LOUIS MACKALL, M. D.

ON ELECTRICITY.

* * * * * But there is a law of nature operating in many physical phenomena that seems to have escaped observation. I have ventured to call it *the law of the life-current.*

Assuming that there is but one element of matter, a subtile fluid or ether that should be called life,* and assuming further that in every material body there is a combination of this element that constitutes the *specific life* of such body, by means of which, in some way, its continuity of substance or its integrity is preserved—the nerve-fluid in the animal body being a specimen of this *specific life*—when an electrical or other current passes through or near to any body of matter, animate or inanimate, this *specific life* tends, by virtue of this law of nature, to leave its own body and to pass into and along with the passing current, that I have termed a life-current. Notable instances of the actions of which I have been speaking, are presented in a stroke of lightning. Electricity having gathered or accumulated in a cloud, a current is started and, in its progress towards the surface of the earth, the *specific life* of the bodies through which, or near to which it passes, is given off to this current, and such bodies become decomposed, or are left in a state favorable to decomposition. Thus, the clouds and the atmosphere are decomposed along the course of the current, and at the moment of decomposition give off the light and heat exhibited in the flash of lightning. If this current

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* See my essay on the Life in Nature.

pass through or near to the body of a living animal, its nerve-fluid or *specific life* passes from the solids and also from the blood and other liquids of the body; if through or near to a living tree, its *specific life, the analogue of the nerve-fluid,* is lost to it, its solids are shattered, and its fluids decomposed or changed in character.

The operation of this law of nature is evidenced in the decomposition of forms of matter when subjected to the currents of electricity produced in the voltaic battery; for it is to the agency of this law principally that such decompositions are due.

But the point of greatest interest to which a knowledge of this law of nature leads, is to be found in the explanation it furnishes of the phenomena presented on passing a weak current of electricity through the living animal body—in giving, what is termed, an electrical shock. Through ignorance of this law, electricians and physiologists have been misled in their explanation of these phenomena.

In my essay "On the Law of Muscular Action," I have shown, I think, conclusively, that the *action* of a muscle consists in the *erection* or *active elongation* of its fibres; and that the contraction of a muscle, which is not the opposite state to that of its action, is induced by a *withdrawal* or by an *abstraction* of the nerve-fluid from its fibres. Now, in the electrical shock the muscles are *contracted* or, in other words, *are thrown into a state of contraction,* and this state is induced by the *withdrawal* of a portion of nerve-fluid that is drawn off from the fibres to be carried along with the current of electricity, by virtue of the law of nature to which we have adverted. In this experiment, then, it should be understood, the muscles are not brought into *a state of action* by the electrical discharge as has been hitherto taken for granted; but they are thrown into *a state of contraction* by the *loss* of their nerve-fluid that is essential to their action.

As physiologists have given much attention to electrical experiments, supposing them to afford the best means of elucidating the subject of muscular action, and as the phenomena presented in these experiments have been made use of to rivet, as it were, on their minds former errors on this subject, the explanation here offered, when properly considered, may serve to disabuse them of such errors.

The life-current is not confined to electricity, but is ob-

servable in connection with almost every kind of matter, as in the currents of heat in combustion, of steam in steam-boilers, of air in winds, of water in streams, &c. All these are life-currents, and on certain occasions are so powerful, or embrace so much matter, that not only the *specific life* of bodies exposed to them is taken along, but forms of matter of considerable size and weight are swept along by the force of this law of nature. Thus lava and rocks are raised and taken along, or are passed into the life-current of the volcano, trees and houses into the life-current of the tornado, and these, together with boulders of considerable size, are carried along in the life-current of swollen streams.

May not the vexed question among physicists that is now engaging much attention in our country, in relation to the cause of the bursting of steam-boilers, find its solution by a reference to this law of nature? The specific life of its substance, or of the metal of which the boiler is composed, may, under peculiar circumstances, pass into the currents of heat or of steam within, and a solution of continuity in the boiler being thus effected, a vent is given to the steam.

In this way the conditions favorable to the operation of the law of diffusion being provided, by virtue of which the imponderables are diffused, this law of nature is brought into operation, and the bursting of the boiler, the diffusion of the steam, &c., is attributable *to the force that is associated with this law* and not, as is commonly supposed, to the expansive force inherent in the steam, which, in itself, is as inert and powerless as any other form of matter. *In this instance, as in every other instance of the operation of a law of nature, the force exhibited is proportionate to the matter that is subjected to its influence.*

The law of the life-current, or a law very analogous to it, may be observed in operation in the moral world; but I will not stop to trace its effects longer than to point to the moral tornado that has just desolated our once happy country.

From all that we have here presented on the subject I think it is plain, that electricity is not *an affection of matter*, neither is it *force or motion*, nor *a mode of force or mode of motion* as is represented in the physical theory or theories now so popular among the scientists of Europe; and that it is safe to adopt the conclusion, *that electricity, in common with all the imponderables, is simply a form of matter*, that is governed by the laws of nature provided for this purpose.

OF CHEMICAL AFFINITY.

By a strange vagary of the human mind, a mere mental conception, that of chemical affinity, is classed by modern scientists with electricity, heat, light and other imponderables. This classification has its origin in false reasoning. Whenever force is exhibited in natural phenomena, scientists have felt themselves constrained to find some object, either material or purely imaginary, to which to attribute this force and which they may afterwards regard as a potential or as itself a force in nature. Thus, without adverting to the axiom in physics, THAT MATTER IS ABSOLUTELY INERT, *the truth of which they admit in the abstract*, observing the imponderables when influenced by, or when under the operation of a law of nature, and witnessing the power exhibited on such occasions, they have falsely concluded *that this power was derived from the imponderables*, when it, in fact, was derived from *the law of nature that was in operation;* and from this false step in their reasoning they have proceeded to the yet more false conclusion, *that these imponderables are physical forces.*

In chemical phenomena where the matter is palpable, they get by this axiom of physics, by forming an imaginary entity, that they call chemical affinity, and transfer to it the power, and invest it with the title, of a physical force; and in this way it is brought into the class with the imponderables. Now, the whole of this false reasoning and these absurd conclusions, may be entirely discarded from science if we adopt the plain and almost self-evident proposition, that *in all physical phenomena the force exhibited is derived from the law or laws of nature that are in operation, and not at all from the matter that is moved or influenced.* To understand this proposition rightly, it should be borne in mind that the term, laws of nature, is not intended here to mean the normæ or rules of relation that have been traced out and established in science by the human intellect; but the term is used here to mean, *the ordinances that have been decreed from the Beginning, by the Author of Nature.* All power is from Him originally; but He has delegated or imparted power to His laws for their execution; and these laws have thus become the true and sole *secondary causes* in physical phenomena. The scientist, in explaining such phenomena, need not go beyond or behind these laws; but if he stops short of them, his explanations are imperfect, and unsatis-

factory to the human mind. In the economy of nature the part assigned to man is, to discover, by the exercise of his reason, the laws of nature; and then to search out the conditions that are favorable to the operation or necessary to the execution of these laws. When he has accomplished this, he has obtained *no mastery over nature*—I shudder when I hear such expression used—but, as a reward for the proper exercise of the faculties with which he is endowed, man is graciously permitted, when the laws of nature are in operation, to make use of the power associated with them, for the accomplishment of his own purposes. More than this he does not, nor can he do.

The inherent weakness and folly of the human mind, that becomes manifest when it attempts to free itself from immediate dependence on the "ordinances of heaven," and to make laws for its own guidance, is strikingly exemplified in this new theory in science relating to the Correlation and Conservation of the physical forces. What can be more extravagant than this, from one of the originators and a leading advocate of this theory? "What takes place when we raise a weight and leave it at the point to which it has been elevated? *We have changed the centre of gravity of the earth and consequently the earth's position with reference to the sun, planets, and stars; the effort we have made pervades and shakes the universe*"! This, to my mind, is a complete refutation, by a *reductio ad absurdum*, of the whole argument by which this theory is sustained.

The absurdity of the dynamic theory, as it is called, appears not only in tracing physical force to its distribution throughout the universe, as we have seen, but is equally apparent in the retracing this force from its exhibition in physical phenomena to its source or origin in the material world.

Take for instance the force by which the pendulum of a clock is moved; this force according to this theory may be traced back to that of the arm that winds up the clock-weight; from the arm to the food consumed by its owner; from the food or the animal or vegetable matter of which it is composed, or simply from vegetable products, to the force of the sun; which latter body is regarded as the concentrated and immediate source of all the force or power in our cosmical system. But finding this localization of force too much within the field of human observation, these theorists have traced this force still further back, to the meteors that

fall into the sun; and thence to some indefinite and unknown source. And all these wild speculations are wound up with the acknowledgment that the human mind is not possessed of faculties suited to such investigations. No, indeed, it is not; but every human mind is possessed of *a moral sense* which, when unswerved by authority, is capable of detecting the absurdity of such idle speculations.

Again, it is assumed as a postulate or self-evident proposition in the dynamical theory, that there can be no new creation and no annihilation of either matter or force; but that the same quantity of both have continued from the beginning. Indeed, the whole theory is based or founded on this postulate or axiom. Now, this proposition is certainly false; for the evidence of its fallacy is continually before our eyes. In every part of the material world, new forms of matter are constantly being *created* and as constantly, as forms, are being *annihilated*. They are created in the same way now, as they were at the Beginning, that is, by the intervention of the "ordinances of heaven." Light, we are told, was created by virtue of a law of nature, or of nature's God, and so have all other forms of matter been created, down to the present time.

Whenever the conditions proper for the operation of the laws of nature of this character are provided, as for instance of the law of chemical combination, new forms of matter are the results or the effects of such operation; and are in every sense new *creations* of *matter*; and in all such creations or combinations the original forms or the constituents are decomposed and *annihilated*, as forms of matter. The abstract question, whether there is or has been an increase or diminution of the *element* of matter is one of comparatively little interest to mankind.

And so in respect to the physical forces—whenever a law of nature is brought into operation, a force is originated, generated, or *created;* and when the operation of a law of nature ceases, the force that was exhibited during its operation *is annihilated.*

It is a needless and altogether fruitless employment of the mind, or rather of the imagination, to follow this force through the several forms of matter that may have happened to be influenced or moved by it, or that may be supposed to have been effected by it, other than the palpable motions and changes that were designed to be effected, by bringing the law into operation.

In the computation of force in physical phenomena, it is wholly unnecessary to take into consideration the force that has been employed in providing the conditions necessary to the execution of a law of nature. In computing this force we may start from that that is evolved by the law or laws that are, for the present time, or for the particular occasion, in operation, and may neglect, or throw out all other factors.

Now, let us go over the same phenomena and suggest explanations in accordance with our view of the physical forces. When the pendulum is set in motion by any impulse, say that of the hand, the force by which this motion is effected is derived from the law of nature called the law of muscular action. By virtue of this law, as I have proved in an essay on this subject, when the nerve-fluid is determined to a muscle its fibres are *actively elongated*, and when the nerve-fluid is withdrawn from a muscle its fibres are contracted. By this active elongation of some of the muscles of the arm or hand, and by the contraction of others, the impulse is given to the pendulum. By this force then, the pendulum is thrown from the line of gravity, (or from the line drawn from the point to which the pendulum is attached by its wire towards the centre of the earth,) where it rested; and then the conditions favorable to the operation of the law of nature called the law of gravitation, are provided; and this law being thus brought into operation, by its force the pendulum is carried back towards the line of gravity whence it started; when arrived at the line of gravity, the pendulum, having acquired force from the law, is carried beyond the line by its inertia or inability to resist the force—mind, I do not say by its *vis inertiæ*; for the vis or force was derived from the law, and had no real connection with the matter of the pendulum nor with its inertia. When this first force of the law is exhausted or expended, the pendulum being removed from the line of gravity, the law of gravitation again comes into play, and in this way it is carried back and forward in its oscillations.

But the forces from the law of muscular action, and that from the law of gravitation acting only on the pendulum, being both weak or feeble, would soon be exhausted or expended on surrounding matter or bodies of matter, and the oscillation or motion of the pendulum would cease, if this motion is not continued by a stronger and more persistent force derived from the law of gravitation operating on the

running-weight of the clock. To bring this last force into play, the conditions necessary to the operation of the law of gravitation are provided, by raising the clock-weight by means of a pulley, and leaving it suspended.

This new supply of force is communicated to the pendulum by means of machinery, and the motion of the pendulum is continued until this force ceases to be supplied, or until the law ceases to operate—which occurs as soon as the clock-weight is no longer suspended.

In computing the force by which the pendulum and other parts of the machinery of the clock is moved, it is wholly unnecessary to take into consideration the force exerted by the arm in winding up the clock. The whole of this force is derived, as we have said, from the *law* of *gravitation* operating on the *running-weight, and from no other source.* The great stress that, in the dynamic theory, is laid on the force exerted by the arm in winding up the clock (and they trace back the whole power exhibited in the motions of the clock to this source) is done, merely to save the theory—a leading point in which is to trace back all power, as we have seen, to the sun. The winding up bears the same relation to the motions of the clock that the raising of the *starting-gate* of the water-mill bears to the vast power exerted in a large flouring mill or cotton factory. It would be simply ridiculous, to attribute this vast power or force to the slight exertion made in pulling down the lever of the starting-gate.

The force of a law of nature, I repeat, *is always proportionate to the quantity of matter that is influenced by the law,* thus the force of gravitation is in proportion to the weight or matter gravitating; the force or power of a horse is proportioned to the quantity of nerve-fluid he can command or determine to and from his muscles; the force exerted in the phenomena of electro-magnetism as in the telegraph is proprotioned to the quantity of electricity that can be brought to permeate the wires; the force in the steam engine is proportionate to the quantity of steam that can be employed in raising the piston, and so on. But, what is of the greatest importance in a practical point of view, this force can always be graduated, by either increasing or reducing the quantity of matter subjected to its influence, or by providing conditions more or less favorable to the operation of a law of nature. But to return to the subject of our present heading.

The chemist, if he will trace up the laws of relation, ot

which his present stock of science consists, to the true laws of nature, and will then be at the pains to form a proper conception of these laws, of their divine origin, of the power with which they are invested, and of their true operation; and if he will then find out the conditions necessary to bring into operation the laws of nature that belong to his department of science, will find, that on entering his laboratory, he has nothing more to do than *to arrange these conditions;* and that he may then await with confidence the results or effects that his experience has taught him to anticipate. And, what is of vast importance in physical science, he will find that he can divest his mind of all the *affections* of *matter* and of the *affinities* and *aversions*, of the *attractious* and *repulsions*, in fine, of *all the occult properties of matter*, and *of all the metaphysical entities* with which it has been heretofore clogged. With the view I have suggested, of the true character of the laws of nature, he may discard all these as mere chimeras, constructed by the human imagination, that have had their uses, as scaffolding, to build up science, but which may now be entirely dispensed with.

In accordance, then, with the above theoretical views, if a salt is to be produced, the Chemist arranges the conditions necessary to bring into operation a law of nature that he has in view—say the law of chemical combination, by bringing in contact, either by pressure or by solution, the constituents of the salt; when this is done, the law comes into operation, and by virtue of this law the combination is effected and the salt is formed.

In many, and indeed, in almost all chemical phenomena, several laws of nature are engaged, or are in operation at the same time. For example, in the simple combination we have just supposed—at the moment of conversion or of the decomposition, preparatory to a change of form by the several constituents, a portion of their elements is re-combined into the form of the imponderables, as of heat, light, &c.;* and then these imponderables immediately come under the operation of another law of nature that we have called *the law of diffusion*, by virtue of which the particles or molecules of such forms of matter are made to be diffused among surrounding forms of matter, in the same way as the particles or molecules of *ponderable bodies* are made to move

*See advertisement to this extract.

towards the centre of the earth, by virtue of the law of gravitation.

The force of this law of diffusion is proportionate to the quantity of imponderables that is formed on such occasions; when formed or liberated in large quantities, as in explosions of gunpowder and other explosive mixtures or fluids, the force of this law of nature is enormous.

I have on a former occasion treated of the law of nature that I have termed *the law of the life-current*, that is engaged in many chemical phenomena, and particularly in those presented in the use of the voltaic battery. The operation of this law of nature may also be traced in the phenomena of electro-magnetism, wherein it plays a conspicuous part; for it is through its instrumentality that the magnet is formed, and, by the force derived from this law, the iron filings and other bodies are made to cling to, or to be raised with the magnet.

In the foregoing paper it may be thought perhaps by some, that I have gone, at times, out of my way in order to oppose the dynamical theory; and have not treated with proper deference, opinions that are entertained by the greatest minds of the age. But my excuse is, that on a very careful examination of the subject, conducted through series of many years, I have been led to adopt the opinion, that this theory is a mere metaphysical refinement, as baseless as a dream; and yet, from the great authority that has been brought to bear in its favor, it has become the most serious obstacle to the advancement of true science.

OF ELASTICITY.

Elasticity, like chemical affinity, the attraction of gravitation, and all the other so-called occult properties of matter, is the result of the operation of a law of nature.

There are in nature certain forms of matter, as caoutchouc, a steel spring, wood, glass, &c., that have their particles or molecules arranged in a certain fixed position relative to each other.

When this natural arrangement of their molecules is altered, or, when this natural order of their particles is disarranged, as by the stretching of the caoutchouc, by the bending of the steel spring, the wood, the glass, &c., these molecules *tend* to resume their former or natural relative position by virtue of the *law of elasticity*, or, by the force associated with the operation of this law of nature.

Here, then, again we find, that the force exhibited in the movements of elastic bodies, is derived, not from the matter concerned in the phenomena, but from *the law of nature* that governs the motion of the molecules of these bodies. The force exhibited in the operation of this law is also seen to be in a direct ratio with the quantity of molecules subjected to its influence; as this force is proportioned to the mass of the caoutchouc, to the size of the steel spring, or to that of the bar of wood, or of the rod of glass, &c.

When the spring of a clock or watch is forcibly bent or has its molecules removed from their normal state, by winding it up, the conditions favorable to the operation of the law of elasticity are provided; the law is thus brought into operation and the force associated with this operation is developed and is imparted by machinery to the pendulum; in the same manner as was the force of the law of gravitation, to which we referred on a former occasion, when speaking of the motion of the pendulum. When, however, after a certain interval of time the molecules of the spring are restored, by means of the force exerted by the law of elasticity, to their former position, this active force ceases, and consequently the pendulum, being deprived of this extra force, has its motion suspended, until the law is again brought into operation by winding up the spring.

This extra force might be derived from the operation of any other law of nature, the force of which could be imparted by machinery to the pendulum—some extra force constantly acting being all that is required to sustain the motion of

the pendulum. It may be remarked that in the restoration to the normal state of elastic bodies that are *bent*, as a steel spring for instance, there is a double force exerted; as the molecules on the surface of the side to which the spring is bent are compressed, while those on the opposite surface are stretched, so that the law is at work on both surfaces, *extending* the molecules of one surface and *reducing* those of the other.

OF HEAT.

Science is emphatically a human institution, and consequently the general propositions of which it consists, and that are derived from human reasoning, should not be regarded as being infallible or as being absolutely true. I think it can be shown that some of these propositions, or some of the theories that have occupied the highest positions in science, as Sir Isaac Newton's theory of gravitation, Harvey's theory of the circulation of the blood, &c., are false or fallacious, as being founded on erroneous principles or propositions. All that should be required of a proposition to entitle it to a place in science is *its utility as a means of aiding human invention*, or, in enabling man to attain the various purposes of his existence; and further, that it should not be at variance with other well established principles of science. Whenever a new principle is established in science the old propositions or theories should be amended so as to accord with it; but before amending the old it should be seen clearly that the new is more correct and more useful as a means of aiding the invention. Now, heat was formerly regarded in science, or, in its philosophical sense, as a subtile fluid or form of matter commonly called caloric; but modern scientists seem disposed to regard heat rather as *a mode of force* or as *a mode of motion*. To my mind the latter theory is founded on false reasoning, is wholly untenable, and is not by any means as useful as the former, either in furnishing explanations of physical phenomena or in aiding human invention in other respects. It is also at variance or wholly inconsistent with what I think should be admitted as a principle in science, namely—that physical force is derived solely from the laws of nature.

In treating of heat here, then, I shall adopt the old theory, so far as to regard it as a subtile material substance, or fluid form of matter; and shall consider it as being governed in its motion, changes of form, and combinations, like other

forms of matter, by the laws of nature provided for such purpose.

Heat, or caloric, to use its scientific term, is one of the imponderables, and as such is subject to the law of nature that we have called the law of diffusion; and by virtue of this law is conveyed rapidly to all surrounding bodies until an equilibrium is established between these bodies and that from which the heat emanates. A portion of the element of all bodies, when being decomposed, takes the form of heat as a convenient form for diffusion among other forms of matter, to which their particles or their elements are to be transferred.

When heat is diffused as we have seen, by virtue of another law of nature, it *tends* or it *is made* to permeate all bodies with which it comes in contact, to be insinuated between their molecules, and thus to increase their size or their diameters. Heat is also subject to the law of nature that we have called the law of chemical combination, by virtue of which law it becomes a constituent of the bodies into which it enters; and in some instances this combination results in the production of forms of matter of distinct and peculiar characters. Its combination with the metals renders them fluid, with ice produces water, with water produces steam, and so on.

OF STEAM.

When heat or caloric is applied to or brought into intimate union with water, a new substance or form of matter—steam—is generated. Steam, then, is the product of the chemical combination of the caloric with the water, as water is the product of the chemical combination of oxygen and hydrogen.

By this combination a new substance is formed, having characters peculiar to itself; and in consequence of these peculiar characters is ranged under the head or in the class of imponderables.

Now, the characteristic of the imponderables or the distinguishing mark of this class of material bodies is, that they are diffusible; that is to say, that the particles or molecules composing such bodies of matter tend to be diffused among other surrounding bodies and especially among the forms of matter that are above them.

The imponderables, however, are not centrifugal in regard to the earth, as is sometimes supposed, their law not

requiring them to move in a precise direction *from the centre of the earth;* but only that they should be diffused among surrounding bodies or forms of matter; and, as they are more readily diffused or lose their identity among volatile forms of matter, many of their molecules are carried above for this purpose. Sparks do not all fly upward, although a sufficient number do so to give the impression that this is their tendency, or at least to give rise to a saying to this effect.

Steam, being one of the imponderables, is subject to the law of nature called the Law of Diffusion; and the force of steam, which has erroneously been referred to the expansive property of the steam or of its molecules, is properly attributable to the law of Diffusion, that compels, or, that enforces the separation and diffusion of its molecules. As the circumstances most favorable to the operation of the law of gravitation is a clear passage towards the earth's centre, so the circumstance most favorable to the operation of the law of diffusion is, an exit or vent to the atmosphere or forms of matter above the surface of the earth.

When steam is confined within a metallic tube in which a piston moves, the whole force of its law is, or may be caused to be, expended in raising the piston; but when the steam reaches the atmosphere the same force of its law is frittered away by the diffusion of the molecules of the steam in all directions. The same force may also be suddenly suspended by having its nature changed by being decomposed and reconverted into water and heat as when water is used as a condenser.

The quantity of steam provided for an exhibition of force must always be proportionate to the amount of force we wish to have exhibited. Steam is also subject to the law of nature that we have called the *Law of the Life-current;* hence, when a strong current of steam is generated in steam-boilers, there is danger of the bursting of the boiler as formerly explained.

OF LIGHT.

In the dynamical theory of heat the greatest difficulty that presents itself in regarding heat as a mode of force or a mode of motion, is found in the fact of its making an impression on the sensory nerves of animals; and the difficulty is acknowledged by the advocates of the theory to be so far insuperable. This impression implies a material sub-

stance or form of matter by which it is made or from which it proceeds, and thus presents the *proof* of the *materiality* of heat. The same proof of the materiality is presented in the case of odors. The impression on the olfactory nerves made by ammonia or musk is undoubtedly derived from a material substance. There is the same proof of materiality of sapid bodies, as sugar or salt, that make impressions on the gustatory nerves. None, I presume, can have the hardihood to deny materiability to ammonia, musk, sugar or salt, or could say that these are not forms of matter.

Of the materiality of Light we have not only the proof just mentioned, from the impression it makes on the optic nerves; but we have the strongest proof that is furnished by analogy. As odors and sapid bodies have special organs and special sets of nerves on which their impressions are made, so in animals there are special organs and special nerves for the reception of impressions from Light.

Light as a form of matter, seems to have been created with an especial reference to living Beings; for the existence of such Beings is greatly dependent on this form of matter—their actions of nutrition, &c., being suggested, as will presently be explained, by the presence of Light. This is true of the vegetable as well as of the animal kingdom; the latter for the most part being endowed with a special class of nerves and with organs adjusted to the reception of impressions from this source alone.

On the laws that govern the motion of Light from one body to another in the universe, I need not dwell here, further than to suggest to scientists that such laws that are now but rules of relation, should be traced up to the true laws of nature, from the force of which this motion is derived.

Light being as we have seen, a form of matter, and consequently having the same element with other forms of matter, we can readily comprehend how it is convertible into any other form, and how any other form of matter may be convertible into light; thus light is absorbed by many or most bodies and undoubtedly furnishes, when decomposed, a constituent of such bodies—as many bodies of matter when in decay give off light. The nerve-fluid is sometimes converted into light, as that of the fire-fly, &c.; heat under some circumstances is converted into light; and so are many other forms of matter when exposed to an electric current; the light or flash of lightning is derived from the clouds or from the atmosphere that is decomposed by

means of, or, in consequence of, the passage of such current.

The light of the sun is unquestionably an object of vast importance in our cosmical system; but its principle use is derived from the circumstance, that it is appointed to be a suggestive impression that suggests to animants obedience to many of their instincts or laws of nature that are made to govern their conduct, as intimated above when speaking of the nutrition of living beings; but the agency attributed to this luminary in the Dynamical Theory, appears to me to be absurd and preposterous. The sun is but a form of matter, and as such can be possessed of no active properties within itself, is incapable of any action whatever, and is indeed but an inert mass of matter, in its philosophical sense of meaning. Whatever motion or change of form there may be among its particles or molecules, are referable to the laws of nature, that are made or decreed to govern these motions and changes, and are not at all attributable, *in any sense* to the *matter of the sun.*

In considering the idea of causation in connection with the sun, it becomes necessary to draw off the attention from the inert matter of which it is composed, and then "to look aloft" to the true laws of nature—to the ordinances decreed by the Author of Nature—for secondary causes. By means of the laws of nature the emanations from the sun were at first created; by the force or power derived from the laws of nature these emanations are impelled in their motion through space; and by virtue of the same laws the light and heat of the sun are constituted the suggestive impressions that are made to awaken as it were the dormant energies of all organized Beings.

OF SOUND.

It has been remarked that every hypothesis that has ever found a lodgement in the human mind must have had some truth in close connection with it, or otherwise it would not have been entertained. The truth that commends the hypothesis in which the imponderables are regarded as modes of force or motion, is to be found in the fact that these forms of matter being readily influenced by the laws of nature are most frequently observed while so influenced, and have thus been liable to be confounded, and have been confounded, with the force from the laws that impels them or causes their motion. The truth that commends the hypothesis relating to the correlation, the convertibility and the conservation of

the physical forces, is to be found in the fact that there is, indeed, a correlation and a convertibility of the *forms* of matter and a conservation of the *element* of matter. All forms of matter are correlated, in having the same basis or element; and having one element are convertible, the one into another. There is also a conservation of this element; for, being indiscerptible and indestructible, none of it can be lost. The truth that has taken along the hypothesis that sound is a mode of motion, is found in the fact that there are undulations or waves in the medium through which sound is propagated; but these undulations furnish no more proof of the immateriality of sound than the waves of water of the immateriality of the air or wind by which these waves are attended or are said to be caused. There is the same double proof of the materiality of sound that there is of the materiality of light that we formerly presented.

As we have seen the nerve-fluid or specific life of animants is convertible into light, so the same fluid is convertible into sound, as in the lowing of cattle, in the song of birds, and in the hum of insects, &c., all of which sounds are produced by the expenditure of the nerve-fluid, or are mere combinations of this fluid.

ON COMBUSTION.

The proper phenomena of combustion, or those belonging properly to this process, are the results of chemical combination, or are the effects of the operation of the law of nature that I have called the law of chemical combination—oxygen being what is called a supporter of combustion, combining, by virtue of this law, with the carbon or with a metal, and forming an ash or an oxide.

The heat that is formed during combustion is an incidental formation that takes place, as was formerly observed, at the moment of the decomposition of the fuel or of the metal and of the oxygen or atmospheric air. This heat gives rise to force, by being subject to or by supplying the condition favorable to the law of diffusion, and it also supplies a condition favorable to the operation of the same law by combining with water and forming steam, which is highly diffusible.

Being misled in their explanation of the phenomena of combustion, physicists have lost sight of the immediate or primary results, and have fixed their attention on these collateral or incidental issues. Thus in the burning of coal,

the law of combustion or of chemical combination only gives rise to the force expended in forming the ashes, whilst all the other force exhibited is derived from other laws of nature, as from the law of the *life current*, the law of diffusion, &c., that act on the imponderables of whatever kind that are formed during combustion. The idea, then, that there is power or force in coal is utterly fallacious, as are also those that refer to the wind, to running water, &c., as immediate sources of force or of power; for all these forms of matter give occasion to the exhibition of power merely by serving as one of the conditions that are necessary to the operation of the laws of nature, with which alone in the economy of nature is power immediately associated.

OF THE FORCE OF RUNNING WATER, CALLED WATER-POWER.

By virtue of a law of nature, water or other liquids are made to move or to flow along a certain plane on the earth's surface, called the water-level. To bring this law into operation it is only necessary to bring the water to a proper relation to such plane, and then we have the force connected with this law of nature exhibited to an amount proportioned to the quantity of water so arranged.

When a large body of water is collected, as in a mill-dam, and a water level is prepared as a mill-race, the force of the flow is proportionate to the quantity of water that is above the bottom of the race, unless a portion of this water is obstructed by a water-gate or other obstacle.

Water, however, being a ponderable body, is subject to the law of gravitation, and the force of its flow is increased by the force of this law of nature when it falls perpendicularly, as when it falls into the buckets of the water-wheel; but the facts or the phenomena presented in the flow of water plainly lead to the apprehension of the law of nature to the force of which I have attributed its flow, and which may be called the *Law of the Water-level.*

OF THE FORCE OF WIND, CALLED WIND-POWER.

When a portion of the atmosphere is rarefied from any cause, the circumambient air, by virtue of a law of nature, is made to flow towards the rarefied point. This law of nature may be called the Law of Atmospheric Equilibrium. Currents of air induced by the operation of this law constitute the winds, the force of which is in a direct ratio with the

quantity of air that is brought under the influence at any one time of this law of nature.

When a current or mass of moving air is thus generated, it is carried along in a direction where there is least resistance, and is, in consequence of its inertia, carried by the force of the law beyond the rarefied point, and then is again returned to the same point by virtue of the same law of nature; so that we frequently have contrary or adverse winds succeeding each other, in a manner resembling the oscillations of the pendulum of a clock.

When the rarefaction is removed, or when the temperature of the rarefied point becomes equalized, the force of the law ceases and there succeeds a calm.

OF VITAL FORCE OR THE FORCE EXHIBITED IN CONNECTION WITH ANIMATE OR LIVING BEINGS.

The subject of Vital Force, or, of the forces that are at work in the economy of a living being, is so complex, and the phenomena presented in this economy are involved in such an intricate maze, that to explain them fully is a task much above my humble capacity. I shall therefore only venture to offer a few suggestions in relation to this subject, that may serve as hints to others who may be better prepared to undertake this most important task.

The great principle that I have heretofore, in this paper, gone on, namely, that all the power exhibited in the economy of nature is derived from the operation of the laws of nature, will be found of infinite service in explaining vital phenomena. The force or power, and the motives or the forces impelling the acts of living beings, or as I shall hereafter term them *animants*, are all, as we shall presently see, derived from the laws of nature that are provided for these several purposes.

The laws of nature that are made to govern animants or to which these beings are subject, may be divided into two grand classes or codes, if I may be allowed the use of this term here; the one designed to govern the changes of form and motions of the material forms of animants, and the other designed to govern or regulate the acts or conduct of their immaterial portion, or their spiritual existence.

The first of these two classes or codes, I propose to call the laws of organized matter, or simply, *the organic law;* and to designate the other class by the term *instincts*. These are the laws that are characteristic of animated forms of

matter, although the same forms are subject to some of the laws of nature in common with inanimate matter, as, to the law of gravitation, and, in some measure, to the laws of diffusion, when such bodies are filled, as they sometimes are, with diffusible gases.

OF THE ORGANIC LAWS.

The organic laws are the laws of the combinations and decompositions that take place in the living body; and these combinations and decompositions are merely dual; that is to say, there are but two constituents immediately engaged in these processes in the living body, namely, the nerve-fluid or the *specific life* of the Being, and the material with which it combines. There may be, however, a number of re-combinations with the materials as they become elaborated or influenced by the nerve-fluid, in the passage of such materials through the living economy; thus the combination of the nerve-fluid with the masticated food produces chyme, in the stomach; its combination with the chyme produces chyle, in the small intestines; and its combination with the residual contents of the small intestines produces faces in the colon and rectum. Again, when the chyle is taken up from the intestines by the lacteals, and is conducted through the receptaculum chyli and its ducts to the left sub-clavian vein, the combination of the nerve-fluid with it, converts it into blood. And, again, the combinations of the nerve-fluid with the blood gives rise to the secretions, whence the nerve-fluid is derived for the general supply of the system. When the nerve-fluid is withdrawn another series of changes occur that take place for the most part, within a system of vessels called the lymphatics. In these the fluid secretions become decomposed by the loss of their nerve-fluid, that is taken up by the afferent nutritory nerves, that are probably branches of the sympathetic nerve. In this way, the secretions are reconverted into blood and are poured into the left subclavian vein along with the contents of the ducts of the receptaculum chyli, and are finally thrown out of the system along with the excretions from the lungs, and afterwards from the colon, rectum and urinary passages.

A portion of the food of animals is thus seen to be converted into the nerve-fluid and another portion as it is carried along in the circulation of the blood, is combined with the nerve-fluid it meets with, and being thus prepared, when it

reaches the several organs or the tissues of these organs, by a recombination with the nerve-fluid, peculiar to these organs or tissues, it is converted into the tissues of the several organs to which it is carried. When they have accomplished the purpose for which they are designed, these tissues become decomposed and, with the loss of the nerve fluid, the effete portion is again taken into the circulation and is finally thrown out of the system along with the excretions.

Now all these changes of form of which which we have been speaking—these combinations, recombinations and decompositions—take place by virtue of the organic laws, and at the moment of each change a portion of the element of matter that is set free, is recombined into heat; and this hypothesis fully explains the formation of heat in the living body, without the aid of the absurd supposition or hypothesis of the ignition of carbon within the body. Let it be clearly understood further, that no force is conveyed into the system by the food; more than by its furnishing one of the conditions necessary to the operation of the organic laws of nature; and that then all the force generated in the operation of these laws is expended in the several acts of combination and decomposition of which we have spoken.

The food has no direct connection with muscular movements, and is only remotely or very indirectly connected with them, by furnishing the materials for the formation of *the nerve-fluid*, which, as we have elsewhere shown, is an essential prerequisite in inducing muscular movements, or, furnishes a necessary condition to the operation of the law of muscular action.

OF THE INSTINCTS.

The Instincts are the laws of nature that are addressed by their Author to the immaterial portion, the spiritual existence, the soul, or mind of living beings, and are designed to govern or to regulate the conduct or acts of such beings. These laws differ essentially from the other laws of nature, in regard to the force or authority that is associated with them for their execution. This authority is not absolute, as in the other laws of nature, but only extends so far as to prompt, to urge, or to suggest to beings on which they operate, obedience to their demands. Every being is left free to obey or disobey them, as his own particular judgment may dictate; "His service is perfect freedom;" but it is a most important fact or truth, that has been ignored or passed by

unnoticed in philosophy, although partially recognized in theology, that, *in the economy of nature, pleasure or happiness is proposed as the reward for a due obedience to the Instincts, and that pain or suffering is the punishment appointed for a disobedience or for an undue or improper obedience yielded to these laws.* There is no pleasure enjoyed nor pain suffered by animants that may not be readily traced to these several sources.

To direct man in the attainment of pleasure or happiness. and in the avoidance of suffering from these sources, he has not only his individual judgment and moral sense constantly being improved by exercise or experience, but he has also precepts both moral and religious, the rules of society, and the laws of government, that are all designed to contribute to the same end.

By virtue of the Instincts the performance of all the functions of living beings, both mental and corporeal, or the exercise of all the faculties with which they are endowed, is prompted; and, as all the other laws of nature require certain favorable conditions for their operation, so the Instincts require like conditions in order to bring them into operation. These conditions are the impressions made on the mind by what may be called, in reference to the body, internal and external material objects—each law or instinct requiring its own impressions, derived from peculiar forms of matter, in order to bring it into operation. These impressions on the mind we have called *suggestive impressions,* because they serve to suggest obedience to these laws—each impression suggesting obedience to some particular instinct. Thus the sight of food is *the external impression* that suggests to the animal the act of taking food, but to make this impression operative there must be at the same time an appetite for food, that is, a state or condition of the stomach in which it is prepared for the food—as a proper secretion of the gastric liquor, &c.; this state of the stomach is *the internal suggestive impression,* without which the act of taking food can not be perfect, or without which, this function is not properly performed; the sight of the female is to the animal the external suggestive impression that suggests obedience to the instinct that urges him to gratify his venereal appetite—but to perform this function properly there must be an internal impression made by the presence of the secretion of the semen, &c.; and so of all the other functions of animals; light suggests the act of seeing, but must be

aided by the normal condition of the organs engaged in this function; sound suggests the function of hearing; odors that of smelling, the presence and solution in the saliva of sapid bodies that of tasting, and so on; but the internal impression of which we have spoken, must be present in order to render these acts complete; for the spiritual existence to which all the functions of living beings should be referred, does not go through with the several stages of these functions unless such impressions are received by it, or unless it is prompted in these several stages by these suggestiue impressions.

What has just been said may serve to suggest a rational explanation of the difference in the movements of the voluntary and the involuntary muscles; the movements of the latter, whether of contraction or of action, requiring the presence of some internal suggestive impression—as that from the contents of the tubes—in order that the mind may determine the nerve-fluid to or from the muscle, and thus bring into operation its law of nature—the law of muscular action; while the former only require the formation of a design in the will, in order to induce the mind to make this determination of the nerve-fluid.

The hypothesis I have suggested embracing *the spiritual existence* of living beings, *the instincts*, and *suggestive impressions*, will be found of infinite service in explaining the phenomena presented in the performance of all the functions of animants; inasmuch as it points out the causes, their natural sequences, and a rational connection between cause and effect, as is instanced in the hasty sketch, I have given of the most important of the corporeal functions, in my essay on the Law of Muscular Action, to which I beg leave to refer the reader.

The same hypothesis will be found to throw much light on the moral and social system of humanity; so that both the moralist and the socialist will find it greatly to their interest to study this hypothesis well, in all its bearings. What are termed "the snares and temptations of the world" when carefully examined will prove to be the suggestive impressions of which we have spoken, and the idea of duty that occupies so prominent a place in socialism, when analyzed will be found to be resolvable into that due obedience to the instincts that are always rewarded by the sensation of happiness or of well being; it may also be added here, that the phenomena commonly explained by a reference to

the association of ideas, find a more rational explanation under this hypothesis.

OF CAUSATION AND PHYSICAL FORCE.

The notion entertained by scientists, and particularly by the mathematicians, in regard to causation and physical force appear to me to be confused and erroneous. The whole idea of cansation as we have before said should be transferred to the laws of nature, as we have defined these laws. The various and diversified phenomena constantly to be observed in nature should be regarded as effects immediately resulting from the operation of the laws of nature as their causes; the several motions and changes of form in matter as effects must have a variety of causes to bring them about, and this variety is found in the laws of nature—some of which we have enumerated above. In a former part of this essay I have in many instances traced up physical phenomena to the laws of nature as their true causes, and on a fair induction I think we may conclude that every motion and every change of form in matter has for its cause the operation of a law of nature. This proposition is one of the most important truths, as it is the most practically useful principle in science. The motions and changes of form of matter embrace all physical phenomena with which we are concerned in science, and to effect or to bring about these, we have only to invoke the operation of the laws of nature by arranging the conditions favorable to the operation of such as we may wish to make use of, and our object is attained. If, then, by study and by reasoning we discover the several laws of nature, and then by observation and experience find out the conditions necessary to the execution of these laws, we can readily accomplish all that we are appointed or are permitted to accomplish in this department of the economy of nature—I mean the department of science.

But if the laws of nature are the sole secondary causes in physical phenomena, what rational conception can be formed of *physical force?* I would suggest this: *Physical Force or the power in nature is that which is super-added to the laws of nature as secondary causes, to give them efficiency.* Force or power *is not a property of matter* but is *an attribute of the Deity.* It originates in the Author of nature and is delegated or imparted by Him only to His laws to give them efficiency; and consequently, all the force exhibited in nature is found to be in connection with the operation of these laws. The idea that

a man can impart force to any object, say to the pendulum of a clock or to an arrow from the bow, is preposterous; for he cannot impart that which he does not possess. Man possesses no force or power whatever—not even over his own muscles—and can command none, except through the intervention of the laws of nature; but he can bring into operation the law of elasticity by bending the bow, or he can bring into operation the law of muscular action by determining the nerve-fluid to or from his muscles, and, in this way, can command or obtain the required force.

But the grandest error and the most amazing folly that has been committed in the experimental philosophy, or in modern science, consists in the mixing up and in jumbling together in the mind, the ideas relating to force, to motion, and to the imponderable forms of matter. These several objects of thought are in their natures totally separate and distinct, and this confounding them together serves to stultify the mind by effacing the clearest distinctions among its ideas.

As if, however, to compensate for this want of proper distinction, when they are indispensable, mathamathicians have introduced distinctions in the idea of force—the grounds for which it will be difficult to find. Why should pushing or pulling force be called "*dead force*," and falling force be called "living force?" when the force in each of these instances is derived from the operation of a law of nature and is in both instances identical. It is this sameness under all circumstances, that precludes it from being regarded as a *cause* in nature; for the same cause could not produce the variety of effects observed in physical phenomena.

The distinction, I suspect, is based on the truth to which I have formerly adverted, namely, *that in calculating the force of a law of nature, the force exerted in bringing the law into operation may be neglected.* That which is properly calculated is regarded as the "*living force*," and that that may be neglected is regarded as the "*dead force.* The force used in pushing or pulling a stone over a precipice would be called by mathematicians, "dead force," while that by which the stone falls would be called the "living force." In moving the hand *from* the body, as in pushing, the *action* of the muscles engaged in this act predominates over the *contraction* of the same muscles; while in moving the hand towards the body, as in pulling, the *contraction* of the muscles predominates over the *action* of the same. Both of these movements are referable to the law of nature called the law of

muscular action, as is fully explained in my essay on this law. The force exerted by the muscles, however, in pushing or pulling the stone was merely used in providing the conditions necessary to the operation of the law of nature—the law of gravitation—by virtue of which the stone fell, or from which the force was derived that was exhibited in the falling of the stone.

All this confusion of thought and false reasoning on ihe subject of physical force has proceeded from a want of definite ideas, and from a want of precision of terms, when treating this subject.

APPENDIX.

OF REASON—ITS PROPER FUNCTION, AND THE SEVERAL ACTS IN THE PERFORMANCE OF THIS FUNCTION.

Reason is one of the compound mental faculties, its action or performance of function, called reasoning, being compounded of that of several of the simple mental faculties.

The first act in reasoning is, the exercise of the observation. By means of this faculty we apprehend or take notice of some particular fact, instance or phenomena to which our attention has been called.

The second act in reasoning is, the exercise of the imagination in finding an explanation of the instance or fact observed. In this exercise, we cast about, as it were, or diligently search for some proposition that may furnish the desired explanation; and having found one this second act in the process of reasoning is completed.

The exercise of the Judgment is the third act in reasoning. The first part of this exercise consists in reflecting on or in reconsidering and amending the proposition found by the use of the Imagination, so as to adapt it as perfectly as possible to the explanation of the instance under consideration; and the second part of the exercise of the Judgment is employed in collecting and in collating a number of facts or instances of the same character, and in generalizing or in adjusting the proposition to these instances, so that it may embrace all the instances or facts of this kind that can be adduced or collected. This second part in the exercise of the Judgment in collecting, collating, and comparing, a number of facts, is what should be understood by the term Induction—which is the most important stage in the pro-

gress of reasoning, as it is that on which most study is expended.

When the proposition found, passes this ordeal, it is approved by the Judgment, and then the third act in reasoning is completed. Before, however, the reasoning process is perfected, the proposition reasoned on should have the sanction of the Moral Sense—a faculty of the mind whose special office it is to distinguish truth from error. To the Moral Sense, then, is the final appeal in all reasoning, and its approval is the consummation, the crowning act of the reasoning process.

The formula I have here presented as the natural process of reasoning, differs materially, it will be observed, from the Baconian or inductive method that is adopted in Modern or Experimental Philosophy. The error committed in the latter method consists in the transposition of the proper steps or stages of the process. The collection of facts or instances is insisted on as the first act; whereas it properly belongs, as I have stated, to the second part of the third act or stage of the reasoning process. A single instance always suggests or gives occasion to the exercise of Reason, and this, when properly observed and well considered is sufficient to lead to the apprehension of a scientific principle. I have no doubt that if every scientific principle that we have, could be traced back to its origin, each would be found to have been suggested by or to have originated in some one particular fact or phenomenon. A single fact is the suggestive impression that calls into exercise the Reason as a single suggestive impression may call into exercise or suggest obedience to the instinct that prompts to the performance of any of the functions of animants; and when this impression is received the mind instinctively proceeds to reason from this single fact. But if it is inhibited in this natural proceeding, and is forced into another and a very different pursuit—that of collecting facts similar in some respects to the one just observed, then the mind ceases to reason, and is led off into this latter pursuit or employment. Modern Philosophers need to be constantly reminded that the collecting of facts is not reasoning; but is very commonly a means of checking the mind and of destroying its saliency, or, its natural disposition to enter upon this process. In the induction in the third stage of reasoning, the collection of facts is important, as furnishing the means of

confirming the approval of the proposition by the judgment and of amending it, if defective, before it is offered as a scientific principle. This induction the mind makes *instinctively*, or, without forming a fixed design of its own to do so.

A confirmation of the justness of the above objections to the Baconian method of reasoning may be found in the fact that has been frequently remarked: that Lord Bacon, the founder of this method, never arrived at any scientific principle, and never even suggested one; neither have any of the advocates of this method—so long as they have strictly conformed to the rules laid down by Lord Bacon.

THE PROCESS OF REASONING INSTANCED IN SIR ISAAC NEWTON'S SUPPOSED DISCOVERY OF UNIVERSAL GRAVITATION.

In illustration of the view of the formula of the reasoning process presented above, we offer an example of reasoning that is familiar to scientists.

When reclining in his orchard, Sir Isaac Newton, it is said, saw an apple fall from a tree. This phenomenon attracted his attention and suggested the exercise of his Reason. He *observed* the apple when detached from the tree falling towards the surface of the ground. This was the first act of his reasoning, in which he exercised his Observation. The question then occurred to him, "why did the apple fall in this particular direction rather than in any other?" To explain this fact he called into exercise his Imagination as the second act in his reasoning. By the use of this faculty he finally arrived at the proposition *that it was attracted towards the earth by the inherent occult property of the earth, called its attraction.* When this proposition was found the Imagination was dismissed, and in its place the Judgment was called into exercise. By the aid of his Judgment, on due reflection, he was at first enabled to amend the proposition found by the imagination so as to make it express the fact *that the apple fell in the direction towards the centre of the earth;* afterwards he applied this proposition to other bodies and then generalized it, or made the proposition general, by extending it, first to all ponderable bodies on the earth's surface, then to the moon, then varying the centre he applied it to the planets, or the solar system, and finally, again changing the centre, he extended it to all the celestial bodies, making the proposition universal by this Induction. This

was the proposition that Sir Isaac Newton arrived at when reasoning on this subject, that is improperly called the *law* of universal gravitation. This reasoning has led to vast improvements in many of the Arts, as the Astronomical Art, the art of Navigation, &c.; and for the aid afforded to Human Invention, by the several propositions established, these propositions are properly regarded as scientific principles, and are fairly entitled to a place in Science until more rational propositions are substituted.

It will be observed that in the above instance of reasoning, an important part, that is, the last and crowning act of this process was omitted. Sir Isaac Newton did not gain for his proposition the approval of his Moral Sense.

This reasoning was fallacious in assuming the occult properties of attraction and repulsion as an axiom in science, and his induction was erroneous in bringing under the law of gravitation the phenomena presented in the motion of the bodies of space in their orbits and on their axes. The final cause of the law of gravitation or the end to be attained by the enactment of this law was clearly, to preserve the integrity of these bodies that without such a law would soon be annihilated by masses of their matter flying off into space; but their motions to which we have referred could not with any show of reason be attributed to the operation of this law. The splendid and most useful inferences that have been deduced from the law of universal gravitation could be drawn as well and much more rationally from another law of nature by means of which the motions of the bodies of space are readily explained. The law of nature to which I allude I have elsewhere designated as the Law of Interchange of Life.

The above is, I believe, a correct account of the process of reasoning, and of the whole process as it is appointed in Nature; and if the several acts we have mentioned are properly performed, the results or propositions arrived at may be regarded as truths. All merely human knowledge is attained only by reasoning; and this division of the process into its several acts or stages, will be found highly useful in enabling us to detect errors in our own reasoning or, as in the instance just presented, in the reasoning of others, by examining it carefully in each separate stage.

OF EXPERIENCE AS A MENTAL PROCESS.

Experience, in the sense of the term here used, is tacit or

unconscious Reasoning. It is very surprising to one who considers this subject for the first time, that a person should *unconsciously* give his attention to some particular fact that has come under his notice, and in order to account for or to explain this fact should find a proposition by the exercise of his Imagination; should then go through with long and laborious processes of reflection and of induction to gain the approval of his Judgment, and finally, that he should obtain for the proposition he has been considering the sanction of his Moral Sense.

That all these several difficult acts should be performed without consciousness is indeed astonishing and almost incredible; but yet this is the only rational explanation that can be suggested of phenomena constantly presented to our observation. We find a knowledge of principles clearly implied in the acts of individuals in every profession, in every art, and indeed in every condition of life; and the only mode that can be conceived in which they could arrive at this knowledge is, by this tacit reasoning or by this process of the mind that we have called Experience. As a corroboration of the correctness of this explanation, we find these principles or propositions applied to the attainment of ends in the same way as scientific principles are applied.

And this application too, is made unconsciously; for the individual making it, is unable to state the proposition, he is thus using, in words; and if so stated to him he would in all probability reject it on account of its novelty—such instances are of common occurrence among members of the medical profession.

The process which we have been speaking of is, like scientific reasoning, liable to erroneous conclusions, and as might be supposed, is frequently elliptic, and very imperfectly performed.

THE END.