THE

PHYSICAL BASIS OF IMMORTALITY

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NEW YORK

G. P. PUTNAM'S SONS

182 FIFTH AVENUE

1876

PREFACE.

IT cannot be doubted that the great question of to-day, for Science and Religion equally, pertains *to the nature and to the duration of Personal Life*. The inquiry embraces all lives; our own, and those of other beings who are either above or below mankind in the scale of existence; but who may possess, like ourselves, the similar attribute of an individualized consciousness.

Between Prof. Tyndall and his friends on one side and the Christian community on the other, the really vital point at issue concerns the Personality or Impersonality of Uncreated Being—the Ultimate; Science has not proved that this Ultimate is Conscious and Infinite Intelligence. The religious man knows that if he cannot cling to a Personal God, he must equally let go his firm and assured hold upon an immortal consciousness for himself.

Prof. Tyndall falls back reverently upon an irrepressible, intuitive conviction that there must be a Superior Intelligence to his own. So undoubtedly do many others. But if the foundations of religious belief are to be shaken ever so slightly in the name of Science, then the first work for Science must be to search diligently for other foundations which are laid firmly in the unchanging Constitution of Nature.

But there are many recognized leaders of modern thought or of scientific investigation, who are forward to argue that the nature of the Ultimate is not merely wholly unknown; but that it is absolutely unknowable. Hence, it being removed entirely beyond our ken, they teach us unqualifiedly, that we can expect to do nothing better than to leave the whole subject contentedly outside the pale of human knowledge, and even of rational investigation.

Possibly we might do even this. But going yet a step beyond, in the name of philosophic Science, they claim to prove that all things knowable, mankind included, are but shifting modes or manifestations of one all-comprehensive force. Their arguments lead us squarely up to the inference—which

English speaking reasoners generally allow us to make, at our leisure, for ourselves,—that the present conscious life of each of us is a complex, fleeting relation of forces; destined probably, to lapse again at death into the all-embracing unity, the Unknowable. Their position, if accepted, must compel us to believe that we can have no more certainty of a continuous personal consciousness, than we can have an intelligent assurance that the Ultimate Force is a Rational Beneficent Being. When all phenomena are resolved into perpetually changing relations of force, human life can be nothing higher or more permanent than a temporary, organized experience. We live to-day; but life must ebb away to-morrow. As the candle burns itself out, and can exist no more as a candle forever, unless some inscrutable power recollects and recombines its scattered elements, so we shall die; and dying, personal consciousness must cease with the dissolution of the body on which consciousness is wholly dependent.

This is the appalling outcome which speculative science has achieved by its interpretations of "the new system of dynamics."

Other philosophers, like M. Papillon, who first reason away immortality, attempt to draw it back again through some metaphysical loophole in the chain of argument. In his view, "It is plain, and it would be childish to deny it, that any psychical or sentient manifestations, and any concrete represeu-tation of the personality are impossible after death. The dissolution of the organism annihilates surely, and of necessity, the functions of sensation, motion, and will, which are inseparable from a certain combination of material conditions."*

"Our true personality, our real *I*, that which may without illusion, count on a future life, is unity released from every material bond, and all concrete alloy; it is that force, necessarily pure, which has a more or less clear consciousness of its own relations with the infinity of like unities, and which more or less draws near to them by thought and by love."†

This personality, without "sensation, motion, and will," certainly is not the continuous personal identity which has become known to each one of us through his individual experience. Modern "dyna-

* Nature and Life, p. 327. † Ib., p. 328.

mics" can give us no unchanging self-hood. Growing with the growth of associated elements, our individuality must change as they change, from infancy to age. We are never the same yesterday and to-day. Is this Nature's truth? Not to me.

True personal identity, in the present and in the future, is the vested kingdom of all religious aspiration! Continuous individual rectitude becomes impossible otherwise. To exist, yet to be shorn of all that has constituted existence hitherto, explain the fact on whatever theory we may, is a woful outcome for science in this 19th century. *Matter* may be proved indestructible, *force* may be proved indestructible, but the great question to us all is: Is there an actual, continuous, unchanging personal unity, the living *me*, which is also indestructible? Science and religion are equally interested in grounding themselves upon the basis of an imperishable self-hood, if this be possible.

Then is it possible? The present work is an earnest attempt to answer this question in the affirmative. It claims to be in the direct line of modern science; to accept, in their fullest significance, the generally accepted facts and principles of the physical universe, including the great law of "the correlation and conservation of forces;" in other words, "the new dynamism." But it presumes to offer a new theory of reconciliation between the facts of personal identity and the associated facts of the mutual convertibility of equivalent physical energies. It is worth while to make a life-long personal study of these great questions. Everything is at stake. So long as the wisest men can neither live, nor can cease to live, for any one of us; resolutely attempting to study for oneself, directly from Nature's open book, the character and the duration of personal existence, can involve no undue presumption.

And so long as science fails to come forward in the character of her accredited apostles with a definite answer to the question which is in every heart and on almost every lip; Is my life, immortal life? even the feeblest effort in this direction must be far from really contemptible. The authors of the *Unseen Universe* have tried to show us that immortality is a physical possibility, perhaps even a natural probability. But more than ever the soul cries out; Give me a positive assurance that my present conscious life is so deeply grounded in the very constitution of Nature that while this existing order of Nature remains unchanged, I also shall continue unchanged in true personal identity!

Trusting, religious natures, who can find God and Immortality in the Scriptures and in the unquestioned assurances of the soul's own plainest affirmations, may be repelled by this inquiry, at the outset. They believe that immortal life cannot be revealed to us through observation and reasoning. This slow, cold, passionless progress, to them will seem as sheer presumption. To them, this whole discussion will be but as the pitiful attempt of total blindness to portray to others a light of which it knows nothing.

And if there is no Rational Mind behind the universe as its intelligent Architect; if the present order of nature has arisen without plan or prevision, there can be but little expectation that human beings will be able to penetrate to a knowledge of the real nature of ultimate units of being, even if such exist. There may be no definite structures and no indestructible unities. There may exist no order in phenomena which is not itself destructible with some new turn in the vast cycle of eternal changes. Whatever is, is. That is all.

If, on the other hand, the universe is an infinite, related system of applied thought, in a sense as actual and as literal as that in which a machine or a garden are practical realizations of the thoughts of men—there must be excellent grounds of expectation that we shall yet be able to discover Nature's Basis of Immortal Life. We know that in some sense we are ourselves individualized. We have a present unity of individual consciousness. This consciousness, whether it is to be regarded as destructible or as indestructible, must have a definite structure or constitution. It exists and acts in connection with all the other powers of Nature. Then, by adapted methods of study, mankind can assuredly unravel the present mysteries of physical and psychical individuation.

We can imagine ourselves to be indestructible unities which are conserved in the midst of all changes. But if an Infinite Beneficent Mind has coördinated the universal constitution of all things, it is hardly reasonable that our conceptions should rise higher than his achievements. A half truth may bewilder and mislead; but the whole truth is organic in the deepest heart of Nature. Men may yet reasonably hope to find a more comprehensive rendering of the scheme through which definite *units of being*, physical and psychical, may persist as units, and yet be able to coöperate endlessly in a system of universal changes.

But, if possibly this truth can be discovered, no other pursuit in life is at all comparable to this one. So I reasoned. And so I enlisted for the search fully a quarter of a century ago. During all these intervening years, life and immortality have both seemed waiting to be brought into the light of established science. They have been waiting to be proved as admitted facts in nature which could become known to us through a mass of cumulative evidence, all converging toward the truth that the ultimate elements of Universal Nature are all simple and indestructible.

A class of investigators may declaim against the warped attitude of mind which could go out in quest after a definite and greatly desired boon; whereas any genuine student of science should be content simply to find the truth whatever that may be, searching after it without bias and without prepossessions. Possibly human beings may attain to a serenity of feeling which can consent to be personally annihilated without a pang. The absorbing joy of finding out the real state of the case, to a few minds may compensate for the annihilation of all hope of continuous living experience. To others, such impersonality is equally impossible and undesirable. Life, with its infinite expectations, is worth more than truth — if truth be a pitiless fatality like this.

And yet the truth, whatever that may be, will in time make itself manifest. It will be known and appreciated! The facts of nature lie about us on every hand. It is the manifest destiny of the human mind, little by little, to learn to comprehend these facts as they exist in all the multiplicity of their relationships. It is they which must test every theory.

If a passionate desire to justify a preconceived conviction which stood always forward as a permanent desired goal is to be considered a scientific disqualification, then I am eminently disqualified for this investigation. It culminated in a desperate reaching after—not simply immortal life—but after an abiding personal identity without which morality itself and all the nobler sentiments of a social existence are but a bitter mockery.

And what of the result? To my apprehension the present amount of gathered evidence is as strong as demonstration. But it is not demonstration. Nor can it be made wholly in the nature of positive truth which cannot be controverted. The scientific world has not seemed ready to concede the central claim that each division of force is inseparable from its adapted division of extension; yet the conservation of every *unit of being* must depend upon *a constitution in which these two ultimate elements of being mutually limit and define each other*. The evidence offered in proof of this hypothesis may be questioned or proved to be inconclusive. The whole line of argument may be much less satisfactory to other minds than to my own.

The scientific data itself must be in the main such as will be generally accepted; for I have understood that the great body of science laboriously brought together by many careful investigators, was the only basis on which to build, if there was to be a shadow of hope for success.

In 1869 I published a work, "Studies in General Science," kindred in topics, but especially in underlying theories, with the present discussion. The seven added years of brooding study have unfolded those earlier views without greatly modifying them otherwise. The subject has become more and more familiar to me.

In the meantime there has been a remarkable growth in public thinking; and scientific discussion has been tending strongly in the same general direction. The disastrous effects upon all personal interests which result from reasoning all phenomena into one ultimate—Force; and of assigning to it the unique task of *relationing itself into shifting divided centres and modes of co-operation*, is steadily becoming much more clearly apprehended. It is no longer thought to be utterly impossible that nature may yet show us that we are conditioned as indestructible conscious units. Men are everywhere appealing to science in proof that God and immortality are not disproved by physics. Others are insisting that science is in harmony with Revelation. The theory of indivisible "mind-body,"* is becoming the accepted hypothesis of one class of scientific thinkers.

This natural drift in the current of thought is inevitable. Physics and metaphysics, matter and mind, if they are but two phases of a common nature, must be recognized as equally legitimate departments of natural science. The confident looking to Nature for a solution of controversies, and for her unraveling of the deepest problems, is a spontaneous growth in the right direction; as the twig grows unwittingly from the live tree. It must continue to grow like any other natural product; its roots being among the most deeply grounded of natural antecedents.

The possibility that a writer on this class of subjects may gain a hearing, is much greater than even a few years ago. My chosen public, is that already

* Relations of Mind and Body. Bain.

large and now rapidly-growing class of intelligent, independent, inquiring, and possibly half skeptical minds—some of whom are among my personal acquaintances and friends—who know something of science; being ready to turn a quick ear if she would but speak with unquestionable authority; but who, in the rush and hurry of active life and its duties, find only time to keenly appreciate the scientific discredit which has been brought latterly upon the subject of continuous personal life.

It shall be my aim to make each point plain in language, direct in statement, and so amply illustrated that any intelligent person may easily follow the discussion from point to point. But the way is long and intricate; it must be pleaded in excuse that the Author of Nature has seen fit to place existences of all kinds in intimate and complex relationships. Whoever desires to know how any of us can be supposed to exist as unchanging personalities, yet taking an active part in a universe of endless changes, must simply make up his mind to the attentive study of a vast subject. It can by no means be made so obvious in character that one may expect to apprehend such truths as a child understands his picture-book, neither knowing nor caring about the alphabet which might help to explain the meaning.

The attempt to describe the action of a newly-discovered mountain having peculiar volcanic and magnetic relations, simply enough to make it fairly intelligible to the average reader, would be far from an easy or a brief task. With the best intentions, one might yet measurably fail. Let him begin where he will, he must begin in the very middle of a complex discussion.

But conscious *units of being*, if such exist, exist not only in the midst of relationships which are infinitely involved; but they are invisible units, destined to remain unseen to human eyes, if possibly they can be perceived by human intellects. Doing my best, then, will the people turn away from the investigation as from a fool-hardy enterprise?

In any event, to the writer, these great subjects have been a perennial source of unfailing interest and contentment. They have removed the ills of life backward to an almost vanishing point in comparison with the good which clusters about every pathway. They have enhanced every personal relationship; they have caused the wrongs of society to be borne with the equanimity of one who knows that they shall one day be righted. Whether we can find the truth or not, the search after truth is its own unfailing reward.

CONTENTS.

IV.—FORCE; WHAT IT IS AND HOW IT ACTS.

V.—MODES OR ENERGIES OF FORCE.

VI.—SYSTEMS OF FORCE.

VII.—SYSTEMS WITHIN SYSTEMS.

XI.—SENTIENT OR LIVING UNITS.

XII.—CO-OPERATION, PHYSICAL AND PSYCHICAL.

XIII.—CONCLUSION.

THE

PHYSICAL BASIS OF IMMORTALITY.

INTRODUCTORY.

Value of an hypothesis.—Units of being briefly indicated.—Reasons for an appeal to Nature.

AN unchanging and an unending conscious identity, with an ever increasing accumulation of added new experience, is the one thing to be desired by every sentient nature which has been so constituted that it finds in life much more of pleasure than of pain. And if life is eternal, if the personal consciousness is as indestructible as the material atom, and if both are as lasting as the existing nature of things in which they are securely and unchangeably grounded, then each intelligent person must desire to know this, that he may bring himself into line with those harmonious influences which can increase the happiness and diminish the suffering of existence.

What can we know, then, concerning life and immortality? Can Nature teach us that we must live forever? Can she convince us that each individual consciousness is a persisting unity established and sustained by immutable law? Can she instruct us as to how this consciousness is related to all other things, and is necessarily coöperative with them?

If these are facts in Nature, if they represent real and positive data held in her keeping, then to the eyes which can perceive and interpret them, she can and will undoubtedly reveal the true and exact state of the case in all of these respects. Soon or late, therefore, we might expect such knowledge would be attainable by mankind. To our faltering human intelligence the waiting lesson might be but slowly learned and repeatedly misapprehended; but if personal immortality is one of Nature's abiding facts, what can hinder us from finally learning to perceive it and to comprehend its true import?

Negative evidence can be of but little value in disproof of any supersensual existence. Life, whether a simple persisting unit, or whether, as has been latterly assumed, a highly complex and ever varying quantity, is in either case a fact standing in complicated relationship with a multitude of other conditions, none of them more than partially apprehended, and many of them doubtless very widely misapprehended. Hence, their apparent testimony must always be closely questioned, and to the last received with many degrees of allowance. Life must give us evidence for itself and of itself before we can even begin to apprehend its nature or its relations in the universe.

But when we can gain an hypothesis distinct and definite as to what life is, and as to how it coëxists and coöperates with the physical forces of nature, here is something positive which can be held up to observation in many new points of view. It can be variously tested as to its agreement or its disagreement with the other facts of the universe. An hypothesis never arises out of nothing. Even the ancients, who tried to master the secrets of nature by bringing them within the compass of their ingenious theorizing, had yet a broad underlying basis of observation for their mental superstructures. When they held that the earth was stable and motionless and that the sun made its great circuit about it every twenty-four hours, the hypothesis was directly founded upon their too limited observation of the facts; yet it was based all the same upon positive evidence furnished them by nature herself.

The value of any theory must evidently depend upon the intelligent selection, the comprehensiveness, and the consistent unity of the opinions underlying it and grounded with it upon a basis of observation. If it can establish itself firmly upon the plane of accepted science, and can satisfactorily account for all the phenomena of the subject to which it pertains, it must be accepted, at least provisionally, until other facts accumulate and a still broader explanation is necessitated. Hence it becomes apparent that by steadily and judiciously widening the field of observation, in time we are likely to arrive at the actual truth; at the sufficient and positive explanation of the matter of inquiry, whatever this may be, and that no farther modification of theory will be demanded in subsequent investigations.

It seems impossible to call in question our present theory that the earth turns on its axis every day and that it revolves around the sun every year. This knowledge is so assured to us by many corroborative evidences and is based upon such an exhaustive consideration of the many related facts, that there seems to be no possibility of its future overthrow. Compared with the evidence in favor of the older system, there is all the difference between them that there is between clever guess-work as to a set of complicated perturbations, and the careful, accurate measurement of them.

Yet it is impossible to demonstrate the motions of the earth in the same absolute way in which we can demonstrate that the three angles of a triangle are equal to two right angles; or that five and five are equal to ten. An abstract proposition can be demonstrated; but every question of fact must be left to prove itself by its manifestations of perfect and entire accord with the conditions imposed by the abstract hypothesis.

In a logical proposition, we can show that the conclusion must follow from the premises; but all premises, from the nature of the case, are simply assumptions. We cannot see the earth move. We must assume that it moves; then we can prove that if it moves so and so, such and such must be the results. Now, on turning to the facts, if we find that they correspond in all respects with those demonstrated results, we inevitably conclude that this earth does move as we suppose. The conclusion is not so much in the nature of a demonstration as of a more enlightened perception of the actual facts! It is a scientific perception of the complicated, movable relations existing between the earth and the other members of the solar system, extending even to the other less closely related, and more distant worlds.

The greater the number, the variety, and the modifying interaction of the movements supposed, when the facts agree everywhere in detail with the mathematical deductions, the higher must be the evidence that a true explanation of the phenomena has been achieved. The theory involves not only the movements of the earth through space, but also the complex and perpetually variable movements of all the other members of our earth's family-system of worlds. Yet the mathematicians could affirm, by the accurate working out of the results of the theory, that there ought to be another planet, an unknown member of the solar group, occupying a certain place in the heavens. The astronomers were able to point the telescope as directed, and to find this much needed world just in the place where science decided that it ought to be: such evidence that theory really accords with fact becomes irresistible. And when again and again, without mistake, by calculating the various rates of planetary movement, eclipses and other far off astronomical events are predicted with almost absolute accuracy as to time and place, what shadow of doubt remains that theory and fact are here in close accord?

Yet the earlier astronomical theories were based upon fact, only the facts being so few, so limited in range—the earth being taken as the fixed stand-point of observation—no hasty theory arising from them could cover the whole ground. A man sitting in a moving ship would try in vain to estimate the rate at which other vessels were moving around him, so long as he maintained that his own ship was stationary. The greater his scientific skill in exact calculation, the more inaccurate might be his various estimates. Every theory must involve a balance in the underlying factors or it will be necessarily far out of accord with many of the observed facts.

Thus facts and theories act and react upon each other. The facts are the premises; the theories are the logical following out of these premises to their legitimate conclusions. Theories necessarily grow as new facts are revealed in their wider relations; the facts being in their turn tested by the theories, and yet other facts foreshadowed or predicted and explained; the theory being thus in turn verified and enlarged, till, in time, Nature's facts and man's explanations of them must grow into harmony.

Man's logic and Nature's logic, and their mathematics which is but one division of logic, have been found again and again to agree. Man himself is but a part of Nature; it is presumed, therefore, that the whole of Nature is in essential accord. That human perception can become at one with the real and the true in the universe, we must assume; otherwise, all knowledge would be a chimera and all science an impossibility. In time, then, the existing objective facts and their logical, often revised explanations, must agree, and may be supposed adequately to cover the ground on any subject to which they pertain. Indeed, successive generalizations may usually be said to have "included and expanded, rather than superceded those which went before." The facts never change in their nature and meaning: it is man's wider observation of them, and his acceptance of other data necessitated by close unquestionable logic—verified in turn by conclusive evidence—which gives to mankind a continually higher insight into Nature's laws.

The writer has adopted the theory that *every living or sentient atom, like every other unit of being, is indivisible and indestructible; and that all its modes of sentient force, are unique in kind though interchangeable in mode among themselves; are also definitely related to associated physical forces with which they are not interchangeable in modes of activity, though inhering with them in the same indestructible physical atom. These two sets of energies mutually limit and modify each other; and together form the immutable basis of one immortal existence.*

The value of this hypothesis (hereafter to be stated more in detail, and carefully tested,) must depend upon its ability to explain and harmonize the known and accepted facts of science relating to matter, mind, and force. To be of much worth it must be securely built upon the accumulated knowledge gained by previous investigation. It must be able to present evidence, not contradicted or disproved by science, that a persisting, conscious individuality can exist, and can coöperate with other mental and with material forces and yet retain its own unity unchanged. It should moreover offer a fairly adequate explanation of *how* the sentient unit can be supposed to continue intact while yet acting either in conjunction with its organism or otherwise. It should endeavor to indicate the nature of the bond of union between the two types of force supposed to be conjoined as one; supposed to be but two phases indeed of one indestructible unity. Moreover, it should be able to offer some explanation of the nature of their supposed mutual dependence, and of the determinate action of each upon the other and upon the outside forces of nature at large.

That a theory of this character can be distinctly conceived and definitely stated, is something gained. That it can be very widely applied in explanation of multitudes of the known and classified facts in the case, must be of a certain value as leading to a wider apprehension of a great class of extremely intricate and involved phenomena.

Whether higher and broader explanations are waiting yet beyond, can only be answered in the future. Many details need farther development, and need verification. The theory as a whole waits to be variously tested by the different branches of physical and mental science. There may be found in it flaws serious enough to invalidate the hypothesis as a successful attempt at explanation of the intimate constitutional dependence of matter and mind. But even then it should do good service of its kind as pointing toward something yet more satisfactory beyond.

At the least, such a theory upholds the hope of personal immortality by the more or less successful attempt to show that immortal life is not essentially incompatible with any of the known processes of nature; but that it is in truth an integral part of the constitution both of matter and of mind. By continually seeking to indicate, through comparison with known and accepted parallel facts and other pertinent analogies, the possible *how* of the continuous coöperation of conscious life with its unconscious organism and with nature generally, the investigator will be led on toward clearer conceptions of these marvellously fascinating but extremely complex and necessarily supersensual life problems.

Where experiment falters, and quantity becomes too intangible to be directly tested by mathematics, there logic can still penetrate with its ever legitimate conclusions. But the premises! we must find those as best we can within the steadfast, changeless depths of Nature herself. Under her round of eternal changes, we can surely decipher something of her equally eternal immutability.

Whatever the limitations of the hypothesis, however halting or fallacious it may prove itself to be in the future, it is the expression of a profound and changeless conviction that the indestructibility of the personal consciousness, like every other great natural fact, is but waiting to be verified—is but waiting to be unquestionably revealed to men, by whomsoever shall be able to search wisely enough to penetrate to those mysteries of the abiding constitution of the individual mind.

However inadequate the achievement compared with this strongly impelling conviction lying behind it as an almost infinite motive, yet in this conviction one may live and die, as absolutely expecting to live on elsewhere unceasingly, as we expect the present constitution of the universe to continue forever!

Whence came the conception of immortality originally to mankind? Shall we say through a revelation of its truth to the hope and to the clear apprehension of men fitted by their moral and intellectual gifts to comprehend and to appreciate the inestimable boon? The same appreciative mental insight must yet learn to demonstrate the truths of immortal life so clearly that the most skeptical can no longer find room for doubt; for, if unchanging personal identity is an irrevocable gift to each sentient being, it is and must be an essential part of the existing nature of things seen and unseen.

And if each personal life is one and simple in the structure of its being and is organically indestructible in every possible condition of its existence, then however repeated our mistakes, misapprehensions, and wholly inadequate conceptions of it, from our blind groping along a difficult pathway, still, in time, the human mind shall yet fathom the depths of this all important truth. Nothing which science has *not yet done* can ever shake the well-grounded assurance that life and immortality shall yet stand revealed together, one and inseparable, in the undimmed light of Nature.

THE PROBLEM STATED.

Triumphs of Chemistry.—Isomeric substances.—Theory leading to discovery.—Properties dependent upon structure of Molecules.—Carbon isomers show that structure must mean more than mere arangement —Chemical poles or bonds.—Physical poles.—Fusel oils and crystals.—Structure in the chemical atom is related to many coöperative forces.—Extension and lines of force.—Is the ultimate atom, sentient or unsentient, indivisible and eternal?

SOME of the most curious as well as the most suggestive practical triumphs of modern science have been achieved by chemistry. Those savants who have learned to deal with the atoms of matter skillfully enough to thoroughly pull to pieces any substance till they reach its smallest known divisions, have learned also to rebuild many of these structures with an artistic skill which fairly rivals the handiwork of Nature herself.

What has Nature among all her treasures more delicate than the perfume of her roses? What do we prize more admiringly than the scent of her violets and her lilies of the valley? or what flavors are more enjoyable than those of her many delicious fruits? In advance, every practical business man would have affirmed unhesitatingly that all these subtle odors and savors are inimitable. But at the World's Fair of London, in 1851, there were exhibited many varieties of artificial aromatic oils which were the exact counterparts of the perfumes of flowers and fruits. At our Centennial we shall see a still greater variety. All the countless brands of universal spiciness will doubtless be gathered there on exhibition. The best achievements of science always make haste into marketable commodities.

But the greatest marvel is yet to be mentioned. The essential oil of a large number of very pungent and widely unlike aromatic substances is found to be identical in chemical composition. Thus the odorous principle of lavender, of the gillyflower, of juniper, of savin, of bergamot, of pepper, of lemon, of cubebs, of neroli, of terpentine, ect.—all substances about as unlike in odor and flavor as can well be imagined—are one and all composed of ten parts of common tasteless carbon to sixteen parts of perfectly inodorous oxygen.

If it is possible to crowd a more pungent set of characters into one family, I do not know of it. But the aromatic group is a large one ; some of the members masquerade in quaint disguises and they are liable to turn up any day in some new part. The pleasant, fruity, agreeable flavor of the apple, and the unpleasant, disagreeable taste of rancid butter, are composed of the same elements combined in the same proportions. There is also a third triplet in this group, which is composed, as both the others are, of four atoms of carbon, eight of hydrogen, and two of oxygen. This third form of the same chemical substance was discovered, like the planet Neptune, as the predicted result of scientific theory.

Many other isomeric substances have been obtained in the same way. Hundreds of learned and eager minds, supplemented by deft fingers and by delicate, ingenious mechanical appliances, have been busy for years past in laboratories, seeking, through the varied action of different chemical agents upon the same compounds, to discover the internal structure of the molecules in substances generally, and especially in those which are unlike in properties while they have yet the same chemical constitution.

The result must have equalled the most sanguine expectation. Again and again chemists have been able to predict that such and such substances were possible and ought probably to exist. And directly after they were discovered! What theory can require a higher test than this? And yet no chemist has ever seen an atom or a molecule, nor ever shall see them with any other eyes than those of the intellect!

The supposed atoms are the smallest divisions of matter which are known to exist on the earth; molecules, the least particles of any compound substance, are composed of two or more atoms, sometimes of more than a hundred. These atoms are generally, though not invariably, of different kinds. The properties of the compound, as indicated by the marvellous unlikeness of lavender, pepper, and turpentine, are found to depend quite as much upon the way in which the several elements are put together as upon the kind of elementary substances which make up the compound.

The chemical problem is, then, to find how they are put together. This is indicated by the way in which they break up and recombine under the influence of different chemical agents. Several atoms are often found to hang together more persistently than some of the others—acting as a root or nucleus to which the latter attach themselves; and by skillfully detaching these less firmly secured particles, it is found that whenever any two substances which are identical in chemical elements are yet very unlike in physical properties, they are always differently put together.

The inference is inevitable—the physical properties must depend upon the structure of the molecule. Of course the chemists bend their utmost energies to the discovery of what that structure is in these various forms of *isomeric* compounds. They can point out the various parts of each molecule; the various ways in which substances are actually put together, and the other ways in which it is possible for the same kind and number of elements to be arranged. They seem to have attained to a wonderful proficiency, and often to a thoroughly reliable and accurate conclusion, as to these apparently most occult facts of molecular structure.

Their process can be conveniently illustrated by a well-known fact in geology. Nature very often dissolves away some portion of a wood or a mineral, and substitutes some other mineral in its place without disturbing the arrangement of the remaining parts. The new mineral being a solid, generally retains the form and appearance of the original body; but the new compound, being either a fluid or a gas, is also able speedily to adjust itself to its new character and to exhibit all the properties dependent upon its modified constitution.

The chemists may be said to have sufficiently proved experimentally that special traits so characteristic of different substances, are dependent on the structure of molecules—the molecules being the smallest pieces into which any particular substance can be divided without destroying the properties of the substance. Thus a molecule of sugar has all the qualities of sugar, and a molecule of salt all those of salt; just as the least particles of a magnet are themselves magnets, with powers of magnetic attraction and repulsion like those in the larger magnet, and differing only in amount.

When the molecules are divided, the substance is no longer sugar or salt, but a new substance with entirely different qualities. There are unlike compounds which have the same percentage of like elements, but which have different molecular weights. There are others which have the same percentage of elements and the same molecular weights. Chemists have admirable devices for weighing and counting molecules and atoms with accepted scientific accuracy. The minute precision of these and similar measurements is not the least of their triumphs.

Any new arrangement of atoms within the molecule, as we have seen, may result in a compound possessing properties quite unlike those of its former condition. Such isomers, as they are called, may be nearly alike, or they may differ totally in every detail. All the essences noted above represent sufficiently obtrusive dissimilarities. One would as readily believe that gold and sawdust are alike, *at the roots*, as that lavender and turpentine are. But nature's plain testimony must be accepted. Lumps of black and brittle charcoal are the isomers of hard, sparkling, transparent diamonds; yet they are composed wholly of one element only,—simple carbon. Graphite is a third form of carbon. All three differ about as widely in general appearance, and in all definite physical properties, as any other three substances in nature. And each retains its own special characters to the last.

If this diversity is dependent also upon structure, then structure must mean more than any mere order of arrangement. It must involve possible unlikeness in the properties or powers of the same atom. Otherwise how should the same simple carbon atoms be able to assume three very distinct and definite types. This fact, more marvellous even than those first mentioned, requires explanation in its turn. But the attempt at explanation is not wanting. Atoms are supposed to have various definite poles or bonds, points of attraction, through which they unite atom to atom. Carbon atoms are found to have a number of such bonds. The carbon which is always a solid, is well adapted to act as a skeleton frame-work about which other and more volatile substances readily group themselves in a complex molecule. The molecules into which carbon enters are often extremely complex, comprising sometimes scores of atoms all ranged in a uniform manner in every separate molecule. These atoms, with their several uniting bonds, associate among themselves about as freely as with foreign atoms. Hence the three very unlike varieties of structure which give us carbon and graphite for the most varied uses; and diamonds, which are so absorbingly beautiful we readily forget that they also have a real utility.

This explanation, like the other, is good so far as it goes; but what causes the difference of structure in molecules, heterogeneous and homogencous? What is it which causes one set of carbon poles to coöperate at one time, and another at another time. The answer is *force;* different attractions and repulsions, modifications of force, produce these different results through the coöperation of the different carbon poles. But how is force associated with the carbon atom?

1. Is force in the atom as a part of its fixed constitution?

2. Does force act upon the atom as something from without?

3. Or is the atom nothing but a centre of forces?—force being the only ultimate to which we have yet arrived.

Evidently we can turn nowhere but to Nature herself, for a definite answer to all of these questions. The chemists have most carefully studied the operation of these so-called atomic bonds or poles. They find that some atoms, as hydrogen, sodium, and chlorine, have only one pole apiece—one point of molecule-forming attraction. They can form molecules together only in pairs, two and two. Oxygen has two bonds; it can unite with two hydrogen atoms, one on each side. But each carbon atom has at least four bonds; and it, in connection with other atoms, can form compounds in a large variety of combinations.

But if we are to regard these bonds in the light of so many established and unchangeable fastenings or hooks, by which they are able to grapple themselves to other atoms in the molecule, what then are we to do with the extremely slight variations? There are cases in which there is but the merest shade of unlikeness in two substances which are essentially alike in all other respects; yet this difference, such as it is, persists throughout many changes just as fixedly as do the greater differences. Some of the atoms must require a great many more bonds than they have yet received credit for, in order to account for the many determinate shades of unlikeness which exist in nature and in the products of the laboratory. Making the needful allowance for all merely temporary variations, still the permanent differences seem to have all the intermediate degrees of variation. If the atoms are anything except forces pure and simple, then it would seem that *the forms of the atoms must be themselves as variable as their forces.* Do they vary together?

For example, there are two fusel oils scarcely to be distinguished in general character; yet they and their derivatives persist in maintaining their respective peculiarities with as much resistance to change as the oil of turpentine manifests. We all know how determinedly it remains turpentine to the last, after it has been diluted and acted upon by a dozen other substances. So of these fusel oils. There is a little difference in their solubility; but their chief unlikeness in structure is revealed only by a ray of polarized light. One of these fusel oils is without action upon the polarized ray—the other turns the plane of the ray to the left—a difference no greater possibly than that between a "left-handed" quartz crystal which behaves in a similar way to polarized light and an ordinary quartz crystal. But it is a real structural difference, and seems to be an effect intermediate in its character and causes.

Other crystals, by being heated or electrified, can be made to turn the polarized ray or to transmit it as the case may be, when in this condition; but when returned to their normal condition they transmit the light in the normal direction or they are wholly opaque to it as before. The size and shape of bodies is changed by heat.

At least it becomes evident that structure depends upon an active combination of many differing but coöperative modes of force. Something holds together the molecules themselves in larger masses. This must require a new set of bonds, since the chemic bonds are supposed to be all employed and satisfied within the molecule. Besides every body is known to act upon every other throughout the universe, and it is supposed that there must be an invisible medium through which this continual interaction is effected. This requires still other sets of bonds, coöperative points of attraction or repulsion still pertaining to the atom—how many it is impossible to imagine, but the investigators are steadily widening the number and the character of the coöperative activities which are maintained between atoms in the most distant worlds. These may be termed the physical poles or bonds.

Gravitation has been called "the solder of the universe," and light, "the transported shiver of bodies countless millions of miles distant." The supposed luminiferous or inter-stellar ether which acts as a medium of coöperation between other worlds and ours is supposed also to penetrate the most solid bodies and to act between molecule and molecule, perhaps even between atom and atom. This medium, if it exists, is itself matter in as positive a sense as the most solid bodies are material—that is, it possesses or must be supposed to possess real extension as they also do—*extension standing for the* *one thing in bodies which most people think is not to be confounded with force.* Lines of force there certainly are.

Professor Tyndall says: "The notion of this medium must not be considered as a vague or fanciful conception on the part of scientific men. Of its reality most of them are as convinced as they are of the existence of the sun and moon."

But our atom of carbon, if through this intervening medium it is to exert a gravitative influence on every atom in the sun; if in its different conditions it is to vibrate with the different waves of light in the sunbeam; if also it is in magnetic coöperation with electrical phenomena in the sun, as the scientists are now beginning to decide that it must be; if all this and much more of like character is true, our simplest atom, whether it be carbon in the most elementary form now known to us or some much smaller sub-division still, our ultimate atom, instead of having four or six or a dozen bonds or poles of attraction, should possess an almost infinite number of bonds; each linking it to some portion of the vast universe outside. We may liken it to a star with an uncounted number of rays which vibrate with lines of force reaching in every direction.

Force is represented by motion, by change, by work. A centre of force is never at rest. It vibrates in unison with an immense number of various, of continuous, yet of closely inter-related and mutually modifiable activities. In the midst of all these changes is there anything permanent and immutable? May this centre of forces itself possess a definite, indivisible structure? May it possibly have an established constitution in which force and extension, mutually limiting, defining, and modifying each other, can coëxist together in an indestructible alliance? What is there in the modern discovery of the correlation and conservation of forces, when correctly understood and applied, which compels us to believe that force proper—force, the inherent power of action and of coöperation with other forces—ever is or ever can be transferred from its own atomic centre? If nothing, then every ultimate atom, sentient or unsentient, may be a self-centered indestructible unit of being. We appeal to the atomic constitution of the universe, as it has revealed itself from time to time to science, to solve the problem for us.

But indivisible centres of force, if they exist, are known to us only in coöperation with other persisting centres of like force. We must begin by asking how forces coöperate.

ALL OF NATURE'S CHANGES ARE EXCHANGES.

Nature a coöperative system.—Action and reaction equal and opposite.—Laws of Motion.—No visible body can change of itself.—Motion and resistance to motion two halves of a balanced activity.—Heat; its mechanical equivalent.—Various exchanges of motion illustrated.—Motion changed by the mode of resistance which it meets.—Energies and work.—Energy in Resistance.

NATURE as a whole must be regarded as in some sense a unit. The longer it is studied in the almost infinite variety of its parts, the more clearly it is discovered that all of them are so mutually dependent, so closely related, and so interpenetrated each by the others that they are like the cogs of a vast revolving wheel, useless in purpose and impossible in action, except as they work together in the one endless circle. The physical universe is looked upon by all scientists as a virtually infinite machine which persists and which is absolutely indestructible both as a whole and in all of its minutest parts. It changes endlessly in detail; but its changes are regulated according to certain fixed and unvarying laws.

Science has proved that all change is always an interchange. It is literally *a change*, as the name implies; a mutual transfer of processes; the direct and equal exchange between them of definite opposed modes of being and of doing. Hence every activity involves the giving and the taking in return of exactly equivalent changes; so that the two sets of modifications are coupled invariably in pairs and are the mathematical correlatives each of the other. Hence no particle of matter in the universe and no unit of force can ever be modified to the least degree without involving corresponding but always unlike modification, either in its own structure or in some other particle or some other unit with which it coöperates. In other words action and reaction are found to be everywhere equal and opposite.

This universal, absolute, constitutional principle of related change has been discovered little by little; first, as applying in one direction, and then in another and another, and yet another. That it is even now always clearly seen and consistently accepted in all its bearings, is most improbable; and yet it is certain that no well instructed physicist can be found who will venture to deny that its dominion must be coëxtensive with all changes. It is one of Nature's constants; the great key by which she winds and unwinds all her processes and holds in well regulated check the whole vast realm of eternally varying phenomena.

Newton announced the principle as the third law of motion:—"Action and reaction are equal and *opposite*." But what are known as the three laws of motion, taken together, are necessary to the full expression of the principle in its application to visible motion.

1. "A body if acted upon by no external force remains at rest; or if in motion, continues to move uniformly in the same direction.

2. When any number of forces act upon a body in motion, each force produces the same effect in altering the magnitude and direction of the body's velocity, as if it acted singly on the body at rest.

3. The velocity generated in a unit of time by a force continually acting upon a body, is proportional to the force.

These are the three laws as more recently stated. They seem like self-evident truths and possibly they are such, but they have all been proved in many ways by their agreement with a multitude of related and often very involved facts. We need to get distinctly in mind that no visible body can move or can change in any respect of itself alone; that it must move or otherwise change when acted upon by any force whatever, to an amount which exactly equals the force acting upon it; and that, if there are a dozen unlike forces at once, it reacts against them one and all, with a force equal to the sum of all the other forces acting on it, and that its modifications are the resultant and the measure of their equivalent modifications. Thus, when it takes the motion which they communicate, it gives to them in return an exactly equal power to resist motion, to just the same extent. What it gains in motion that they lose in motion, and what it loses in the power to resist motion, that they gain by the exchange.

It is action and reaction everywhere necessarily equal and opposite. Thus motion and resistance to motion may be broadly classed as comprehending the total of the two opposed manifestations of all physical force whatsoever. They act always in pairs; and the action is mathematically equal and cotemporaneous. It is indeed but the two halves, the two opposed sides, of the one balanced activity. And Nature, in the unchanging constitution of things, has insured to herself the eternal balance of all action. She has established an immutable equilibrium which regulates not only all visible motions such as the translation of bodies from one place to another, but which equally dominates all invisible molecular and atomic motions among every least particle of matter.

The laws of motion were originally discovered and announced as the laws which govern the sensible movements of tangible bodies. But it is now known that they equally govern all motions of all kinds from the least to the greatest. They apply to the science of mechanics; they govern the movements of the heavenly bodies, and they underlie the great modern discovery of the correlation and the conservation of all force; which is justly regarded as the most fundamental physical truth which has yet been announced and to a large extent experimentally demonstrated.

The later applications of the principle were indeed originally truths demonstrated by practical physicists. Count Rumford, observing that a very large amount of heat was generated in boring brass cannon, began to ask himself where this heat came from. By a series of conclusive experiments, he proved that a continuous and unlimited amount of friction would produce a corresponding continuous and unlimited amount of heat. He comprehended that the friction must be the source of the heat. The motion produced in rubbing two solid bodies together being changed into heat, heat must therefore be a kind of motion produced among the molecules or small ultimate particles of the two bodies. He succeeded in determining about how much of the one kind of motion would produce an equivalent amount of the other kind.

Dr. Joule, measuring still more accurately, found that 772 units of visible motion, are equal to one unit of heat motion; that is, a 772 pound weight moving through one foot of space, calls into exercise exactly as much force as one pound of water does when its temperature is raised one degree by the thermometer.

When, therefore, there is an interchange between these two unlike modes of motion, it must always be made upon this quantitative basis. The motion of the falling weight being changed to heat motion, there must invariably be this definite and measurable proportion between them. It is like striking a great mass of gelatine with a heavy downright blow, and setting all its particles to quivering laterally as though it were a live thing and resented it. The quivering motion is the original motion transmuted merely in its mode of moving. It is called a reaction in a sense exactly parallel to the reaction which drives an elastic ball up again to the hand when it strikes the resisting floor; but in the latter instance the floor rejects the motion, and it is still retained by the ball, while the jelly accepts the motion in a changed form and in a changed direction, but returns to the hand an exactly equivalent power to resist motion.

The structures and the positions of the colliding bodies must severally help to determine the relative distribution between them of the motion and the correlative energy to resist motion. These opposed energies must be equal and opposite; but the share which each body will finally take of either must depend upon conditions which inhere not simply in the bodies themselves, but also in their surroundings. The sum of each kind of energy will remain unchanged; but the striking body may retain the whole or nearly the whole of it, as in the case of the elastic ball, it may part with nearly the whole of it as in striking a mass of jelly, or it may retain a proportion anywhere between these two extremes. Hence the reacting body must retain, at every stage of the process, just the amount of each kind of energy which will leave the two kinds always equal and opposite, and undiminished in quantity.

Thus if the ball be not elastic, it will lie where it falls; yet in the reaction every one of its smallest particles will probably take up some portion of the resisted motion. These particles begin to vibrate, that is, to become heated; but the molecules of the floor also take up some of the same class of vibrations and the amount of all these added vibrations is just equal to the original motion which produced them. But it is also true that the amount of force which is called into action to resist motion, thus becoming for the time itself an energy, is and must be mathematically equal and opposite.

Let us suppose a heavy body to weigh 772 pounds and to fall through one foot of space into a basin containing a pound of water. If we suppose the motion to be all taken up by the water in the form of heat, the water will then become heated exactly one degree, and the weight will lie at rest. But as a matter of fact, the weight, the basin, and the surrounding air, would all of them take up and would gradually send away by radiation to other bodies each a portion of the unit of heat. The case is analogous to that in which a body in moving strikes one at rest, and they both move on together, but with diminished velocity, the original body having lost motion, but the other having gained it; the sum of the two remaining equal to the original amount. In the last illustration, the motion is not changed in kind; it remains simple translation through space, while in the first it is changed from visible motion into heat; but this change has nothing to do with the amount of motion which is retained by each of the two colliding bodies nor with the equal amount which is called out in resistance to the motion. That depends wholly upon the initial, motion-producing force.

When A strikes B with a force equal to 10, then B resists with a force equal to 10, but if A's force equals 20, then B's resistance will equal 20, or if A's force equals 100, B's resistance will equal 100. In every case the initial activity must determine the amount of reserve power which will be called into exercise as its opposing correlative; but the form in which this opposition of energy will become manifest will depend on a multitude of conditions, some of them to be more fully indicated hereafter.

What Dr. Joule and other physicists have accomplished for the advancement of science has been the producing of proof by actual trial of the possibility of changing one kind of motion into a very different kind. Practical science alone can determine the conditions under which such transmutations will occur, and it only, is competent to estimate the equivalent amounts of the many different kinds of possible motion. It has been diligently attempting to make such estimates, meeting everywhere with most encouraging success; and the promise of still more ample results in the future is as certain to be redeemed as human energy is to be unfaltering in its search.

Visible motion is found to be interchangeable with heat, with electrical and magnetic currents and various other forms of electrical activity, with chemical action, and with many kinds of vital activity.

Nearly all of these very diverse kinds of motion have been repeatedly transmuted into several of the others, and where the exchange has not been directly effected between any two, it has sometimes been indirectly accomplished through the intervention of a third or intermediate motion; as when two oppositely electrified bodies together produce a current of electricity, and this current is converted into heat.

Now since all these various energies are shown to be interchangeable, it necessarily follows that in action they are all modes of motion and in the reaction they become modes of resistance to motion. Just as a blow when it strikes a fixed mass of iron becomes heat, a motion invisible to the eye, but when it strikes a mountain of gelatine becomes a quivering visible motion among the particles, and when it strikes a ball becomes a motion which sends the ball rolling along the floor; making it evident to us that the one original kind of motion is changed by the conditions under which it meets the resisting force, so all motion is changed by the mode of the resistance which it meets.

If all force in action must be regarded as either producing motion or as resisting motion, then when wires carry electrical currents in the same direction, we know that there is some unseen motion within the wires, and when the wires begin to move bodily towards each other we must infer that the original movements are changing into the visible motion of the wires. Or when bodies are oppositely electrified and there is electrical repulsion, here is another form of electrical action becoming visible motion. And when electricity is made to decompose some substance, say water, tearing apart the atoms of oxygen and hydrogen of which the water is composed, and driving them in separate directions, we know that the electrical motion is changed into the repulsive motion of these atoms. It has overcome the forces which held the particles interlocked together, as certainly as the initial motion in A when it hits B and sends it flying to a distance, has overcome the resisting forces which originally held B at rest.

When a magnet draws one body towards itself and drives another away, we are compelled to believe that unlike invisible motions are swaying the invisible particles of all these bodies, and that the resulting actions and reactions are unalterably equal and opposite. At every stage of each process, the amount of motion distributed between the acting and reacting particles must be equal and opposite, and the amount of resistance to motion must also be equal and opposite. The atmosphere or any other visible ether coming between them not only may be, but it must be, sympathetically influenced magnetically, and coöperate accordingly, since all adjacent substances are known to act and react in correlation.

One set of the magnetic currents must be conceived of as acting in such a way as to draw the two bodies together, while the others push them asunder. All force, and all motion which is the measure of force, must be regarded as belonging to one or the other of these two types, the result being either the further separation of the reacting bodies, or the drawing of them nearer together; or, when the opposing sets of activities balance and thus for the time checkmate each other, the interacting bodies are then held stationary, while perhaps their particles are undergoing a series of perpetual vibrations like so many pendulums. Such bodies are said to be in equilibrium. If their forces are still in action, as we know that they must be, their motions are invisible to our senses. They are not energies or forces capable of doing work which can be made available to mankind.

We have no direct means of estimating the amount of force which is inherent in even the least atom, but which is thus balanced by forces acting against it, and holding it in apparent inaction. But the force special to each atom must be almost incalculable; for, however great the amount of calculable energy brought to bear upon the most apparently inert mass, it has always in reserve an adequate power which is able to manifest itself in some form of appropriate reaction.

Men of science, almost equally with practical men, have very naturally turned their attention chiefly to the available energies of nature; to the various modes of action which, by being changed from one kind of manifestation into some other and different kind, are accompanied either by definite changes in the structure of the bodies acting, or by calculable and visible motions through space. When one form of energy changes into some other form, it is thus said to perform work; and it is often made practically useful in effecting certain desirable changes which help to further the various interests of mankind. Thus heat, by driving apart the particles of water into the much more bulky and rarefied form of vapor, enables men to make use of the elastic force in this water-vapor to propel machinery of all kinds, and to perform a vast amount of necessary work in every direction. The heat motion in the coal, changes in the kind of motion in the heated water, again in the water-vapor, yet again in the movement of the piston, and in the wheel of the machinery, and yet again when it crushes the grain between the ponderous millstones or drives forward the massive railroad train as though it were only a toy bubble for lightness.

The majority of unscientific persons would be expected to take much more interest in these tangible and useful changes, than in the scientific fact that at each change in this progressive series of motions, there has been an equivalent reactionary series of resistances. But there is also a fascination to the lovers of pure science in tracing the multitudes of curious and often unexpected modifications in various substances, which result from the transmutations of the modes of force.

To be able to manipulate the forms and properties of things down even to their ultimate structures; dissolving solids into gases and building gases up again into solids with as much precision as we can add unit to unit, and place each in its right relations in a simple arithmetical equation, is an end to be sought diligently and with unremitted zeal. It is impossible to over-estimate such pursuits. Learning how to lay one's hand intelligently upon the main-springs of nature and bidding them at will to bend in this way or in that, is an object of endeavor worthy of the gods.

Even in an æsthetic point of view, the study of the correlation of energies can appeal more strongly to the love of fitness, of order, and of the beautiful in every form, than anything more superficial. No painter or sculptor can harmonize colors or create forms so matchless in all respects as can the physicist. This is the art of arts. It is literally repeating the perfect skill of the great Artist.

And it is science as well. It is dropping the line and plummet into the midst of nature's subtlest energies, and learning to estimate them according to their several values. To be able to determine just how much sunshine is needed in order to rout the superfluous oxygen of the carbonic acid in the leaf, and to wheel the carbon particles into position to enable them to build up one grain in weight of the marvellous living tissue, must be work which belongs to the highest science. And yet the physicists seem to be approaching even that incomparable achievement. The sunshine is already held in leash; and Mr. Crookes is driving his pith balls to and fro at will, with the sunbeams for his motive power. Certainly he can learn to measure the force which he has brought so adroitly to do his bidding.

But the comparatively dull and masked reactional energies which do nothing but resist, resist, and put on the brakes remorselessly whenever there is a stir anywhere, can never be as picturesque as the others. They are not of the pictorial class, and never can be made visible to the senses. They cannot be made the subtle, strong and obedient servants of man.

Yet they are properly energies. They accomplish a work which is mathematically the equivalent of all the marvellous work done by the energies of motion. They are the true peers and equals of the motive forces, and at any turn in the tide of affairs, they become themselves motive forces as we have already seen; exchanging, measure for measure, the energy of resistance for an equivalent amount of the energy of motion. Thus the interacting bodies, between them, never lose any thing. The sum of their added *energy of motion* remains unchanged, and the sum of their added *energy of resistance to motion* remains equally unchanged. Or, if their apparent motive energy is all carried away, and appropriated by a third body, while they are both left at rest, then this third body has returned to them its equivalent in the form of energy of resistance to motion.

In any case the body and its inherent force never part company; they remain one and inseparable, and its force is always available instantaneously to meet every possible emergency of action or reaction to which it may be subjected.

We return, then, to the position that no force acts except as the correlative of some equal and opposing force. In gravitation, the attractive force lies equally in the two attracting particles; they must draw each other forward in space, probably along some coöperating line of force; and in repulsion they thrust each other mutually asunder. The inexorable law of equal exchange, of equivalent for equivalent, enacted absolutely and under all conditions, is, as we have already seen, Nature's one constant, underlying her entire system of endless change. This point of rest which is as eternal as existence itself, is the fulcrum against which we may place the lever which can raise the fact of immortal life up to the great plane of accepted science.

If all action and reaction is equal and opposite necessarily between every two interacting atoms, the innate atomic force, however various and interchangeable its modes of action, must be forever unchangeable and forever untransferable. The atom, then, must be a permanent centre of individual existence, and of individual power. And if any atom be endowed with sentient force, this living or conscious force must also persist. It is immortal life. It is unchanging personal identity. It requires an unbroken continuity in the endless series of the individual sentient experience. But with all this, there must be physical action and reaction equal and opposite between this living centre of abiding force and all the other atoms with which it stands in the closest coöperative relationship.

That force proper is not only indestructible ; but that it is also untransferable from its own atomic centre, seems to me to be susceptible of the most positive proof. It will be my aim to make this clearly evident from many various points of view; for I hold it to be the most fundamental fact which has yet been made known to us concerning the vast scheme of the existing universe.

It is a simple necessary and logical consequence of the long established law of equal action and reaction. But it may also appeal to experimental tests, and it must be made clearly evident in the light of repeated illustrations.

FORCE; WHAT IT IS AND HOW IT ACTS.

Force a practical worker.—Principles compared wfth details.—Force as easy of apprehension as body. Is more akin to consciousness.—Habits of acquiring knowledge.—Indivisible centres of force the basis of science. In what sense force is a unity. In what sense force is divisible.

THE entire subject of the correlation and conservation of the modes of force, appears to many minds to be exceedingly difficult of apprehension. They regard it as highly abstract and almost metaphysical in character. Nothing but actual physical demonstration would convince them that the various energies of nature can be made known to us as simply and mathematically interchangeable. These energies do, indeed, belong to the unseen universe; we can know them only in their effects; they and the ultimate particles of matter to which they pertain and which they variously modify, causing them to change in so many mysterious ways, are all of them, when regarded singly, wholly imperceptible to our grosser senses.

We see only those bodies which have attained to a considerable size and only those motions which are the motions of a mass of small aggregates. A large portion of the people would never have really believed in the almost omnipotence of these subtle powers, if no one had taught the impalpable steam to propel the massive iron engines which send steamboats over the waters and railcars across the land; if no one had ever felt an electric shock smiting him with an unseen blow, and had not received messages from distant friends written by the prolonged electrical pen. As it is, nobody can doubt that force is force.

And just as little can it be doubted that some men do know something about its mode of acting, and that they are able to guide and control it, often to extremely useful purposes. Indeed the whole subject of forces and of their various doings, taken in its broad general aspects, is in reality simple and easy enough of comprehension. If, in the details, we know very little about it, is not this equally true of every thing else? A mere child can tell a tree when it sees one; it can distinguish a man from a horse, and a carriage from a dwelling-house. Even the dumb animals can do as much as this.

But could the most intelligent man descend to particulars and give a really ample description of even so much as one of these things? The human mind is not yet able to grasp any object down to its multitudes of complicated relations. As well expect to see visibly the ultimate atoms of which it is composed. But all comprehensive features of likeness or unlikeness are so plain that he who runs may read. A tree is plainly a tree, and a horse a horse. Half a dozen different trees or half a dozen unlike horses are enough to teach any intelligent person the general aspect of trees and horses. Exactly so of a knowledge of forces. When we can comprehend something of the forces of collision acting between two solid bodies, and when we appreciate that it is force which resists our touch, and force which is exercised in touch itself, it will then be easy to understand the general family relationship between all the various modes of force.

Laws are nothing more than the expressions of broad and general facts. They may pertain either to changes or to existences. The law that all action and reaction shall be equal and opposite, is as universal, and no more so, than the law that all force and all substance are indestructible. It is no more difficult to understand that all force in action must always be coupled in its action with a mathematically equal opposed force, than it is to understand that every living thing must either take frequent nourishment or die. Indeed the two laws are really one and the same. The appropriation of food may be regarded in a general sense as the action, and the use of it in all forms of muscular and nervous activity, as the reaction.

The reacting body may often seem to us to be at rest, because its motion is not visible to our senses; but all kinds of resistance must be accompanied by motion, visible or invisible. To resist, is to repel the force which must otherwise either shove the resisting body wholly out of its former place or else penetrate it; which would be dividing it asunder and shoving it out of its place by a different process. Hence, when the floor repels the elastic ball, it must push back in order to resist the forward motion of the ball, and to actually reverse it, sending the ball back again to the hand. It is not needful to think of the whole floor as moving bodily from its place; but we must think that the repelling particles begin to vibrate, to literally push back; and thus to send the intruder whence it came.

It can be no more difficult to get a clear conception of force, or energy, than of body. If the one appeals to us chiefly through the eye, and the others through contact with the more general nervous system, yet the idea of resistance offered us by a solid body which counteracts all efforts of the hand either to penetrate it or to move it from its place, is as real, and it may become as definite, as the idea of the size, form and color of the resisting body. This resistance is force in one of its manifestations. A moving body, coming into violent collision with our own, gives a striking conception of a different manifestation of force; heat, communicated by a heated body, of still another mode; a shock of electricity, of yet another, and the biting action of an acid or of an alkali, of still another.

And when we move our own limbs or the whole body; when we use our eyes to see, our teeth to crush and masticate a mouthful of food, or our minds to read a printed page with an apprehension of its meaning—all these and multitudes of other manifestations of active force are a part, as it were, of our very consciousness itself. We know the meaning of a push or a pull.

In reality we can have a more intimate and personal appreciation of the nature of force, of actual power, real and intrinsic, than of any visible object whatever. The force, though it be but a physical force, is more akin to our real selves. We make a voluntary and varied use of it every waking hour of our lives. It closely pertains to our own personal consciousness; and if, as I think, it is really a part of our immutable selves, we can experience what it is in a more intimate sense than we can ever experience the modes of extension or body proper. It is not hard to learn to see the world through some other sense than that of eyesight, though undoubtedly that is the child's first method; as it seems to be the only possible method to the mere animal.

But to a rational being, to any mind which can clearly understand that two and two make four, that two parallel lines can never meet, that justice is a moral law which is obligatory between man and man —to any such mind the study of forces can offer no more actual difficulty than the study of the bodies which are variously modified by the action of those forces. I believe it to be solely a matter of habit. The only difficulty lies in not having begun to study this class of invisible things in childhood, at the same time that we began the study of visible objects. Or, otherwise, if commencing later in life, it is then necessary to start at the beginning and to first clearly master the most primitive facts.

When a few modes of force are distinctly understood as to their general laws and their more common methods of working, then every other class of force, as it comes to light, will present itself like an old friend. We shall know where to place it, and shall at once comprehend something of its ways of doing as readily as we shall know that a tree is a tree, even though it be of an entirely new species. The perception may be as positive and as definite in the one case as in the other, though the one will have a visible and the other an invisible background. But the whole science of arithmetic is an invisible science. How much more of a task is it to learn that two and two make four, than it is to learn that two apples and two apples make four apples. Principles belong as much to the existing nature of things as bodies do. Let us patiently but absolutely teach ourselves to realize this vast fact; every real difficulty in all subsequent study of the unseen elements of the universe will be swept away by it at a single stroke!

Natural sciencc concerns itself quite as much with the invisible things of nature as with the visible. No force can be seen except in the modifications which result from its action. Force produces motion, but in the majority of cases even these motions are invisible. We must turn to other effects, to changes which the varying modes of force register in visible things or which the scientists contrive skillfully to make manifest by various delicate tests.

But force is not separate from matter—that is, from bodies which have dimensions real or apparent.

After all, we are only required to learn that two and two make four, by first learning that two apples and two apples make four apples. Electricity pertains always to an electrified body, and heat to a heated body. In general, force is never separated from body, in other words from extension or the extended. In this view, body and matter are exactly parallel terms; they include the extended and also its innate, special and inseparable force. Hence, force and extension are mutually dependent and indivisible; together they constitute matter or body. Each division of a small piece of matter possesses limited force. Atomic extension is joined to atomic force.

In this view, force and extension together are held to be *the whole of matter as known to us. And force, extension, and sentient or living force, are supposed to constitute the whole of mind*, as known to us. But *extension or extended body is often maintained to be in the last analysis, nothing besides force pure and simple.* That is the hypothesis of many physicists.. It has been much argued and sometimes apparently adopted or provisionally adopted. But it is a theory which never has been, and never will be spoken about or thought of *except by coupling the force with a conception of extended body.* Every scientific writer, therefore, without exception, in order to make the subject of force comprehensible, always writes about both force and extension just as if they were, as I hold that they must be, two real, distinct, but inseparable phases in the constitution of atomic matter. To that subject we shall turn in due time.

At present it is not necessary to argue the point. If extensions were proved to be nothing but centres of vibrating, unextended force; the vibrations by their prolonged effect upon the retina of our eyes producing in us the sensations of extended or continuous substance—the best method, perhaps, of representing to ourselves force as producing in us the effect of real extension—still I should urge, without qualification, that no force ever is, or ever can be, separated from its own individual centre of force. It either carries its centre with it, or else it exchanges *energies* (modes of action) with some other force and remains itself with its own centre.

Thus *an indivisible centre of forces would be the* *true atom.* Force itself would be individualized or divided into units. All physical force must be regarded as identical; as one and simple in ultimate nature as really as all gold is like all other gold; yet, like gold, it can be divided down to that least unit, the indivisible centre of force limited and specialized. And that centre of force, whether we regard it as extended or as unextended, has manifested itself both to the physicists and to the chemists to be indivisible and indestructible. Neither can science possibly ignore the atomic centre of force. Without it there could be no intelligible theory of chemical combination! Without it no science of physics could exist in any definite or tangible form. The ultimate atom, one and indestructible, is the underlying basis of all science.

Yet it would be too much to affirm that all scientific men are ready to accept the atomic theory in this definite and unqualified statement of it. Those who incline to believe that in the last analysis all things are resolvable into pure force, though driven to the hypothesis that there are and must be *unextended centres of force*, have yet none of them, so far as I know, ventured to maintain that these centres of force *must* persist intact so long as force itself persists. There are obvious difficulties in the way of such a conclusion; for if these pure force-centres persist as units, what makes them persist? What distinguishes force from force, and makes the division of it into these definite points of force? To effect this, there should be something differentiated from force. But, whether hypothetic *points of force* persist or not, there must be something in nature which is able to produce them even temporarily! What aggregates force into force-centres?

It must be a part of my effort to offer sufficient evidence that actual and indestructible centres of force do exist in nature; and that no force is or ever can be, during the present order of natural events, separated from its own individual centre of activities.

If this form of the atomic theory can be proved; if atoms can be shown to exist and to persist in the midst of all changes, these atoms then become the unshaken basis of a personal immortality. We have only to farther show that there are centres of atomic force, some of whose modes of energizing are sentient modes, and the whole case will be gained.

But we return again to force as it manifests itself to us by the changes which it effects in visible and extended, or at least apparently extended, bodies.

The subject of the interchangeable relations which we proved to exist among the different modes in which force is found to act, has been made unnecessarily difficult, possibly by some confusion of thought, and certainly by more or less ambiguity in the use of terms. Thus the term force is used in different senses; and several different terms are often used to signify the same thing or with but a shade of difference in the meaning; which becomes confusing to any mind which finds this whole class of topics troublesome of comprehension at the best. In one of the volumes of the "International Scientific Series," Prof. Le Conte, treating of "the correlation of vital with chemical and physical forces," refers to the above difficulty in an explanatory footnote as follows: *

"In recent works the word *energy* is used to de-

* Appendix to The Conservation of Energy, p. 172.

signate active or working force as distinguished from passive or non-working force. It is in this working condition only that force is conserved, and therefore *conservation of energy* is the proper expression. Nevertheless, since the distinction between force and energy is imperfectly or not at all defined in the higher forms of force, and especially in the domain of life, I have preferred in this article to use the word *force* in the general sense usual until recently. I may sometimes use the word energy instead. If any one should charge me with want of precision in language, my answer is: Our language cannot be more precise until our ideas in this department are far clearer than now."

It is the learned Professor, not the writer, who laments as above the need of perfect clearness in the conceptions even of the most distinguished men. Entire precision is always desirable; but not by any means easily attainable. So long as perspicuity of ideas, which themselves depend necessarily upon a multitude of most various facts, all of them more or less difficult and obscure, yet requiring to be brought into entirely harmonious relations, is not yet attained, language must share of necessity in a corresponding want of perfect precision. To be wholly silent on a question like that of the correlations which exist among modes of force, because one cannot see from the beginning to the end of the whole subject, would be folly.

But in the general and wide sense in which one may attain to clearness of conception as to certain inclusive general truths, while yet greatly ignorant of essential details, my ideas seem to me to be neither vague nor wanting in discrimination.

The term force, in my use of it, will mean force and nothing else—that is, force independent of its many ways or modes of action. The *state* of the force, whether active or passive, is not taken into consideration—the term referring solely to the thing itself; to that power or property in nature by virtue of which all changes are wrought. It is limited also to physical force except when otherwise indicated by the connection; yet physical force is made to include "*vital force*" and that whole class of *measurable, related energies* which act in living bodies and nowhere else.

Force, thus defined, is held to be one and identical in nature, to be a unit as to likeness of kind; a simple power which is absolutely identical in all its parts; but it is divisible into parts as really as gold or water are divisible, yet are alike in nature down to the least possible division of each. Force, then, does not differ from itself in character; but in its many ways of acting there is an almost infinite diversity. These *modes of force*, as heat, electricity, vital action, etc., all depend not on force itself, but solely on the conditions under which it is brought into action. The same essential force acts at one time as heat, at another as chemical affinity, as vital action, or as visible motion. These *modes* in which force acts have often a very definite and changeless character; this also depends on the established relations which subsist among the various conditions which determine the particular mode of the force. *Modes of force* and *energies* are synonymous terms.

These extremely diverse energies produce effects which are strangely unlike and which must seem, on a first acquaintance with them, to be produced by the action of powers radically unlike in their own proper nature. A child would never dream that one identical force lies behind the energies which work such various wonders. Can it be the same force which is flashing out vividly in the lightning; which is bubbling, singing, burning him, pushing up the lid, shaking the whole stove, and sending out torrents of steam from the spout of the furiously boiling tea-kettle; which is whirling and humming in his spinning top, which gives his top its color and its form and holds its minutest parts together as a firm and compact wood that stoutly resists both his small fingers and his jack-knife; and is it the same force which is streaming down to him in sunbeams that warm, light, beautify, and give vital energy to every living thing? Yes, it must be.

All force is force; it is power to act, to produce changes; there is no term in any language that is more simple or more forcible in which to express it. It is a term so generic that it must embrace not only all physical but all mental energies as well; so that we obtain a realizing sense of what it is *in kind*, more from personal experience and from our own ability to will and to do, than from any other manifestation of it. Yes; force is force pure and simple; *one, but not indivisible.*

All water is water, and possesses the whole nature of water in all respects, down not only to the smallest drop, but down even to the smallest division which can possibly be made and yet leave the structure of the substance unchanged. But vapor and ice are both equally water; yet the energies which manifest themselves in the fluid, the solid, and the vapor respectively, are curiously unlike, working all of them by different processes. It is the same force remaining, each portion of it, with its own least particle of the substance; but the mode in which the force acts varies greatly in each of the three forms of water. As all the conditions vary, so the mode of the force varies; and the force modifies the form of the substance in which it inheres as it is itself modified in its action. The least division of body and the least division of force can never part company.

The total sum of variable conditions determines both the mode and the amount of energy which shall be called into present manifestation; but these conditions themselves depend upon prior energies. All action arises out of some former activity, and the series of changes thus remains everywhere unbroken.

All force must be regarded as always in action. We may run backward indefinitely to the beginning of the present constitution of the universe (supposing the present order of Nature to have had a beginning, as I reason that it must have had) and we shall find that the same force has been forever changing its modes or forms of energy, and that these modes arise one out of another in an unbroken series of changes.

It must follow not only that the total of force has produced a total series of continuous changes; but it follows also that each least division of force must have been producing a small continuous series of its own. It must itself have taken part in one unbroken process of changes. No smallest division of force could be exempt from this necessity. But the smallest possible division of force must be regarded as the true *centre of force* which is not susceptible of division without utter annihilation.

MODES OR ENERGIES OF FORCE.

Energies as related to work.—Different types of energies; as heat, electricity, etc.—All energies have a twofold action.—Transformation of energy.—Equal exchange of energies.—Energies are of two classes.—Coöperative action of several forces.—Action of resistance to motion.—Pendulum-like vibrations of the ether in transmission of light.—Electricity.—*Conditions* influence the action and exchange of energies.—Forces are never exchanged.

ACTIVE or working force has been called *energy* "to distinguish it from non-working force;" but if all force is active or working force in reality, then the distinction lies only in the fact that the one class can be made available by mankind in the furtherance of desirable ends, while the other cannot. Thus the carbon which is stored away in coal possesses itself a store of inherent force, which, when once ignited, can go on uniting with the oxygen of the air to produce heat. This joint action of the forces in coal and oxygen is called energy because it is said to do work, that is, to produce the desired heat. The action and reaction between a definite mode of force in coal and another mode of force in the oxygen of the air, by thus coöperating, produce a new mode of force called heat.

It is obvious that whenever two opposed modes of force can together produce a third mode, by the transmutation of their joint process into a new form of process, this change is called work. Thus any transformation in kind of action, is work; and the forces which produce the change are energies. But if force is active from the necessity of its own nature as force, and if a given amount of all force is in continual coöperation with an equal amount of opposed force, then whether they produce a change in the form of the activity or not, still they are both energies in the proper sense of that term. Their joint action becomes a mode of force.

Hence I propose to define an energy to be a mode, any one of the modes, in which force coöperates. By this definition energies are not distinctively "*force in action;*" but they comprise all the various *modes in which force can act.* They are *the actions* or *processes of force.* The reason for giving a somewhat new meaning to the word energy is that change or transmutation cannot take place between *forces proper;* since all divisions of force are absolutely alike. They can differ only in amount of force; as more or less. But in action, every force works in an opposed direction to its coöperating neighbor. They may therefore exchange processes or ways of acting—that is, they may exchange energies; though they cannot exchange themselves. They cannot each go over to its neighbor's centre for energizing; but each must remain intact in its own proper atom. All energies act in correlation.

But force in action is perpetually changing the form of its activity; that is, it exchanges its own action for an equal amount of some opposing energy. The more special modes in which force can act have many of them a very definite and unique character of their own. None of them can be easily confounded with any of the others, since the obvious peculiarities of each generally enable us readily to distinguish it from all the rest.

The principal energies are known as heat, light, electricity, gravity, visible motion, chemical action, and vital action. But each of these broad *classes* has distinct and definite *varieties* of its own. The general type of the class is unmistakable. Visible motion or the passing of the whole visible body from one point in space to another, is not easily confounded with any other kind of energy; yet there are many kinds of such motion. The branches of a tree sway to and fro in the wind; but a cannon-ball makes a regular and mathematically calculable curve until it drops to the ground. A balloon rises and an apple falls.

Heat is always heat, and not to be confounded with any other form of energy; but heat radiated from the sun, or from any other luminous body, is very different from the heat which we speak of as temperature—as the general and apparently uniform condition of the heated substance.

Polarized light behaves in an extremely unlike way from ordinary light. They may be classed as distinct varieties of energy; each, however, being easily changed into the other by the proper conditions. There are many distinct kinds of electrical energy; each of them, though so nearly allied, being produced by a definitely unlike, yet kindred, preceding process; and each gliding into either of the others with ready facility. Magnetic action is a form of electricity. Each of these varieties belongs as undoubtedly to its own class as every tree belongs to the group trees; yet each is as fixed and definite in characteristics peculiar to itself alone, as an oak, an elm, and a beech.

Chemical energies seem to be even more varied in kind than any of the preceding. The same elements in combination often produce the most unlike products—products which differ in every kind of manifested energy; yet whenever all the preceding conditions are alike, then all the results correspond. Preceding conditions obviously determine both the class and the variety in all chemical action. This is even more true, or at least it is more manifest, more characteristic, and therefore more striking, in vital energy. *A like anccstry in vital action of all kinds produces its like* as certainly as the form and other modifications of the child's physical system are determined as *the resultant* of like characters in the parent. Yes; all energy of whatever kind, arises directly from preceding energies. It may be but the continuation of the ancestral process, or it may be a transformation of such ancestral energies. That also is determined as the resultant of all the conditions.

It is of the utmost importance to note, *that all these energies and all other energies of every possible variety in every possible class are duplex or two-fold; the two moieties working together either to continue the existing process or to change the form of the energy.* There is no exception to this law. All energy is conserved; but *everywhere the two parent energies together produce the new energy.* This is equally true when the form of the energy is not changed, and when it is changed. The successor to the prior action is necessarily the result of opposed or unlike activities coöperating.

The force acting in the wind, and the opposed force acting in the anchored roots, together sway the branches of the tree; the projectile force of the expanding powder in the cannon, and the force of gravitation together bring the flying ball to its position at the foot of its long curve; and then the earth and the ball between them share the transformed energy of heat, and together they share the equal energy in the form of resistance to being moved otherwise. If there were but *one* force in action at any time, it would, as we have seen in an earlier chapter of this discussion, act on in a straight line forever. The motion which it produced would never become either more or less, or changed in velocity or in direction. But force is everywhere; and no sooner does one form of activity begin to arise, than instantaneously counter energies are aroused as opposing activities.

Heat is a molecular motion—the swinging of the molecules of the solid body, or of the invisible ether of the sky; (molecules or atoms also according to the hypothesis;) but if there were no opposed, correlated forces at work, every atom would fly off, bodily into endless space. *Gravitation is correlative force acting in both of the gravitating bodies;* connected probably by a physical line of coöperative vibrations. Cohesion, chemical action, in short all energy whatsoever, can be shown to act as a double process which produces a corresponding resultant. An energy acting singly is impossible.

Accordingly we may group all these various double forms of opposed activities in two vast divisions—as the energies which produce motion, and the energies which resist that form of motion. We have found that they each tend in reality to the production of motion in opposing directions; the forward motion in one direction calling out the backward motion in the opposite direction; and that both equally resist motion in all directions except that produced by its own action. We might call them the *energies of action and the energies of reaction*, except that they are equally actions or active energies; and that they are also equally reactions or resistances to all activities unlike their own. Their action at any moment is equal in amount; the one possessing exactly as much energy of motion added to its energy of resistance as the other does; so that when the one takes the other's motion, it gives at the same instant an equivalent amount of its former resistance. I can do no better, therefore, than to distinguish the one half of every joint process as *the energy of motion* and the other half as *the energy of resistance.*

It must be remembered that, as a matter of fact, no two bodies can ever act together through their two sets of forces only, independent of all other bodies. Other bodies with their innate forces press about them on every side and take a greater or less share in their activities, whatever form these may have. Thus a ball tossed into the air is pulled downward by the gravity of the earth, is resisted by the atmosphere through which it passes, and is stopped at last by the wall against which it beats. The final outcome of the whole, is a compounding of these various energies on the principle of equal action and reaction between the ball and each of the other resisting bodies acting upon it independently.

Suppose the ball to be thrown with a force equal to twenty units of motion. Then if there were no resisting force in action during its progress, it would strike the wall with a force equal to twenty units; and if ball and wall were perfectly elastic, it would be driven back with a force equal to twenty units. But during the time of its approach to the wall, the earth pulls against it with a force equal, say, to five units. The ball must therefore lose five of its units of motion in its resistance to the downward pull of the earth; and this reaction will leave it with only fifteen units as it reaches the wall But the ball is obliged to cleave its way through the atmosphere which also resists its progress from first to last. Let us call the sum of this resistance one unit. What now is the result? The ball will have given up six units of resistance to a forward motion. It started with twenty units and it arrives at the wall with but fourteen units of motion. But the atmosphere has gained one unit of motion in the form of atmospheric vibrations, and the earth has gained five units which have carried it infinitesimally upwards towards the ball.

At this point, collision occurs. The ball strikes with a force equal to fourteen. Now if ball and wall were both perfectly elastic, as the resistance would also equal fourteen, the whole motion would be reversed; the ball flying backward with its fourteen units of motion, undiminished. But the colliding bodies being neither of them perfectly elastic, some portion of those units of motion will be converted into heat. Let us suppose that the wall can resist the motion and turn it back with a force equal to ten; but that it accepts the other four units of motion, transforming them into heat vibrations among its own particles. It must, in return, give four units of resistance to motion to the ball, together with the ten units of reversed motion. But probably one or two of the ball's remaining units of motion will have been changed, by the structure of the partially inelastic ball itself, into heat-vibrations among its own particles. This heat is motion; but it is not now a projectile motion which can carry the ball forward in the direction to which it was turned. The ball can only go forward, therefore, with a force equal to eight or nine units; and as the atmosphere begins its resistance afresh and the steady pull of gravity is unabated, it must soon be brought to the ground; when the small residue of its units of projectile motion will suffer another partial rebound, and the remainder be at once converted into heat.

The total of acting force in the ball during every successive stage of this process remains unchanged. By adding together its energy of motion and of resistance at any moment, the sum of the two would be twenty. It started with no units of resistance, but with twenty of motion; half way to the wall it had seventeen units of motion + $2\frac{1}{2}$ of resistance exchanged with the earth, + $\frac{1}{2}$ exchanged with the atmosphere = 20. At the moment of turning back from the wall it had given five units of motion to the earth, one to the air and four to the wall; receiving in exchange ten of resistance; which, added to its remaining ten of motion, one of which had been transformed into heat, is also equal to twenty.

The earth, the air and the wall, each of them had also an unchanged amount of energy throughout the time of their participation. The earth exerted five units of resistance to the motion of the ball; exchanging these successively for five units of its own motion in the direction of the ball. The atmosphere's resistance to the ball's progress became a vibratory motion caused by displacement among the air particles; and the wall whose fourteen units of energy were called out instantaneously by the colliding body, was left with ten units of heat and ten of successful resistance.

But to resist being compressed or penetrated is to move—to thrust back the intruding force. This forward thrust in its turn implies reaction; implies some variety of vibration among the particles of the wall. We may suppose that the wall molecules at first yielded or were driven back by the ball; then they reacted and drove it in an opposite direction. This is exactly what an elastic body does when its motion of resistance is visible motion.

Thus if a ball should strike a steel spring, the spring at first would bend backward, the ball going on with it until the elastic force in the steel spring could react, when it would return to its former position or perhaps bend a little outwards in the opposite direction; and the ball would be sent flying either in the direction from which it started or in an angle of reflection equal to its former angle of incidence, as the case might be. We can *see* this visible motion of the steel spring; but the invisible motion in the particles of the resisting wall, produce a result similar to that produced by the spring. We must conclude, therefore, that the molecular resistance of the wall is like in kind to the visible resistance of the steel spring. The spring and the wall, therefore, will both be left vibrating after the blow dealt them by the ball. These vibrations will be gradually distributed to more distant bodies. Thus the motion of resistance, like all other motion, will travel outward and outward like a wave in the water, until it meets some counter-resistance and is itself turned back or diverted into some new channel.

It is apparent that the possible more or less differentiated energies or modes of the same force are unlimited. Each body must react *in a manner to correspond with the action upon itself*; and *the amount of its reaction* will neither fall below nor exceed the amount of the initiative action. When the ball is heavy or is flying with great velocity, the bend and the recoil of the steel spring will be large, both representing equal and large amounts of energy; but when the ball is light or when it moves slowly, it then represents but a small amount of energy and is resisted accordingly by a small amount of reaction. But if a dozen energies are acting upon the same body at the same moment, it is then reacting against them all at one and the same time.

It should be clearly understood that in every process whatsoever, the two modes of action which we call *energy of motion*, and *energy of resistance*, must take equal shares. The two together make up the *energy proper*—make up all those processes of nature which are called heat, chemical action, gravitation, etc. Radiated, as well as absorbed heat, must be regarded as molecular vibration among the particles which conduct or which retain the molecular, pendulum-like swing communicated to them by the heated body. Every separate particle of the interstellar ether seems to be an infinitesimal pendulum so adjusted to some of the simpler motions which make up the extremely complex vibrations in every sunbeam, that it swings to and fro through a measurable space in a measurable time, without leaving its own appointed place among the other particles which are grouped about it, and all in active coöperation.

It is found by a variety of separate experimental tests, that the pendulum of a clock is held no more securely within its appointed bounds by the correlated forces (correlated through human skill and prevision) which regulate its successive pulses of minutes, seconds, or halves and quarters of a second, than the ether pendulum is by the fixed adjustment of correlated forces which control its infinitely swifter pulsations of millions on millions within every fraction of a single second. The clock pendulum is kept no more steadily in motion, its times of vibration and the arc through which it passes have been no more accurately computed by the mathematicians, than are the corresponding facts relating to the particle of ether which is inconceivably minute. Philosophers might well be excused for concluding that here at least, is a vibrating "point of force" without extension.

But in advance we should have concluded that the vibrations and the length from crest to crest were impossible of measurement. Yet by various separate careful experiments, with the necessary computations of actual measurements and observed results, the length of this ether pendulum's swing and its times of vibration have been really estimated and brought fairly within the required scientific accuracy.

Probably no scientific man now doubts that these are sufficient measurements of actual existing energies. That there are a practically infinite number of infinitely small pendulums taking part in these vibrations, will be less readily accepted as a proved fact: and yet, if force acts only in connection with matter, the vibrating ether particles are as much a necessity as the vibrations. The rates of vibration are connected with the phenomena of color, and since by means of a prism we can separate these various classes of unlike oscillations which are together in the beam of white light, and can then literally see the variously colored waves of vibration, they may seem to some minds to be more real than the atoms which vibrate, but which from their extreme minuteness and swiftness must remain invisible to human sight.

To most minds, movements, where there is nothing to move, are clearly impossible. Hence, if these estimates pertain to real energies, there must be the vibrating centres of energy, extended or unextended. The point now is, that each one of these ether centres is so acted on by the aggregate of all the coöperating forces about it, that it continues to vibrate mathematically within its appointed bounds; while yet the great wave of combined vibrations in the sunbeam, travels outward at the rate of nearly 200,000 miles a second. Thus it is the motion which travels, but not the moving pendulums; each one of these giving up its motion instant by instant to its neighbor; and accepting in return an equal amount of resistance to motion, to exchange again at the other end of its arc for a new motion.. Thus action and reaction can be shown to be equal and opposite, even in the sunbeam, at every successive stage of its progress. The sun can lose no force.

Indeed, however complex any series of active changes, this law must hold good throughout its entire length. To suppose otherwise would be to subvert the most absolute and most universal law of Nature—a law which has been deduced from millions of separate observations, while no shadow of proof can be brought that it ever does, or ever can fail anywhere. Action and reaction are equal and opposite.

In all electrical phenomena, as well as in all chemical action, to which electricity seems to be closely allied, the correlated forces must pertain to unlike bodies. These forces must belong to substances which differ either in chemical properties or at the least in some of their physical conditions, or else electricity will not be produced by their interaction. When two bodies which are exactly alike are rubbed together, the form of energy which is excited will be that of heat; but if the two bodies are dissimilar, then the result of the friction will be electricity. There are many well known methods by which electrical energy is generated, but all of them require the introduction of forces controlled and directed by conditions which are more or less differentiated.

Electricity, like heat, is found to pertain to all matter. Nothing exists without heat or without a capacity to respond quickly to heat communicated from other sources; and equally broad are the electrical relations of bodies universally. They all vibrate to electrical action from without, and all, whatever their condition in other respects, are found always to have electrical activity of their own. But electrical action is polarized. Every particle of matter which takes part in it ranges itself like a magnet, and for the time it seems to have become a magnet with its two ends positively and negatively electrified respectively. When electrical currents are in motion they may move in the same direction, when they mutually attract each other; but if they move in opposite directions they become mutually repulsive.

It is generally assumed that there are two broadly distinguishable electricities; the positive and the negative. But whether these are two unlike subtle fluids or two differing modes of motion is still an open question. It is not needful for us to consider this point; since, whether there is an electrical ether differing from the luminiferous ether or not, or whether there may be two or more of such ethereal substances, it is in any case certain that everything which comes into the neighborhood of electrical action is compelled to take part in the electrical processes. The electricity itself must be an energy, a mode more or less varied from the general type of electrical action; but still distinctively a process —not a substance, but a coöperative series of vibrations going on among unlike substances.

Electrical phenomena are more complicated than those of light and heat. Solids, fluids, and gases, more than one of each, all combine to produce electricities of different varieties; but it remains true, here as elsewhere, that action and reaction, motion and resistance to motion, are invariably and at all stages of every form of it, equal and opposite. The eye is not adjusted to electrical vibrations as it is to the vibrations of light, and it may be long before it can be definitely settled whether electricity does or does not require the coöperation of a special ether of its own in connection with grosser forms of matter.

Electricity is intimately related to all other forms of force and is readily interchangeable with many of them. Having a vital organism to work with, it can simulate vital energies so closely that it is able to move the muscles both of the dead and of the living, and to take an active part in many of the higher processes of the living organism. But electricity and vital action both of them being but modes of mechanical motion, are of necessity interchangeable. It is not *force proper*, but the method of its action, which is correlated to all other kindred methods.

We have seen that the simplest forward motion possible, like that of a moving ball, is yet one series of perpetual changes. Electrical, chemical, and vital energies, each of them a group of complex vibrations at every moment, are yet each of them set in a wonderful series of its own. It is to be expected, therefore, that just as the projectile motion of the ball became changed into a number of other equivalent motions, controlled by the conditions under which it acted, so these higher energies will be gradually transformed into each other, into heat, into any or every motion which presents itself in the line of least resistance.

If a body A, is raised above another body B, and made to fall upon it, this fall will begin as visible motion; but in the reaction, whether this motion will be changed into heat, wholly or in part, or whether B's resistance will send it back to its starting point—or up half way to it; or whether B will be driven from its place and both bodies dropped down to an available lower level; or whether they will both be made to move on more slowly with its motion shared between them; or whether in falling they are both seconded by gravity and made to move much more rapidly than A did originally, must depend not upon the forces of A and B, but upon coöperative conditions which control their modes of action throughout. Every energy must continue unchanged in mode or suffer a change of mode, just as the way is best prepared for it, in either channel. The attending conditions do not themselves act, but they modify action. They are not themselves forces, but they are the moulds in which forces operate and by which the acting energy is directed for the time being.

On this point we shall have more to say hereafter under the head of physical modifications.

It must be apparent to all, that when one body exchanges its energy or mode of action with another, it does not also exchange its force. The energy being the method in which the force is working at the given moment, the force gives up this method in exchange for the method of the reacting force. At one instant the two forces are working in a certain way. At the next instant they have exchanged, and each force is working according to the former way of its neighbor; but each force has remained unchanged with its own body; and it is ready at the next instant to make still another exchange, working on now after this third method. So it will go on forever; never pausing, never resting; working even in many directions at the same moment and exchanging its modes of work with perhaps a dozen separate forces instantaneously and continuously.

But the force cleaves to its own body as it cleaves to existence itself. Separation from it would be annihilation, since the two are bound up in one unity. Each centre of force co-works with all the others; but it gains nothing and it loses nothing; remaining intact from the beginning amid the endless cycle of changes in which it coöperates—on that old eternal basis of equivalent for equivalent, through every possible form of modification.

Energy merges into other energies when the black earth climbs upward in the sweet sap of living trees, refining and brightening itself into the green of delicate leaves or the bloom of many-hued blossoms. But leaves and blossoms return again to the earth; each particle carrying down with it its own forces neither increased nor diminished during this whole magic round of unresting activity. Heavy, sluggish zinc and copper can quicken each other's pulses till lightning is racing through every vein, and every thing about them is penetrated to its centre with this subtle and powerful energy. But the lightning melts into the earth and loses itself again in clods and stones which seem to have no energy except that of dull resistance. Yet resistance is motion, so soft, so delicate, so incomparable in its refinement of activity that even science fails to recognize its significance.

SYSTEMS OF FORCE.

Several gases introduced into the same receiver will not displace each other.—The explanation.—Analogous facts in spectrum analysis.—Size of atoms.—Estimated number of molecules in a cubic inch.—Laws of action.—Explanation of molecular properties,—Action of water vapor compared with that of its elements.—Simple systems aggregated constitute more general systems.—Fluids.—Solids.—Balanced interaction between the parts of every system.

A GLASS flask which is entirely empty in appearance is yet filled with the atmosphere. Matter in many of its forms is invisible and must be made to manifest itself in other ways than through the sense of sight. Many of the commonest things are invisible and inappreciable also to the touch.

The atmosphere crowds into every available space; it might be expected to completely fill the glass flask, pressing against it on every side within and without; and it is true that no more air can be made to enter the flask except upon strong compulsion. But by the proper adjustments in the glass receiver, steam or water vapor can be introduced with no additional pressure and without displacing the atmosphere. The receiver will admit as much steam as though no air were present and the flask a vacuum. Afterwards we can fill it a third time with the vapor of alcohol. It will contain as much alcohol vapor as though it were not twice filled already. Then it can be filled a fourth time with ether, and if the vessel were strong enough to resist the increased pressure, we might probably continue to fill it with different gases one after the other. It will receive as much of each as though none of the others were present.

Now what explanation can be given of this very remarkable fact. Simply this; these gases are not solid or continuous vapors. Each of them consists of minute actively vibrating molecules; little distinct systems of force, free in movement, yet kept asunder at comparatively wide spaces by the interaction of forces operating between the different systems. Each molecule may be regarded as a small separate world occupying its own position in space and exerting its own internal forces unhindered; but its reactions against all the other molecules must determine the relative distance which shall be maintained between molecule and molecule

When but comparatively few molecules of any gas are admitted to the receiver, they take their places accordingly at remoter distances apart; distributing the whole space among their number with exact equity: a portion of this particular gas will be found distributed evenly through every part of the space. The interactions between like molecules is evidently not the same as between unlike molecules.

Let us consider how much is implied in this explanation.

When any vapor has furnished its proper quota of molecules for a given temperature, it can then strenuously and successfully resist the crowding in of molecules of its own class. Thus at a temperature at which water is readily vaporized, if there were fluid water lying at the bottom of the vessel it would not become vapor. A higher temperature or a great pressure in some form would be required in order to change the remainder of the water into steam.

The molecular energies in the steam are exerted strongly against the fluid water to prevent its particles from flying off from the surface in the form of vapor. If the steam were removed, the water would then be very shortly vaporized; but because the steam opposes this process, the water continues in the fluid state. Action and reaction between the water vapor and the water fluid prevent the farther vaporization.

Consider now this other curious fact. Supposing the entire state of things to remain otherwise unchanged; in place of the fluid water let a fluid alcohol or a fluid ether be introduced at the bottom of the flask. Each of these will at once begin to vaporize under the very conditions which would compel the residue of water to remain a liquid. Whatever interaction there may be between the forces of steam and the liquid alcohol or ether, it is of a kind which does not prevent the vaporization of these latter fluids, or indeed of any fluid except that of water only. Evidently the vibrations of water-molecules and of ether or alcohol molecules at a fluid temperature, must be dissimilar. The steam which hinders the water from becoming vapor allows the vaporized particles of the other fluids to fly up into their midst unchecked. These latter apparently glide past them with but little hindrance and slip into the interstices between the molecules of steam

There is a well known fact very analogous to this in spectrum analysis. Each metal and metalloid, when raised to gas in a luminous condition by heat, is found to have a particular place in the spectrum which belongs to itself alone. The light which it radiates when in that condition has a degree of refrangibility which is special to itself, so that it falls into nearly a fixed position in the spectrum and has a definite color and width of bands; enabling one to decide at a glance exactly what kind of light has been thrown upon the screen. By this means the spectrum analysts have been able to decide that about the same substances must exist in the sun and in many stars as upon the earth.

The point to which I would direct attention in both of these illustrations is this. *The molecules of gases are shown to have their special adapted places and kinds of vibration;* both of which are so adjusted to other gases that they can coöperate without much interference. They can be in their own positions and in the exercise of their own proper activities, surrounded on every side by their neighbors of other classes, yet without greatly interfering with them in any way. All their coöperative energies are adjusted each to each.

Yet there is some interference—some overlapping as it were of their various oscillations. It is always difficult to obtain a pure spectrum because the different colors seem to intermingle at the edges, to run a little way into each other's beat. Perhaps it is something like mingling water and alcohol or water and sulphuric acid. The mixture is exactly as heavy as the two substances were when weighed separately. But it shrinks in size. Thus one hundred parts of water and one hundred parts of alcohol will shrink to about one hundred and ninety-six parts, but water and sulphuric acid will shrink fifteen parts in two hundred. The molecules of the two fluids must overlap or interpenetrate each other's spaces.

The molecules of our gases in the glass receiver may interfere with each other in a similar way.

They resist the introduction of foreign vapors to such an extent that the process of diffusion becomes more and more retarded in proportion as the space is already preoccupied. This resistance might be regarded as that of merely passive stationary impediments. If a number of very large men were standing about the porches and aisles of a church, they would effectually repel other large men by simply standing motionless; yet a company of adventurous small boys could slip in under the elbows of the men, finding room for their small feet, though it would take much longer to do this than it would to swarm in a body into an unoccupied building. But no similar explanation will answer among the gas molecules, because they are so extremely minute that *if their coöperating forces would permit*, many millions more of them might concentrate themselves within any given space.

To our apprehension, all molecules are so incredibly minute, that if there were not good reasons for believing they must have a definite extension, the simplest conception would be to consider them as mere points of force absolutely unextended. A grain of musk will send out odorous particles enough to perfume the atmosphere of a large room for months, yet not be itself sensibly diminished. Sir Wm. Thompson, by a series of delicate experiments, has been able to estimate the fact that in liquids and transparent solids the mean distance between two adjacent atoms in a molecule must lie somewhere between the ten-millionth and the two-hundred-millionth part of $\frac{1}{25}$ of an inch. Similar estimates have been reached by others through dissimilar methods. There is a humorous statement of Haller's which must excite a smile because, think of it as seriously as we will, we cannot realize it to be anything more than a whimsical conceit. Yet it represents actual fact. He estimates that the $\frac{1}{2601064000}$ of one grain of amber had saturated a package of papers preserved for forty years. These papers perfumed a film of air at least a foot in thickness for 11,600 days. This illustration of atomic dimensions will make it tolerably evident that when two or three gases, already occupying adapted portions of a given space, interfere to delay the introduction of another gas, it is not because of their size; but because, in their ceaseles vibrations, their different pathways cross and recross. Every molecule is vibrating.

It is estimated with an accepted scientific accuracy, that when the barometer marks thirty inches, and the thermometer 32° F., in every cubic inch of gas the number of molecules is ten multiplied into itself twenty-three times. *At the same pressure and temperature every kind of gas has an equal number of molecules in an equal volume of gas.* It follows, if each molecule is a little separate system of forces, that each one of these small systems exercises an equal amount of molecular energy in maintaining its established rights of position and of vibration. The heavy molecules have a slower rate of vibration. When they go forward into new positions they make a slower average progression; the light ones moving with an exactly compensating velocity. They transmit sound on the same principle.

Thus, however unlike their various molecular weights, all gases are able to exert a uniform pressure under like conditions. *Their volume is directly proportional to a given temperature, and it is inversely* *proportional to pressure exerted upon themselves.* When a vessel contains two or three different gases, the sum of the pressure is then equal to the pressure from one gas multiplied by the number of gases. Each gas and each molecule must therefore directly or indirectly exert its own pressure—equal to that of any other gas or molecule.

These little worlds, when impelled in any direction, move in straight lines like other projectiles. Tossing to and fro, they beat against each other or against the enclosing sides of the vessel in which they are imprisoned, now driven back to their starting places, now reeling off sidewise, or gliding past each other without contact; as disturbing influence drives them about with more or less irregularity. Hydrogen will find its way through a thin partition of graphite or any similar filter about four times as rapidly as oxygen and six times as rapidly as chlorine; and their atomic weights are respectively 1,16, and 35.5. Within certain limits, the repulsive force is found to vary in its action as with gravitation, inversely as the square of the distance.

The movements of molecules though essentially alike in the same gas are thus proved to be characteristically unlike in the different gases. They seem each to keep within their own appointed paths, each class circulating within certain lines or channels of motion appropriated to themselves; perhaps crossing each other's paths as ships do at sea, when sailing in every direction. Two vapors will remain indefinitely intermingled, each forming an atmosphere by itself penetrating to the remotest parts of the space accessible to it; yet each keeping in its own space as rigorously as a set of chessmen move about—the dark men upon the dark squares and the light men upon the light squares—neither class ever trespassing upon the domain of their neighbors.

If two vessels are placed one above the other with an open communication between them, the upper one containing nothing but hydrogen and the lower one only chlorine, about thirty-six times as heavy as the hydrogen, yet the chlorine-centres will ascend against gravity and the hydrogen molecules will descend into the midst of their comparatively ponderous neighbors until both are evenly distributed throughout the entire space — each little system occupying its own square of the joint domain. Interaction between molecule and molecule is more powerful than gravity.

Any gas, however small its amount, will appropriate the whole of its own portion of the space; each tiny system probably swinging through a wider beat in coöperation with its more distant neighbors. Hence, if ever so little of one kind of gas is introduced into an already filled receiver occupied by several other gases, a little of this gas will be found in every part of the mixture.

Hydrogen and oxygen have been known to exist together in the exact proportions in which they unite to form water; yet when thus intimately intermingled, they remained for years uncombined, and were afterwards chemically united with the usual accompanying detonation. Some form of interaction must have existed between them from first to last, but it was not that intimate, nicely adapted coöperation which must exist between atoms which form a common molecule. Here, atom must react against atom in a close perpetual series of vibrations in which there is an exact active balance throughout.

It is these specially adjusted, intimate vibrations, which must give to each class of molecules its particular characteristics—unlike those of all other substances.

How else shall we account for the different pungencies in pepper and turpentine, with all the rest of their isomers? If each atom brings its own class of vibrations with it into the little molecular system, then there is good reason why the way in which they are put together should affect the whole general result. By the different groupings, unlike sets of vibrations would be acting in more immediate coöperation with each other; and the general resultant would necessarily be exactly what it is—a very different whole with each difference in the atomic arrangement; yet each class of molecules would remain the equivalents in force-value of every other class possessing the same chemical elements. While action and reaction are equal between part and part throughout the molecule, they must so far satisfy each other, that their equilibriated vibrations will be equivalent to rest outside of the little system itself.

But when molecule coöperates with molecule, the interactions here will be varied according to the closer variations which are more directly inter-molecular. These, coöperating with our adapted nervous systems would produce the various familiar, characteristic sensations of taste, smell, sight and touch. Hence lavender may well affect us as a mild and pleasant odor ; pepper as hot and biting ; turpentine as turpentine ; and all the rest each after its own kind, according to the class of adjusted molecular vibrations which it is able to awaken within our readily responsive organisms.

We will now return to our molecules of gas to see if we can find in their action any farther corroboration of this theory. We have seen that all substances, when under like conditions and in the gaseous state, exert a uniform pressure to the square inch. Thus water vapor, which is a compound of oxygen and hydrogen, can exercise one unit of pressure ; but oxygen and hydrogen, as elementary gases, can exert one unit of pressure each. A certain amount of energy possessed by each gas is therefore locked up in the inter-activity which is exerted to hold them together in the common molecule. The same is true as to other physical properties. The compound vapor, except in weight, is to most intents and purposes, possessed of no more available energy than is possessed by either of the single vapors alone; action and reaction is proved in this way to be equal and opposite within the molecule as elsewhere.

Moreover the vibrations of the water vapor can be shown to have taken on quite another kind and rate of oscillation from either the oxygen or the hydrogen; since a globe already filled with the compound vapor can be readily refilled twice again with the uncombined elements of that compound. The little systems of water-vapor, therefore, must be supposed to occupy a different position in space from either of its elements. If left comparatively undisturbed to adjust themselves at their normal distances apart, like the interstellar ether particles, the steam would undoubtedly have a very different sweep or amplitude of vibration as well as a different time of oscillation from either of its elements.

This is shown more impressively by its immensely greater susceptibility to the vibrations of heat.

Oxygen and hydrogen have but little power to absorb or to radiate heat; they are nearly transparent to heat-motion of all grades, suffering the little heat-waves to filter through them and pass on their way unchanged. But water-vapor is an eager absorbent of heat; its radiative power, by promoting its condensation to a fluid, is largely the origin of clouds, rain, and the whole wonderful phenomena of atmospheric changes; as well as of all vegetable growths. The action of a perfectly dry atmosphere upon heat is found to be not a seventieth part of the action when the air is saturated with even the ordinary amount of water-vapor. In this respect, the perfectly dry air is just equal to an atmosphere of either oxygen or of hydrogen gas. They are all composed of elementary systems. The molecules of water-vapor are little, complex systems whose intermolecular vibrations are akin to the vibrations of heat; absorbing them as a stringed instrument will absorb the notes to which it is attuned.

Here then is a dissimilarity of molecular action established on well known mechanical principles, and tested again and again in many different ways; by actual measurements, and by experiment varied in every conceivable way; till there can be no more reasonable doubt as to the exact facts than there can be doubt as to any other of Nature's plainest truths. The whole subject of separate little systems of forces called molecules has been perseveringly investigated by many of the most eminent physicists and chemists. There are no scientific facts better established than many of the above cited laws which govern the various gases. That these gases act from different centres of coöperation is past dispute. As to the real nature of these force-centres, there may still be different opinions. But that all substances; gases, fluids, and solids; *owe their properties to a special combination of differentiated vibrations* will not be questioned probably by any scientific authority.

Gases—which are either simple elements, or which usually have but comparatively few atoms in a molecule, with molecules widely separated and partially independent—offer excellent facilities for investigating the action of coöperating systems of forces in their simplest forms.

But every solid body is a larger system of associated forces. So is every mass of fluid. There is a much closer relation between the molecules of a fluid than of a gas; and in solids the union is still more intimate. But in a substance like water, the molecule, in its elements and in the order of arrangement of those elements, remains unchanged in all the three forms, solid, fluid, and gas. And yet the action of the several inter-molecular forces must have undergone successive modifications in each of these very different conditions of water. What those modifications are and how they have been effected, it is not at present our purpose to inquire—as we are concerned now only with the fact that, in every associated mass of matter there must be such action and reaction between all the different parts of the system among themselves, that to every thing outside of itself, internal processes are of no direct account. The interactive energies in the several parts mutually take care of each other, so that relatively to all the rest of the universe it is as though these coöperative actions within the system were all in a state of positive rest—except in so far as they necessarily modify other communications which exist at the same time between the system or any of its several parts and the outside world.

Every system is a centre of forces and is composed generally of subordinate centres in which there are sub-divisions of force. These subordinate centres coöperate together like the partially merged individuals associated in a corporation. Every large mass of matter is a vast commonwealth—a state composed of innumerable multitudes of partial independencies. The only simple and indestructible unit is the ultimate atom.

The little molecule of gas is a very small sovereignty, which regulates its own internal affairs; but it is associated and coöperative with the whole volume of gas to which it belongs, and also with the rest of the world outside—as a town belongs to a state, and states are coöperative in the general government. In a fluid, the molecules are still measurably independent; but they are associated much more intimately among themselves than are the gas molecules. They might be compared to the several wards of a great city. The fluid particles can move about more or less rapidly in the midst of their confreres, as they are impelled by foreign influences such as currents of heat or electricity. They may be often compared to a group of children at play—all changing hands continually in an endless chain; each dropping a hand perpetually, but immediately taking another, and so remaining always linked together hand in hand.

The molecules of a solid ordinarily do not change places among themselves. Their balanced energies of alternate motion and resistance to motion, keeps them swinging endlessly, pendulum-like, to and fro. Possibly their molecular centres of gravity sometimes remain fixed while every point of the star quivers as it stands; never resting, always moving; always in balanced, active coöperation with all other forces about it, within and without its own system.

At any rate we know by many unmistakable evidences that there are always ceaseless vibrations of some kind among the molecules of the apparently most inert mass. Causes often arise which change the position of molecules within a solid body without any change of form externally. A non-crystallized body exposed to the action of sunshine will sometimes become crystallized in this way. Its outside appearance remains unchanged; but on breaking it open its new crystallized structure becomes visible. There must have been complete change of position among the apparently solid and immovable particles.

This change of place among the molecules must extend probably more or less throughout the system, yet its general centre of gravity is not altered; its forces continue to work together as a unit. Action and reaction within the body has occupied and satisfied all internal agitations. They are all *personal to the system*, if we may use that expression to indicate a class of energies which, relatively to every thing outside of the system, has no more *direct* influence than actual and positive rest would have.

Chemistry and physics are both grounded upon this important principle of *balanced interaction between the several parts of every system.*

SYSTEMS WITHIN SYSTEMS.

Each atom the centre to itself of the coöperative universe.—Repeated systems in the vessel of gold-fish.—The ultimate atom regarded as a system.—It is the centre of many systems unequal in kind and extent of interactions.—All intermediate systems are variable and destructible.—The universal system is not destructible. The atom as a unit of the universal whole.—Its many complex and simultaneous activities.

IT has been my steady endeavor to lead up the mind to an adequate appreciation of the fundamental fact that each atom is a centre to itself of the entire coöperative universe.

This assertion is not a metaphor; but a literal statement as to the nature of the great system of coördinations through which all existences are enabled to coöperate. Change of every kind is a link in a chain which reaches before and after. It is also a movement in place which reaches outward in many directions.

But the outward, to every centre of force, is away from itself. Itself is the nucleus of that system of activities in which it takes its individual share. Its coöperations are carried forward in all directions simultaneously. We shall be able to appreciate this the better for fixing the attention as exclusively as may be upon motion; upon a great number of the vast varieties of motion in which every atom of matter takes its own peculiar part. Motion is the measure of force; it is the activity of force; and in studying motion we are studying force in action. But it is, possibly, easier to fix the mind upon motion simply, as something real, tangible, and familiar to our every day experience. It is an old, old friend from childhood up. And motion is physical, not metaphysical. Body is moved.

Let us illustrate farther the omnipotent law that in every coöperative system, large or small, the whole group of motions so balance each other that to everything outside of themselves they are equivalent to actual rest.

Here is a hollow glass ball half filled with water in which there are a hundred gold and silver carp. It is delicately balanced on wheels, on a marble table, at rest—at rest, though the touch of a little finger from without might set it in motion. Of what account to the whole surrounding world is the incessant gliding to and fro of these hundred fishes within the little ocean of their smaller world? Each fish is darting about like a gleam of light within the teeming water; but in the language of Prof Stewart, from whom I have borrowed this "Vessel of Gold-fish;" "we may rest assured that notwithstanding all the irregular motions of its living inhabitants, the globe containing the gold-fish will remain at rest, on its wheels."

Again, within the system of each fish every particle of every drop of fluid is in active circulation; every molecule of its solid substance is in an energetic sweep of vibrations; and every atom within every molecule is in an endless state of quiver to and fro—after its special atomic fashion. But of what account to any of the other fishes are these myriads of internal movements pertaining to either one of the remaining ninety-nine?

They are all important to itself; but the entire mechanism might stop moving and no other fish be sensibly disturbed by the change. All disturbance would be indirect—not direct.

But there are multitudes of organic cells, little complete organic centres which are so far independent of the superior organism that they are able to carry forward a small series of vital operations on their own account. Each cell performs its own functions, changing and renewing itself moment by moment, and it is to all intents a distinct little system whose internal actions and reactions are balanced amongst themselves to such an extent that the other cells and the general organism are not directly affected by them to the least degree. The little cell may break up and die; it does this and other cells crowd into its place, yet all the other organic processes go on quite undisturbed.

And within the cell are multitudes of those still smaller systems—the organic molecules. The balanced interactions within the molecule have been sufficiently considered already. Within certain limits of their own, they are as independent among themselves as any other and larger system can be. Every molecule is the smallest complete part of any substance to which it pertains, and each molecule is as absolute in its molecular independence when closely allied to other molecules of an inorganic solid, or taking its own share of various organic processes, as when it exists comparatively alone in a gaseous state.

But within the molecule is the atom. Is that too a system in which action and reaction can regulate motion between the several parts? We have seen that according to the theory of the chemists, growing out of the carefully investigated behavior of atoms, there is not perfect uniformity in all poles of any atom. Each atom is represented as having one or more bonds or points by which it can adjust itself to other atoms. Whether these atoms of the chemist, indivisible as yet by human ingenuity, are in reality simple, indestructible ultimates, is not at all essential to our argument. *When* we have reached the ultimate, wherever that limit may be, *this ultimate should be itself a system whose vibrations are equilibriated among the several parts of its indivisible structure.* Every vibration implies this—implies motion and reversed motion; action and reaction, change of place and change of form.

The atom is a centre of gravity. Elements uncombined weigh precisely as much as when united in a chemical compound. They resist being moved by a projectile force to the same extent under all conditions. So do all other systems, large or small; their several forces coöperating to form one centre of gravity in common. Every ultimate atom takes its unresting share in all the varied endless movements which are going forward in that active little world in miniature—the glass globe, with its wondrous variation of energies.

Each atom of each shining scale of our fishes, silver or golden, unseen to our eyes, is fluttering like an echo to pulses which vibrate in the remote sun. Why is one silver and the other gold? Hereditary? do we say; and hand the marvel back to ancestral influences? Yet how, by what physical agencies has the result which we can all so cordially admire, been brought to this perfection? Can we hope to trace out the combined, vibrating energies which produce these and the other equally beautiful effects of color and form in the crystal of the glass and the water, and in the yet more transparent crystal of the air?

They all result from coöperative movements; and our atom, like the molecule with which it acts, undoubtedly vibrates of itself and from itself, in response to the vibrations of correlative energies almost a hundred million miles distant. This system is a grand one in its extent; but all its activities are balanced and correlative, as in each lesser system. Every particle of air, of water, of glass, of blood, of bone, of tissue, is found to be in active incessant motion; yet because these motions are actions and reactions equal and opposite in their own kind and degree, the globe as a whole remains motionless upon the smoothest surface. Unless otherwise disturbed it is as apparently passive as a clod or a stone. Indeed it is just as passive in reality; every molecule in a clod or a stone vibrating so rapidly that the eye alone can detect no movement. There is no rest throughout all Nature. Every atom vibrates; and vibration is balanced motion!

The glass globe is itself a system within a system yet more extended. Take away the air which presses against it on either side; the globe would plunge forward into the vacuum. Remove the table from underneath it; it would drop helplessly to the earth. Our atom is stretching always outward in coöperative shivers toward the air and the earth. If it cannot itself reach actually out to either, it can, and it does, join its vibrations to multitudes of others in lines of energy reacting in all possible directions. Like a tiny central star it radiates motion everywhere. It receives motion also from everywhere into its own bosom, quivering in reaction at every impulse which is communicated to its infinitely sensitive structure.

This endless adjustment of all activities, from the least to the greatest, offers the only explanation which can be given of the correlation of the many different modes of energy. Motion and counter-motion, whether like or unlike in kinds of vibration, are equal and opposite. If the centres of these energies are millions of miles away, they are but one system to just the extent to which they coöperate in a common scheme of activities. The atom in the sun is as really and definitely allied to the atom in the earth which is found vibrating in unison with it, as are any of the atoms which are so intimately associated in the same molecule that all their vibrations are merged and coöperative in a common substance. An atom, a molecule, a rock, an animal, the earth, the sun, the solar system, the universe—all these are systems of coöperations, each after its own kind of relationship. The lesser systems are but parts of the universal whole and every atom is the centre of all those manifold operations, near and remote, in which it participates. Its vibrations quiver out and outward in all directions, to every planet, to the sun, to the distant fixed stars; towards every other particle of matter however remote in space; and from all these other centres coördinated to itself there come back to it wavelets of counter-motion, compounded and re-compounded with each other throughout every stage of their ceaseless journeying to and fro.

Each system is measurably independent and complete in its own coöperations; and yet any modification in one, even the least system of them all, must involve a corresponding modification throughout the whole allied universe. But all the intermediate systems between the atom and the universe, of every kind and degree, are perpetually variable. All bodies, inorganic and organic alike, which are visible to us, are in a state of perpetual change. They form aggregates only to break up again into fragments. They grow or diminish; they undergo modifications of every conceivable variety, and yet, in so far as they coöperate directly together, their actions and reactions are so far balanced for the time that to all other systems they are equivalent to actual rest.

The internal operations of the system, however, inevitably modify the system itself in all its parts; thus all of its external coöperations are modified also.

The centre of gravity of no body large or small is ever moved by its own internal forces. Working together, they produce innumerable modes of vibration; but they all coöperate to hold its centre of gravity in a state of rest. They all resist motion in every direction except their own. And the result is an established common centre of inertia. Thus the motion of translation through space can never arise from the adjusted interaction of the energies within the system. It can be moved only by foreign energies. But outside influences, by disturbing the internal adjustments, may break up the system—scattering its fragments through a violent internal revolt. A gun loaded with powder and ball may be regarded as one system previous to the discharge. After the explosion, powder and ball separate from the gun. They belong to it no longer. The hand that pulled the trigger was the disruptive outside influence. And the motion in the living hand was also produced at the expense of some portion of the living organism. That portion of any organic structure through which motion is effected ceases to belong to the organic system. It drifts away from it as the ball and powder are detached from the gun.

All the intermediate systems of the cosmos are in a state of perpetual flux because of the outside coöperations which unite them with many other and larger systems. But the all-comprehensive universe, though changing continually in the internal arrangement of its parts, neither increases nor diminishes in any respect. In this sense it is immutable, indivisible and indestructible. It also must be immovable in space. Its perpetual internal changes are but as the vibrations of its several parts.

The problem which we are trying to solve is this:—are the ultimate units of this substantially changeless whole, little complete types of the whole? Are these also systems; each complete and indestructible; never increasing, never diminishing, but each changing continually as the universe changes—by perpetual vibrations among its parts? Such vibrations would enable all these units of the cosmos to coöperate among themselves and yet to remain unchanged and indivisible as persisting units. Is the cosmos a vast unity embracing the smaller units? Is each unit patterned after the whole—a little determinate structure fashioned in its own likeness?

The answer to this question must be written unequivocally in every atom. The atomic modes of interaction ought to enable us to answer the inquiry either positively or negatively. Since every atom is a coöperative part in the total of all substance, it is either a least unit, a least division which can act as a partially independent centre of energies, or else there is a still smaller division possible. But *the smallest division is the ultimate atom; the unit of force and extension.* Then if the total is indestructible, its least division must be also indestructible. In this way logic would answer the question.

But it must be decided, in addition, by undisputed facts. The exceeding complexity of the atomic coöperations lead us to the conclusion that, simple as it must be in nature, it is yet extremely manifold in functions. The molecule is the unit of the physicist; but within the molecule each atom exerts its own proper forces, many, various, and simultaneous. Gravity is continually drawing the atom in all directions; for it possesses gravity in its own right—not because it takes part in a mass with other particles. Its vibrations of light, heat, electricity, etc., enter into the molecular vibrations and are still an active influence in the combined result. Its cohesive forces bind it to the rest of its molecule and also to the larger body of which it is one component part.

Thus our ultimate atom, when it is one of the active units in a living organism, may be at the same moment gravitating towards the earth with great rapidity and also actively sustaining energetic relations with a number of distant planets, and the sun. At the same instant it may glow with the richest color, may vibrate with heat and with a powerful electrical energy, at once attracting and repelling other bodies; it may move as a projectile, exchanging motion for resistance to motion with the atmosphere; it may bind itself to other atoms with forces more powerful than iron clamps; and it may take its own proper share in the countless number of vital processes pertaining to its organism; such as assimilating and digesting food, promoting circulation, muscular action of many kinds, nervous activity, etc. It may even take some part in the psychical operations which are dependent upon its organism.

The inference is, that the atom which is actively part and parcel of all these many diverse but coördinated movements, vastly complex as they are shown to be, must be itself an extremely modifiable system of forces, held together in one bond of unity by something which is not force though inseparably allied to it. What this something else is, and how they can be supposed to co-exist in one simple and indivisible structure, it must be my next effort to indicate with as much definiteness as is possible.

A NEW THEORY OF ATOMIC STRUCTURE.

Practical science accepts the extended.—Force and extension parallel realities.—They condition each other in every unit of being.—Unextended force impossible in thought and in fact.—Electricity as related to extension.—Modes of force and extension vary in mutual relationship.—Definition of unit of matter.—Illustrated by relations in the triangle.—A conditioned existence requires unlikeness in kind in the conditioning factors.—Matter conditioned by force and extension. Minds conditioned by force, extension, and sentient force of varying qualities.

PRACTICAL science assures us that all substance is indestructible. It proves, so far as proof of any question of fact is possible, that no particle of matter is either originated or destroyed. It proves that force and extension are equally persistent; that force is not extension, that extension is not force; and yet that the two are indivisible. They coöperate in a multitude of ways, the result being the most diverse forms of the extended and equally diverse modes of force—both more than the sands of the sea-shore for number. Each limits the other.

All practical science deals with the properties of the extended, such as weight and structure, in entire good faith; treating them in all respects as literal relatives. It is compelled to regard them in this light. They everywhere assert themselves to be as real, as rigidly determined in their varying phases, as quantitative in every character, as mathematically related among themselves, and as accurately adjusted to coöperative forces as the modes of force are adapted among themselves.

It is said to be "no longer a subject of doubt in the minds of *savants* who have got beyond experimentation, that extension is an image and a show rather than an essential constituent property of bodies." But the surveyor could not easily admit that the broad earth which he estimates by acres can be made up of mere unextended force. The chemist, like the grocer, must believe in his heart that weight represents something different from a vibration or any form of motion—that it represents something more than pure resistance. Size, and form, and structure in bodies, is something unlike *in kind* from the powers or active properties of bodies. The instincts of every child teach it so much; and intuitive knowledge is never wholly at fault. It may be wanting in discrimination; but it has never been found to originate in pure self-deception.

Then if practical affairs, scientific or unscientific, must treat the extended in all of its modes as realities, in the same sense that the modes of force are realities, is not this the highest evidence that they are real in an exactly parallel sense? We hold that they inhere together, mutually defining each other, in every *unit of being;* and that they are joint sharers in every process of change.

The zeal for generalization—the absorbing love of unity, has tempted some philosophic minds to resolve everything into the one ultimate, force. But force limited by extension; the extended limited by force; two phases in each indestructible unit of being, may also lead us to an all embracing unity of which these are the definite constituents. Such a unit, coöperating with others like or unlike itself, may interchange with them *modes* of force and *forms* of extension; and yet remain unchanged in atomic constitution. Extensions and forces, being unlike in kind, cannot be transformed into each other; but extensions can merge into other forms of extension, forces into other modes of force; and being so mutually conditioned that if there is change in either there must be coördinated change in both, this bond of union is the atomic unity; the one immutable element in the midst of all mutations.

To this point we will return again. Let us now ask: Can philosophy determine with unquestionable authority that extension is nothing more than a derived, secondary property of force? Philosophers who take this position admit that they are compelled to add extension to force, before they can either think of force, talk of it, or treat it in any way whatsoever. What kind of derivative can that be which requires to be first created in illusion before its primary can be brought into consciousness either as an ideal possibility or as a real existence? The extended seems, if possible, more real than the forceful.

Mr. Spencer says: "A centre of force absolutely without extension is unthinkable." "The idea of resistance cannot be separated in thought from the idea of an extended body which offers resistance."

No! neither can it be separated in reality. Mr. Spencer himself is obliged to confound actual extension, *the extended*, with place or space, the "blank form" of extension, before he can even seem to derive either space, time, matter or motion from force alone. "Unextended positions" which do not resist are nothings, from which certainly nothing can be derived—unless it be blank space, which is nothing—except as *a relation of the extended*. Divisions of space are relations between parts of the extended. Unextended positions which offer resistance, are inconceivable in thought; and if they exist in fact we cannot really believe that they do; but must believe that they do not. Besides, an infinity of them, provided they could exist, could neither give one inch of actual extension nor one conception to us of the extended.

"Muscular adjustments," involving "muscular tensions" and disclosing to us "resisting positions;" and all other personal experiences; thoughts, sensations, and acts of will; are, one and all, inseparable from accepted extensions—extensions not to be got rid of in thought or in practical estimates. What can we conclude, then, except that it is not force without extension, but force inseparable from extension, which produces all changes. Both may be unconditioned in the Unconditioned, and yet exist inseparably together as joint conditions of every finite atom. As all force is one, so all extension is one. Together they may comprise the totality of all being.

We might concede the claim of modern French philosophers that, "the collision of force with our minds" can give rise in them to all the phenomena of extension, *provided they could show that any force can ever be properly regarded as acting without coöperative extension!* They assume that electricity when producing an electrical shock has no extension. But has it not? If the conducting wire and all its molecules are real extensions, and the electric current only one kind of motion among these molecules, there is no more propriety in assuming that electricity is without extension than in assuming that any moving mass is unextended. Whether a vast body comes through space to meet us, or successive groups of invisible molecules, swinging to and fro, communicate to each other the initial force, a blow is dealt us all the same by force which we claim is inseparable from correlated extensions. The sensation must be equal whether the slow mass or the flying molecule communicates the same amount of active energy. If the sensation is not identical, it is because the modes of force and their corresponding extensions are not identical.

A wave of electricity which can fly from Europe to America in a fraction of time hardly worth estimating for its brevity, must be mighty in power. But it is not mighty enough to act without correlated extensions. One break in the cable of communicating molecules, and the current stops. The long wire may appear to lie impassive in its ocean bed; but the oscillation of every one of its molecules is a fixed mathematical quantity. While the law of equal action and reaction continues, no least quantity of force can really fly away from its atomic extension. The *mode* of force is sent forward—*not the force*. The force oscillates with its extension within their adapted local boundaries.

Is it a real solution of the difficulty to assume that the three-thousand-mile cable is pure metal sensation, wrought in us by outward points of force? —points not infinitesimally small but absolutely unextended? A chain of moving points might be regarded as an extended climax of the unthinkable!

The assumption that any force ever existed or produced effects when separated from corresponding modes of extension, is a mere begging of the question.

The argument is this. There is "a psychological reaction which occurs in the soul when it is teased with a certain degree of energy by nerve-action, which in its turn depends on outward action;" * and as there is no likeness in kind between our sensations of taste, smell, sight, or sound and their external causes, so there is no outward extension to correspond with our sensations of extension. All this is admitted. We have no sensations which are like outward extensions. But we must go a step farther.

The real point is: Are outward actions and extensions like our accurately tested thoughts of them? May it be supposed that our best conceptions can

* Nature and Life, by Fernand Papillon, p. 15.

approach an accurate knowledge of external things? Why not? Light and sound are shown to be two different modes of motion. *That* is our thought of them; it is our thought of what they are in reality. In the same way our idea of extension may correspond to the reality. If not, all things external to us are so absolutely unknowable that we cannot determine whether extension is or is not as real and indestructible as force. We thus reach the unknowable very much this side of the ultimate.

But some knowledge of relations is admitted; and we claim that modes of extension are relative and variable in an exactly parallel sense with the modes of force. If we accept the one class there can be no peculiar difficulty in accepting the other. Even sunbeams are dependent upon extension. Atoms of the sky-ether are proved to swing in definite and measurable times, through definite and measurable spaces, to produce sunbeams; the red wave of the beam is shown to be wider from crest to crest than the violet, and to vibrate less rapidly; they travel on at the same speed; and science assumes, that if these atoms of ether did not occupy space, no sunbeam could visit earth ; no ray of light or heat could travel from star to star.

To escape from unthinkable points of force which yet move through and occupy space, we must assume that all atoms have extension. In the form of gases, liquids, or solids, they are much too minute to be seen by aid of the highest magnifying power known to us. In yet more ethereal conditions they are still farther removed from the senses. But we can readily perceive large aggregates of atoms coöperating together; limiting each other within the bounds of partial solidity. And *mind* can always grasp the idea of centres of force with extension, though it cannot conceive of them without extension.

Nothing hinders us from concluding that since each class of ether atoms is assigned its own special length and rate of vibration, so each may have an adapted extension; as unlike in dimensions and perhaps in shape as their unlike oscillations. There is no inherent absurdity in supposing that all ultimate atoms are extended. But if they are, the nature of things, the necessaıy or uniting bond in all relationships whatever, must require an adaptation of their relations; so that change in one would necessitate change in all. Thus all changes of atomic force would involve equivalent changes in atomic extension. This theory defines the unit of matter to be;—*force and extension so coördinated that to separate them or to change the equivalence of their relations would necessitate destruction of the atom.* The atom may be regarded as *a conditioned unit*, which, subject to many related constitutional changes, must retain its atomic identity unchanged.

Perhaps this theory can be made plainer by illustration.—Every triangle must have both boundaries or sides and enclosed angles. These are its inherent conditions; to take away either class of conditions must destroy the triangle. The sides are not angles; the angles are not sides; neither class can be exchanged for the other; but without a maintained equivalence of relations between the two, there could be no triangle. Even if angles could exist unless defined by enclosing sides; or if sides could exist without limiting space and fixing the enclosed angles, still no combination of angles alone or of sides alone could make a triangle.—It is equally true that no combination of forces alone or of extensions alone could make a conditioned existence.

But a triangle of a given area may be variously modified yet retain a persisting triangular character, provided each modification is so effected as to maintain equivalence of relations between all the several parts. Thus when the three sides are equals the three angles are equals also in their kind. When two of the sides are made equals and longer but the third side unequal and correspondingly shorter, two of the angles must become proportionately enlarged and equal to each other and the third angle be unequal and smaller. When the three sides are all unequal then the three angles will be correspondingly unequal. A triangle, then, has three sides and three angles so necessarily coordinated that to separate them or to change the equivalence of their relations must destroy the triangle.

The triangular unity, persisting amid all possible changes, lies in the always equivalent relationships among the several parts. The variations must be exact mathematical changes throughout; but in even so simple a figure as a triangle of a fixed area, the possible changes are limitless in number. Either line or either angle increased or diminished by the smallest fraction, must initiate corresponding changes in every other factor of the mathematical unit. A triangle is one type of mathematical unity. It is a conditioned ideal, composed of mutually dependent relations; every relative of equal importance in determining the present state of all the others.

The necessary conditions of the triangle may sufficiently illustrate the similar conditions, which, on the new hypothesis, unite force and extension in every atom of matter. The modes of atomic force are held to be mutually dependent among themselves, and equally dependent on their related modes of extension. It is supposed to be a structural necessity that all atomic changes should take place in rigid mathematical relation; modes of force and forms of extension varying together as the two essential, mutually conditioned phases of one existence. A smallest possible division of matter; the least part divided off in structure from all other parts, but itself indivisible, is in its very nature a limitation. Its innate constitution compels it to be a persisting unit in the same sense that every mathematical figure; as a triangle, a circle, an octagon, or a thousand sided and thousand angled figure, is still a unit; though each unit may possess many definite parts within its own structure. The destruction of any one part is the necessary destruction of the whole unity. The parts all exist in mutual dependence. They vary together in necessary relationship, and they must so vary or the entire unit would be annihilated.

The geometrical unit is a logical ideal and as a pure ideal it is indestructible. The unit of being must be regarded as the ideal relationship of dependent parts made actual in real existences. Its individuality, its whole and sole title to existence at all, is conditioned. It is made internally dependent upon the maintained relationship and integrity of all the variable parts within the structure. To destroy this adaptation would be to annihilate the unity which exists in virtue of being thus conditioned. It is on these rigid mathematical terms that force and extension are supposed to *condition each other* in each unit of being. They are not mutually convertible into each other, but continue to be the two mutually limiting and defining constitutional phases of the one unit of being.

Extension may be endlessly varied in form, and force in mode of action; but these variations must be related each to each in as rigid a sense of mutual dependence as that which exists between sides and angles or between inclosed area and inclosing circumference in geometrical figures. In a word, ultimate atoms, the only constitutioned and necessary units of being, aside from the all embracing total which we comprehensively term the universe, are held to be existences conditioned by force and extension in mutual limitation or individuation—each dependent upon the other in such a sense that to divide them is to annihilate both. The *total of force* limited by the *total of extension*, in exactly the same dependent sense, is the universe.

Outside of the universe may be the *unconditioned;* but the universe itself is conditioned. There may be more than one universe, as there is more than one individualized atom; but we know nothing of any except our own. That, we may learn something about; for it is around us everywhere in active operation. We have only to observe and comprehend something of its nature, of its inherent constitution, as manifested to us in its operations. We do not propose to go outside of Nature to learn that every unit of being, like the totality of being conditioned in our universe, is constitutionally indestructible. But by the study of nature, in little and in large, we think we find evidence that form and action, extension and force, weight and work, the something moved and the moving power;—different names all of them for the same jointly conditioned phases of all conditioned being—we think we find evidence that these two mutually defining factors of matter can ensure to every atom in the universe, sentient or unsentient, an absolute indestructibility, an immortality.

All limitation must be conditioned, of inherent necessity. But nothing can limit itself. Nothing can condition its own being. Some unlikeness in kind of manifestation is absolutely essential to all constitutional limitation. No infinity of forces nor of modes of force alone could practically limit or condition each other. They are all nothing but parts of the same phase of being; each can be merged into the other indefinitely. It is the other merely changed in mode of action. Just as any number of angles could not limit or condition one angle anywhere, or give it a definite value; so it is maintained, neither can there exist a universe which is conditioned by forces alone. On this point we shall have more to say farther on. To hold our many points in relation, it seems to be essential that we should turn from point to point, and perhaps turn back to some, again and again.

If this universe as a whole, or if any of its parts are constitutionally, internally, limited and defined, it must be thus conditioned by at least two phases of existence which are so unlike in kind that neither can be transformed into the other. With this provision established, either would then be competent to condition the other. Force could condition extension, and extension could condition force. One mode of force could be merged into a dissimilar mode of force, and one form of extension could be changed into an unlike form of extension; but forces would remain forces, and extensions, extensions. When the mode of force changed, the form of the extension would necessarily change with it; or if the form of the extension was first changed, most directly changed, that would change the mode of force to correspond. They must vary together as absolutely as the sides and angles of the geometrical unit must change simultaneously.

The two phases or essential factors of matter which have been made constitutionally competent to thus condition and control each other, are sought to be included under the comprehensive terms force and extension. And whenever there is a division of force and extension in which the two principles are able to condition each other for the time being, in this sense there is a system of force. To that extent and for that time, such a system acts together as a unit. Its internal actions and reactions are all equal and opposite; and as each molecule vibrates there is change of extension also, either as to place, or form, or both together, as the conditions demand.

But whenever and wherever force and extension are so mutually related that to divide either must annihilate both, there, and there only is the indestructible system—the true unit of being. It is in this way that we explain the *how* of an individualized universe—the *how* of an indestructible atomic unit of being, whether sentient and conscious of its own existence or otherwise. But consciousness—the attribute of true personality—though it must be classed under the broad term force, is yet something so generically unlike mechanical force in all of its modes, while yet inseparably allied to the modes and forms of matter with which it is conditioned, that it seems better to postpone all consideration of mental properties until a later part of the discussion.

Our theory supposes that mind is matter and something more—that *every mind is an indestructible material unit constituted by allied force and extension, jointly conditioned with sentient force or consciousness.* The whole is an indivisible and immortal conscious personality.

We are every day learning something concerning the wonderful amount of force in every least and dullest atom. We are steadily learning more also of the unlike modes and processes by which each atom can coöperate with other atoms in tens of thousands of varied relations. A similar mathematical dependence may condition sides and angles of geometrical figures, and active powers, with their allied forms in the actual extended atom. But there is no more reason for supposing that all classes of atoms are constitutionally limited by the same amount of force, or by the same mechanical modes of force, than there is for supposing that all geometrical units are triangular.

Matter is constituted by force and extension.

Minds are constituted by force, extension, and sentient or conscious force of varying qualities.

Every ultimate atom must, therefore, be regarded as a little indestructible system with a highly variable and elaborate form and structure—its variations corresponding to the varying and often simultaneous unlike modes of its atomic energies. Action and reaction must be equal and opposite, even within the atomic extension itself. Vibration, with no change of the atomic centre of gravity, implies and necessitates this pliancy in the atomic structure; it implies balanced energies between the several parts of the system; and it equally implies changes in form of extension to correspond with changes of atomic activities.

An indestructible system may be a simple unit, may be structurally indivisible except by utter annihilation; and yet it may be composed of many and extremely variable parts, all necessarily, mathematically adjusted among themselves; so that they must not only change in mutual dependence, but the very existence of each and all of them may be conditioned in mutual dependence. This allied and equal dependence is, in my conception, the very essential nature of a conditioned unity. I have already illustrated the possibility of such constitutional interdependence by the well known necessary relations among the several parts and functions of all geometrical units. Even those ideal unities require a logical dependence of all the powers and extensions of the ideal unit. Any change out of relation is structurally impossible.

Such unities exist, then, in thought. Do they exist also in things? Is the whole of Nature composed of coöperative, conditioned units of actual existence? We turn now to the simple question of fact.

EXTENSION; WHAT IS IT, AND WHAT ARE ITS FUNCTIONS?

Extension as related to force.—Nothing can divide and relation itself. —We must find in Nature, if conditioned, at least two principles unlike in kind.—Extension is changed in form, is unchanged in amount.—Two phases of one unity.—Force active.—Extension passive.—Forces coöperate through their extensions.—The nature of elastic force.—The block of iron, how changed in modes of force.—The atom as a centre of many activities.

EXTENSION may be regarded as comprehending every thing pertaining to bodies except their forces and the interaction of these forces. But the exception is so comprehensive that we find many philosophers who argue that, in the last analysis, force pure and simple is all that remains as a basis for the visible forms of matter. The theory may be explained in this way.

Colors are simply rates of vibration; heat is vibration; electricity is motion; gravitation is motion or resistance to motion. In brief, all physical properties result from various arrangements and combinations of forces. Unextended points of unextended force move, or resist motion, and it is their varied coöperations which produce in us the effect of all kinds of more or less impenetrable substances. Their rapid vibrations produce the illusion of perfectly continuous solidity—just as a burning brand when swung rapidly about, gives to the eye the impression of a solid band of light. The motions are so rapid that the communicated action lingers in the nervous system, giving rise in our sensations to an effect like that of actual continuity. All forms of inertia, of hardness, tenacity, or other properties of texture, may be explained on a similar principle.

For ourselves we are quite ready to admit that if unextended points of force could be kept in their relative places; could be made to vibrate in the times necessary to produce the required effect, and could be made to vary, to combine, to separate, to recombine; to act and react in endless new combinations among themselves, always in definite mathematical ratios, in that case perhaps they could be made to exhibit all the visible phonomena of extended bodies. Such vibrations might affect our vision like real dimensions.

But points of force so endowed with permanence and immutability, would be indivisible, ultimate atoms. They would be our units of being in every respect, except that they would be unextended; while the actual units are believed to possess extension. It must be conceded that substance, which is in appearance perfectly solid and without any internal spaces, is not only porous to light and heat, but by sufficient pressure it can be packed still more closely together, showing that it does not completely fill the whole space which it occupies. If there is extension, there must be a limit to compressibility; but it is very far on the other side of what our senses present to us as apparently solid bodies.

But since force is one, is like in essence or kind of existence, how could points of force be kept distinct, if pure force were the only ultimate? Could permanent divisions; incessant actions and reactions infinitely varied in their changes; could the whole endless range of perfectly mathematical adjustments be self-evolved in one absolutely uniform principle? The supposition is incredible, unthinkable. Shall we say it must be utterly impossible? we are either driven to look *outside of Nature* for the proximate cause of mathematical relations between purely arbitrary divisions of a common principle; or, otherwise, *we must find in Nature some unlike principle which is able to make divisions of force permanent, and in their action partially independent.* They must be able to act from their established centres of operation. They must be able to coöperate with other centres of force.

In our view this limiting principle is extension. Its distinct function is to divide off and isolate, individualize, small parts or sections of force by a permanent alliance with it in such small sections—each section of extension being adapted to exactly correspond to and define or bound the force limited. Together they isolate each other in a distinct unity. Together, as one, they persist amid all physical changes.

If we can find extension and also force within the domain of nature, the whole problem will be greatly simplified. That the existing constitution of these units of being, like the total of universal force and extension, may have required adjustment by a Power superior to both, is a distinct question in itself. At present we are students of Nature only. We are simply endeavoring to decide whether or not there is in Nature a physical basis of continuous personal identity; and thus of immortality.

The extended or apparently extended properties of matter, it must be conceded, make up the only differences which exist between pure simple force, and matter as we know it—as something apparently visible and substantial, in which the force as an active principle permanently inheres. When we see a body in motion, we think we see the something which is moved, but we never believe that we see the actual moving principle. The burning brand, when it vibrates, may seem to extend itself into a continuous band of light. We can explain this effect; we know just *how* it arises. But there must be an actual, extended, vibrating, red hot brand which does actually move through a given circuit, in order to produce this continuous appearance.

In the same way there must be actual extension in the vibrating atoms and molecules; then, *if their vibrations are so adjusted that together they cover the* *whole space*, the effect will be exactly what it is; the appearance of a compact solid body. But how points of force absolutely unextended, even if they could be held in their places and made to vibrate through the required circuit, could produce the effect of real extension, it is impossible to imagine. It is in the nature of force to be able to resist the action of other forces; but resistance positively without weight or inertia, that is, without a fixed centre from whence the resistance emanates with its opposition of energy, is equally inconceivable.

Weight has been distinguished as the measure of matter in a sense similar to that in which work is called the measure of force. In this sense, *matter* must signify exactly the same thing that we mean by *extension*, or the extended. A given amount of weight is joined to a definite amount of extension. But the extension does not necessarily remain unchanged in form; it does remain unchanged in amount of substance extended. The pound of water under equivalent conditions, weighs exactly a pound, whether in the form of a solid, a liquid, or a vapor. The extension may be presumed to be the same also.

The molecules of the vapor, though scattered farther apart, may occupy no more solid space than the molecules of liquid water or ice.

A roll of cloth is a firm, compact mass. Unrolled, it will cover a comparatively vast surface. A fisherman's seine tied in a close bundle, is, bulk for bulk, identical with the filmy net-work of open meshes which sweep from shore to shore of a broad river like the Connecticut. There must be a difference similar to this between a pound of solid water and the same pound unwinding itself as water vapor into a great vibrating net-work of coöperative molecules, which partially occupy 1800 times as much space as before. Or, compare it to a pound of compressed, fibrous cotton; puffing itself out, when the pressure is removed, into a huge fluffy mass of white down apparently many times its original dimensions. It is certain that there is the same extent of cotton fibre in the pound mass, let it assume whatever form it may. Spun out into a thread which should reach half round the world, its weight would still be one pound, neither more nor less.

Extension and weight are thus shown to be inseparably allied quantities; two expressions of the same essential fact. Weight is a more convenient, a more available measure than extension; but the relation of weight to force is not more definitely adjusted than the relation of extension to force. Under like conditions of pressure and temperature, a given volume of any substance in a gaseous form will enable us accurately to determine its weight and also to determine the precise amount of several of its forms of energy; as its elasticity, and its relation to various modes of motion. Extension is a measure of force, and conversely force is a measure of extension, when estimated under given conditions.

Moreover when force varies in its form of action, its allied extension can be shown to vary in a determinate mathematical relation. All force is one, and all extension is one, but the modes of extension, like the modes of force, are practically infinite. The forms or shapes of bodies in all their endless variations are forms of the extended. The delicate petal of a flower, the bare, grey, rocky cliff jutting out in solid resistance from the side of a mountain; the pearly cloud hardly visible against the blue of the sky, and the world itself swinging solidly in the same heavens, are all of them but so many widely contrasted forms and quantities of the extended.

It is admitted that unlike rates of vibration in that form of energy which we call light-motion, are reflected from these several unlike bodies; and it is conceded that all shades of light or color are nothing more nor less than slightly varied modes of force. But force acts where it is—not where it is not. Because these bodies are variously extended, and because one identical principle is allied to these extremely unlike forms and amounts of the extended, this same principle force, is made to vibrate—now in the form, and size, and color of a glowing flower petal, now in the neutral tint outline of massive rocks; now to wreath itself to and fro in a vaporous cloud, and now to gird its great bulk together in a vast adhesive sphere twenty-five thousand miles in circumference.

The extension controls the force, deciding the modes in which its energies shall be exercised, quite as certainly as the mode of force, in its turn, decides the form of the extension. They are not two distinct principles held together in an arbitrary alliance. They are but the two phases of a being which can have no existence except in and through the maintained relationship of phase to phase—neither phase anything without the other; both together the effective basis of coöperation with other like units, out of which the universe itself with its infinity of possible, intermediate, but destructible systems, is securely, immutably constituted. Alone they are nothing; together they constitute one something.

Force without extension is as impossible as a child without a parent or as a parent without a child. The two things are conditioned together as necessary correlatives. Various scientific authorities speak of force as a separate principle to be distinguished from matter. When mind is regarded as anything different from an association of matter, it is to be distinguished also from mind. In our view, the material unit is simply a section of force extended—of force which is extended force—that is, force which is measured by and limited or coördinated by extension. Or, reversing the statement; the material unit is a section of the extended which possesses inherent force that limits and conditions its extensions. The force acts in time, moves in time, with definite rates of vibration or other motion; the extension is moved through space; it occupies space, it is estimated in terms of space. The unit as a whole is conditioned both in time and in space.

It may be easier to explain the active than the passive side of matter; but on the other hand it is immeasurably easier to represent or picture to the eye the passive side. Form can be imagined; its likeness can be held up to the eye; and it is equally true that form can present itself. We can perceive it directly. The common people always have perceived it and accepted it. But if we ask what it has done, the answer must be, it has done nothing; it is not the doing power in Nature. That power is force. Extension is the embodiment of inertia; it is the localizing and conserving ally of mercurial force. It waits to be modified; and, as it were, it *passively resists* change.

Change, motion, the exponent of force, is in thought readily separated from the something moved; but what are size, or form, or weight, or structure, without the something which possesses these properties? That something is not force, as assuredly as a line is not an angle; as a child is not its own parent; or as a part is not the whole. A force is virtually every mode of force into which it can be successively transformed. It was electricity; it is heat; it will be chemical affinity. A unit of extension is virtually every form of extension into which it can be successively transformed. It was the simple form of a carbon atom; it is modified in the molecule of carbonic acid; its shape will probably be still more changed when it becomes vegetable tissue. Extension is *effect* to past extension as *cause*; force is *effect* to past force as *cause*; but extensions are not transformed into forces, nor forces into extensions. Force is always active; extension always passive. Neither is *cause* of the other.

Force seems to be acted upon not directly, but indirectly—through the mediation of its extension. The reacting force reacts also through its extension. What is elastic force? A steel spring is bent till it loses its accustomed shape; in the reaction it regains its accustomed shape. There is change in the form of the cxtension ; and was not the force acted upon through this change? Did it not react by restoring the former condition of its extension? It repelled or reflected the original force by undoing the work which that first accomplished—the work being some change in the extension upon which it acted. In every collision there must be some change in the extension of the colliding bodies. It should extend to the atomic structure, which must be pliable or elastic like its allied force.

Let us clearly represent to ourselves two distinct but not separate classes or groups of properties—in the one group ranging all the possible modes of force; in the other, all the possible modes of extension. If it is difficult to separate them in language, or even in thought, this is not remarkable, since they are never separated in things. And yet they are distinct phases of one unity, from a very positive, definite, and mathematical necessity. How then are we, as active powers, to act upon the forces and compel them to change any of their present modes of activity?

Here is a heavy block of iron of a certain temperature; in appearance quite irresponsive to any mode of force which we can bring to bear upon it. Do we say that it *shall* respond, in exact and equal reaction to every mode of force which we choose to exercise? There is but one way to compel such a result, and that lies solely through the passive inertia of its extension. With a fulcrum and a crowbar we may roll the block into a new position. That will be changing *the place* of its extension. Granted that it is force, not extension, which actively resists this change! But it resists by maintaining its extension unchanged in form. It pushes back and repels all change of form, all displacement of parts.

Again, we may beat upon the block with a blacksmith's hammer. This is an attempt to crush in and displace *the form* of its particles. We do this to a small extent; but its elastic force turns upon us and pushes back. Every atom in the solid block begins to vibrate as if in resentment. It becomes intensely heated. If we could bring a crushing weight heavy enough to sensibly compress the iron, we should produce the same result of intense and active heat, which is nothing more nor less than elastic force asserting itself to prevent any essential change in its adjusted extensions. Or shall we ourselves bring heat-motion and communicate that freely to the iron particles which are already swinging in responsive vibrations. The iron cannot resist the heat: it will accept it; but it will return *to the source of the heat* an equivalent amount of resistance to heat motion. Give it heat enough; its rigid forms of extension will be overcome; and the block will fall asunder as a molten fluid. Its resistance has been exchanged for a most active form of motion; but the motion was communicated through the extension. Every particle of the block was changed in form because the force which would have resisted this change, instead of continuing to resist, suffered itself to be transformed in mode of activity.

At any rate, the extension varies as the force varies; and the limitations which are laid by each of them upon the other, condition matter both in time and in space. Hence each atom is conditioned within itself. It is structurally limited and individualized; so that, amid all possible changes, it is constitutionally immutable. We must think of it as always a symmetrical, many sided, pliant figure, thrusting out its points of attraction or of repulsion on all sides in symmetrical or balanced action—its multitudes of vibrations balanced among themselves and in adjustment also with all coöperative outside forces.

Do our infinitesimal atoms seem too minute to be the centre of this almost limitless number of structural energies adapted to their corresponding extensions? The infinitely small is not farther from our conception than the infinitely great. If there are 699,000,000,000,000 oscillations in one second in every violet ray of light, if there are 57,000 waves in every inch of the ray, and if each wave travels 192,000 miles every second, there can be no assignable limit to the wonderful forms and energies of the least and weakest atoms. A structure destined to last forever may well be most aptly and marvellously constructed.

PHYSICAL MODIFICATIONS.

The atom a group of interdependent conditions.—Symmetry as necessitated by the atomic conditions.—The pliancy of all structures.—Many varieties of crystalline modification.—Pliancy of form in organic and in crystalline structures.—Change in the quantivalence of atoms.—*How* force and extension condition each other.—Two theories.—Motion a necessary relation of conditioned force and extension.—The coöperation of atomic units.

IF each unit of being exists as a distinct internally conditioned structure; if it acts from itself in adapted coöperation with multitudes of other units, simultaneously aiding them to carry forward many various processes—every such unit must itself possess a pliant structure whose several parts are so far independent in modes of action that each can perform special functions; though always upon the principle of balanced action among themselves. This unit must be a highly complex unity, whose parts and functions are so mutually adjusted that they are partakers of a common existence. It is *a group of interdependent conditions.*

A unit thus structurally and functionally conditioned would occupy its own position in space; it would have its own rates and amounts of possible internal change and variability of form, to correspond with the variability of functions; and through its coöperation with other units, it could be variously moved and otherwise modified. We have seen that the most elementary substances known to us, when in a gaseous state, are such structurally independent yet externally coöperative systems. We have seen that when two or more of these unite to form a larger system, they modify each other in all their processes; and that they even take a new third position in space. We have seen that through coöperation these various systems are able to move each other from point to point; and to form compounds, with new resultant properties.

Now supposing the atom to be an actual physical structure, it must come legitimately into the rank of physics. We may fairly reason from the established action of the visible body to the necessary action of the invisible one. My theory of the atom is of long standing; it has been carefully considered as to its bearing upon many classes of admitted facts; but experimental science must establish its crucial tests, if possible, and decide beyond question whether it be true or false.

Here are words written years ago: "I regard the coöperation of forces as comprehending not only the push and counter-push between atom and atom, but also the push and the withdrawal of that push by every atom singly and collectively, when not impeded in the completion of the process. Every molecule, (and every atom,) it is believed, is itself endowed with the two reactionary types of the one identical force, which together keep it forever pulsing to and fro like the panting heart of a live creature, each atom a microcosm of the universe with its eternal ebb and flow, its systole and diastole." *

But the axis of the atom, its centre of gravity, can never be self-moved. All its vibrations must be balanced within its own structure; and hence, as all its quantities and rates of oscillation are held in check by allied extensions, the form of every atom would naturally be a symmetrical, a well balanced form. The molecule, an association of atoms, would

* Studies in General Science, p. 90.

demand a like symmetry; and molecule joined with molecule in visible masses, being still governed by the same adaptation of energies, should lose nothing in fundamental symmetry of structure. The theory requires visible order, balance, and symmetry in all the forms of Nature.

Facts justify and confirm the theory. Nature has no forms, inorganic or organic, which are so far out of equilibrium in outward shape that they can be thought of in any other way than as produced by some steadily maintained balance of adjusted forces. Very ugly living creatures are on the earth and in the sea; but not one is without real symmetry in the arrangement of part with part; or without an equal adaptation between the creature and its surroundings, however various or peculiar these may be. The temptation to go into detailed illustration is almost irresistible, but the obvious fact is too familiar to require this. There are no one-eyed, one-armed, or one-sided men, except in fable. Single appendages in all animals arise at the junction of the balanced members of the system, or they can be explained as arising from obvious and necessary conditions which demand the odd member to balance the organism with its environment. A double symmetry—often a manifold symmetry is the universal law.

Every tree, leaf, twig and flower is the embodiment of a solidified equilibrium—each after its own kind. An oak, an elm, and a willow has each a type of its own. Nature maintains a balance of angles in each, within certain limits, as correctly as though she were always ready with rule and dividers to measure off every least beginning of growth, to establish it in the right direction forever. From the seed upwards each growth is like the growth of its predecessor. The honored historic Elm which fell the other day on Boston Common, and whose obituary is to-day printed in many distant papers all over the land, is no higher exemplar of Nature's law and order than is the meanest weed which cumbers the ground. Balance or equilibrium of all form is an absolute principle. Apparent want of symmetry proves to be only a still higher symmetry.

Arrangement of atoms within the molecule is governed by laws of geometry as unalterably as thought by laws of thought. Science has traced equilibrium in the molecule as running often in two directions perpendicular to each other, one at right angles to the axis of grouping, the other parallel to it. Chemists who would represent to the eye any supposed possible arrangement of atoms, instinctively group them symmetrically in the absence of actual knowledge. That molecule allies itself with molecule in stable equilibrium of form, is beyond question. This fact has been determined by the united testimony of light, heat, sound, magnetism and electricity—every one of these various modes of motion being differently transmitted or otherwise affected by the direction which it pursues within the same structure. Light and polarized light, electricity and the magnetic current, when they are deflected at right angles to each other, may be supposed to follow the main directions of established atomic arrangements.

But even the laws of symmetry are pliant to surrounding conditions. Heat ordinarily enlarges bodies in all directions; but in calc spar it produces actual contraction in the direction of the secondary axis. In crystals of three unequal axes, the amount of expansion differs in each of the three directions. The angles are all changed in magnitude. Change of form in bodies subjected to any subtle energy—say to powerful electrical action—is made visible to the eye by polarized light. A ray of this light made to pass along the axis of a prism or cylinder of some transparent substance, as water or glass, has its plane of polarization deflected whenever the medium is subjected to the action of a magnetic current passing around it at right angles to the ray. The effect varies with the strength of the current, and it ceases when the current is broken.

It is not possible to attribute the whole of these and similar effects, as it seems to me, to changed attractions and repulsions between rigid particles which remain always wooden and changeless in their own structures. The expansion or contraction is invariably the same under like conditions, so that regular tables are made out to express the definite amounts; but this would be the result if the atomic extension were variable in form, quite as certainly as if it were absolutely rigid. The most pliant atom would not greatly change its normal shape except under a most complete change of conditions. But it might be expected to bend or sway to and fro precisely as a larger mass does when powerfully acted upon. If the least particle in a magnet is itself a magnet, how can it act at all except by some kind of vibration? and vibration implies pliancy—strain here, and compression there.

Even if we call in the aid of an ether as medium between particle and particle, yet there must be tension somewhere; and to my mind tension presupposes extension. What possible conception can we form of a strain—a contracting pull in unextended force? But if we regard heat and electricity as "transported shivers" sent into a crystal, why may not every part of every atom, whether pertaining to the ether or to ordinary matter, be supposed to shiver in sympathy—every contraction in one direction implying corresponding expansion in the opposed direction? The effect would be such as it now is, unequal movement in dissimilar lines, quite possible to be tracked out faithfully to the eye by the responsive polarized ray.

Unlike conditions must occasion unlike results. Crystals identical apparently in molecular structure—

not simply isomeric bodies chemically identical, but built up from the same molecules,—are often unlike in external formation. Floating crystals have been seen having the primary form distinct and simple; but when they attached themselves to the side of the vessel they assumed secondary forms, these forms clearly arising as reactions. A substance may even belong to different systems of crystalline forms. Carbonate of lime crystallizes in the trimetric and in the hexagonal systems. Titanic acid assumes *three* distinct forms; carbon three, two at least crystalline,—all differing in specific gravity, specific heat, conducting power for heat and electricity, and in chemical relations. Modes of force and forms of extension are modified together. Mere difference of arrangement, with no change of energies and coöperations, would certainly be powerless to effect these results.

The nature of the solvent and of substances held in solution are known to be causes of secondary forms. Salt, crystallizing from pure water almost certainly assumes a cubic form; "in a solution of boracic acid, it always occurs with truncated angles." Many successive changes have been produced in crystallized forms by the presence of different liquids or different proportions of the same liquid in the solution. The unlike reactions give a different total result. We may insist that the molecules and atoms remain unchanged, though *the lines of force vary and thus influence the general grouping;* or we may argue that marvellous, orderly phenomena like these can arise from *unextended force alone;* but the plain straightforward inference is, that *as the molecular forces are changed in modes of action by these foreign substances, all their physical properties change also.* In a given locality the crystals generally assume like forms, showing that like producing causes have effected similar results.

This inference seems still more necessary when we remember that in nature a substance is often removed by successive stages, and with equal progress another is substituted in its place; as when cubes of fluor spar are transformed to quartz; or when the substance of vegetable fibre gives place to a mineral, in "petrified wood." The entire form of the structure, the very graining of the wood is retained in minutest detail. What should we conclude except that, molecule by molecule, the new elements shape themselves into the places of the old, in obedience to the moulding influence of all the other forces about them, and that, when a complete displacement and usurpation has been effected, the new forces and their allied extensions find themselves so equilibriated in all their vibrations of every degree, that they remain permanently as they are, constrained to masquerade in the guise of their predecessors.

Nature's forms represent Nature's energies. In her domain borrowed plumes seem to imply borrowed functions in downright sincerity; she tolerates no shams. She exacts measure for measure in exchanged modes of force; and when one substance creeps into the shoes of another, whatever its internal economy, its coöperations with the outside world must be forced to adjust themselves largely to the steady outside pressure. If it cannot do this, it cannot remain a pseudomorph.

The laws of symmetry have many variations, all of them tending to secure a balance of form which must be effected through balance of energies. Thus when all the parts of a crystal are not similarly modified, then either half of the similar angles or edges, alternate in position, are modified independently of the other half; or, otherwise, all the similar angles or edges may be similarly modified but the usual modification is left uncompleted at a point half way in the process; or perhaps half the replacements will be much larger than the other half. *How* a force *working outside* of solid atoms could be induced to build up these structures under such variable. conditions of balanced form, it is impossible to conjecture; but if form and force wrought together in every separate brick, the final result would not be difficult of explanation. The first atom in the molecule would be balanced on its own axis and the molecule would necessarily range itself about this central root in stable equilibrium. And again, the first molecule taking its position, all successive molecules must perforce attach themselves about it on every side in a like equilibrium if their forces are unimpeded.

Crystals, on this theory, are internally constrained to symmetry. Even the mass of shapeless inorganic substance which to the eye has no regular shape, is found to have the same balanced structure in its minutest grains. And yet with all this, a certain amount of irregularity in crystals is the rule in Nature—not the exception. This corresponds to the similar variability in organic forms as when trees are permanently bent by prevailing winds, or when they receive some permanent twist in the earlier stages of growth. Small but balanced deviations are almost universal. Interposition of a foreign substance will often produce in a crystal what is called "oscillating combinations," parallel ridges. The curving produced in this and various other ways by foreign disturbing causes, sometimes changes the angle of the crystal, precisely, it would seem, as angles are changed in forms of pliant growth. And the foreign matter itself is modified in turn, in adaptation to the crystal. It follows laws of symmetry in collecting about the centre, along diagonals, in planes between centres and edges, or in parallel layers with some exterior plane; often taking the form of small crystals within the larger one.

In non-crystalline substances we find even stronger grounds for inference that the atomic system is variable in form as in modes of force. Those active energies which promote chemical union—the taking hands as it were, or uniting themselves by mutually attractive "bonds or poles," are not always alike in operation. Nitrogen is found sometimes to unite chemically by three poles, sometimes by five—called trivalent and quinquivalent. Manganese is bivalent, quadrivalent, and sexivalent. Iron and other supposed elements have a similar variability in what the modern chemists term quantivalence. Other atoms do not vary in this way, so far as is now known. *These variations involve corresponding changes in all chemical relations*, so much so that two elements differently united, will sometimes be more unlike in properties than two substances possessing different elements; and their derivations form groups which also differ from each other as widely as if they were composed of unlike elements. Modes of interaction determine properties!

But there is the same balance of action to be noted here as elsewhere; "at each successive step the quantivalence increases by two bonds, and never by a single bond." * Univalent atoms become trivalent or quinquivalent. Bivalent atoms become quadrivalent or sexivalent. Two atomic bonds are supposed to "satisfy" or equilibriate each other. Whatever explanation is given of facts like these, there is evidently involved change in modes of force and corresponding change in molecular structure sufficient to modify the external appearance as greatly as the internal characteristics. Each condition of every given atom gives invariably the same results. But as the conditions vary, must we not conclude that the atom also varies, not in essential constitution but in all of its related modes? Like physical properties everywhere accompany like manifestations of force.

The very large number of differentiated organic compounds possessing the same or nearly the same elements, indicates that their unlikeness cannot arise from passive arrangement merely. Different powers or functions must be brought into coöperation in every unlike method of grouping. And the change is evidently carried progressively throughout the

* The New Chemistry, by Isaiah P. Cooke, Jr. p. 247.

molecule—each atom bending to the influence which is brought to bear upon it and reacting accordingly. No fact is more remarkable than that each compound has a definite and eatablished constitution of its own, which is as sharply defined when two substances are almost identical as when they are extremely dissimilar. Combinations of energies so marked that they can maintain a characteristic nature under the widest variety of fortunes, must require the conservative element of allied real extensions.

If each mode of force is conditioned by a corresponding form of extension, we can in part comprehend *how* each may hold the other to stable and determinate manifestations or properties under all like conditions; and also *how* changed conditions can bring with them changed affections in the same material. But if force, though inseparable from matter or extension, may yet be transferred from one portion to another in such a sense that any given substance may possess more and less force at different times, *then* what system of power or of machinery can be conceived of which is able to give to each condition of matter exactly those affections which are adapted to that state and to no other? By what conceivable process can molecules of water be invariably split up into atoms of hydrogen and oxygen, of exactly a given weight, and size, and function, for each atom of each class, supposing force and matter to be two vast units conditioned together as wholes, but not conditioned together as atomic units?

The bond between them, on such a theory, is utterly unthinkable! Here are vast classes of never-varying facts under given conditions; the conditions change and the facts change to another equally unvarying series; but as to *what* the bond is between the two, we know nothing and can learn nothing. The force at one time produces one affection of matter, and then it produces another affection of the same matter; there explanation ends. The whole subject is inscrutable.

But on the new theory we understand something of the nature of force, something of the nature of extension, and also something of the nature of the conditioning influence which each imposes upon the other. We can get some conception also as to the process through which all changes are effected. We ourselves exercise force; it is a part of our most intimate and positive consciousness. Extension, size, dimensions, distance; actual figure of a given kind and capacity; let us use what terms we will to express this conception, is yet a real and positive conception. But force in action is motion of the body to which the force pertains; when confined within the unit of allied force and extension, it is vibration without change of central position; yet even such vibration must change extensions to correspond with modes of energy.

But our pliant structure is acted upon from without. Another body seeks to penetrate it or to thrust it forward in space. If the acting energy is mechanical and but very slight, our atom bends at first; then recoils and expels the intruder. Thus the two may vibrate together as one, may even ally themselves in one molecule. But a great force may come and send them both forward in space. This force also comes with its extension, it deals a solid blow and both systems recoil. The recoil is heat, a new motion possibly. But it also has its reactions; for they are pressed about on every side by other systems, each acting from itself as it is acted upon. Now even if we suppose every one of these distinct units to be absolutely alike, still, action and reaction from unit to unit, could be conceived of as actually setting up among them, by a process of continuous evolution, a universe as complex, as widely differentiated in parts, and as various in its modes of action as the existing universe.

The supposition is a very different one from the theory which has imagined an ether *absolutely uniform throughout*, as a possible starting point of the present cosmos. In such an essence, no motion could arise if not communicated from without. In our theory, motion is the normal expression of force conditioned by extension. Motion is the necessary relation arising between the two. Rest or cessation from motion is a constitutional impossibility. The atomic structure is conditioned upon the principle of eternal action and reaction within and without. Equilibrium is a shifting balance of active energies, not a state of rest. Force is inherent activity; conditioned as to its modes of action by its own actual extensions.

Should the individualized force move in one direction—the balance within its own structure requires counteractive motion in an opposed direction. It can do nothing alone but stand and vibrate. But its chemical attractions unite it, in the molecule, with unlike energies; its atomic possibilities become changed, modified; but they are also enlarged. They are supplemented by unlike powers; for whether or not all ultimate atoms are identical, yet it is certain that with a definite and internally conditioned structure, each must possess unlike poles and be able to exercise unlike energies. Hence, atom united to atom and coöperative with it, would give enlarged scope to each. But with many coöperative molecules mutually attracting and repelling each other on the principle of equal action and reaction, we should arrive at the condition of things which now actually exists among all gases—where each small system is able to maintain its own position, yet in coöperation with all the others. But it is not proved that all units are identical!

In solids, the coöperation is still more intimate. If atoms are self centred vibrating structures, but different classes differently constituted, by more or less of force and extension balanced upon the atomic axis, it must be still easier to explain the endless variety which exists through the compounded action of these unlike units—unlike at least in quantity, and unlike possibly in the whole structural plan—as circles are unlike triangles or rectangles. But we are concerned only with facts as they are now manifested to us; in these facts we are only seeking to find evidence that force and extension are every where conditioned together in divisions or units; in such a sense that the force acts necessarily from its extension, which becomes to it a fixed basis for all of its coöperations.

This position is not wholly without a claim to ground itself upon very high scientific authority. Dr. Balfour Stewart has summed up his views concerning molecules and atoms in these remarkable words: "Molecules are not at rest, but, on the contrary, they display an intense and ceaseless energy in their motions. There is, indeed, an uninterrupted warfare going on—a constant clashing together of these minute bodies, which are continually maimed, and yet always recover themselves, until, perhaps, some blow is struck sufficiently powerful to dissever the two or more simple atoms that go to form a molecule. A new state of things thenceforward is the result.

"But a simple elementary atom is truly an immortal being, and enjoys the privilege of remaining unaltered and essentially unaffected amid the most powerful blows that can be dealt against it—it is probably in a state of ceaseless activity and change of form, but it is nevertheless always the same." *

How molecules and atoms can possess these active propensities and yet force or "energy" be dissipated, degraded, or separated from its own division of matter, or how a universe composed of such eternally active atoms can be fitly compared to a burning lamp, it is for the learned doctor himself to determine. Our universe has many states and conditions of allied force and extension, but no "waste heap."

* The Conservation of Energy, p. 7.

SENTIENT OR LIVING UNITS.

Conscious energies pertain to qualities of experience.—Abstract principles differ in kind.—Applied principles also conditioned by amount.—*Qualities* of experience related to *degrees* of experience.—Definition of mental unit.—Its four phases.—Probabilities as to molecular state.—How physical and psychical facts are conditioned together.—Prof. Tyndall as authority.—Visual facts and explanation.—The relation of physics to consciousness not unthinkable.—The testimony of consciousness.

WE will suppose some few or many of the changes constitutionally possible to an atom to be accompanied by sensations and by other states of consciousness. These varying experiences would thus be conditioned—constitutionally conditioned with varying modes of force and extension. The sentient experiences would be neither forces nor extensions, nor would they be convertible into either modes of force or of extension. They belong to a new, a distinct class or phase of being which may be termed *intension* in discriminating it from *extension*, *qualitative force* as distinguished from *quantitative force*. Intensive or sentient experience is qualitative; force or active power, being generic enough to embrace both quantities and qualities of all possible energies.

The forces which we have been considering hitherto, can all be reckoned by amounts, as more or less. One mode of energy is exchanged with another or is changed into another on the principle of equivalence in amount; a unit of one kind being given for a unit of another kind. One unit of visible motion is equal to one unit of heat, or of electricity, or of vital energy. They are all mechanical or measurable quantities. So far as we know, the forces of *matter properly so called*, are all of this measurable, quantitative variety.

But qualitative force, experience; sensations, emotions, perceptions, thoughts, purposes; none of this class of quick, conscious or living states and energies can be measured by quantity, as more or less in themselves considered. And yet they are all related to quantity; they are all structurally conditioned by variations in quantitative modes of force and extension.

It must be possible to make this distinction plain and self-evident. We cannot say that a thought is greater or less than a feeling, than a volition; there is no possibility of comparison between them on that ground. Neither can we say that, to think two and two equal four, requires a *less amount* of thought than to think that ten and ten equal twenty, or that ten and a hundred are one hundred and ten. We cannot measure the thinking in that way; one thought is as easy as the other to any one who can think them at all. But when we come to say that two things and two things equal four things—that ten things and ten things equal twenty things, etc., here, the latter process is a much larger one than the former. Many a child and many a savage can perceive the small fact, yet be totally unable to perceive the larger one. The quantity lies in the things. The sentient experience is forced to bring itself into relation to this quantity; the *perception is conditioned* by it. All perception of the external world is conditioned by the quantitative facts of the external world. We can perceive quantities where quantities exist.

But when thought leaves the world of things wholly outside of consciousness, when it thinks in principles or thought-relations pure and simple, here there are no quantities, no measuring by more or less. The purely abstract is immeasurable. Justice and injustice are not comparable in terms of quantity. Moral principles are all outside of measurable limits. They may be distinguished as true or false, as good or bad, as practicable or not practicable, etc.; but not as more true and less true, etc. Whatever is not true is not true—that is, it is false. Whatever is not just is unjust. The *quality* is unlike—not the *quantity*. No possible manipulation can convert any abstract principle into any other. They differ in kind; they differ in such a sense as to be forever inconvertible.

But whenever thought is applied to things, it must then suffer itself to be conditioned by quantity. One mile is longer than one inch. The mile and the inch are both measures of extension. One action is more praiseworthy than another. Practical affairs lie nearly always in the domain of measure for measure, but not always. A man may publish a truth to the world and yet retain the whole of it himself.

When a teacher gives to his pupils a knowledge of the multiplication table, he has not thereby lost that knowledge. Pure logic, pure ethics, can know nothing of quantity. Applied logic, applied ethics are conditioned by quantities. We think generally in terms of quantity.

We may draw the same distinction in all classes of experience. A volition is a volition—not some frational part of a volition. The sensation of sweet taste can never be merged into the sensation of sweet sound or of agreable color. The problem is not, how much larger is happiness than unhappiness? but how do they differ? They are two *qualities* of experience, of sentient force. And yet both qualities—all qualities are conditioned by quantity. A large mouthful of sugar gives more of the sensation of sweetness than a small one. A moderate amount of musical vibration is delightful; an excess is deafening. Pain and pleasure are always hand in hand. They are conditioned by the external.

Is it not evident that all the states of consciousness pertain primarily to qualities, and that there are degrees of intenseness only as they are related to measurable amounts through the quantitative phases of being? In other words, experience is not measurable by quantity; and yet, as we know it at least, it is conditioned by quantity, it is acted upon by quantities.

A sentient unit may be defined as *force* and *extension*, *sentient force* and *intension*; *so coördinated that to separate them* or *to change the equivalence of their relations would necessitate the destruction of the unit*. These four phases of one existence are so conditioned together that to destroy either is to destroy the being thus conditioned. They are not four principles held arbitrarily together, but four adapted phases of one entity; so constitutionally related that the existence of the whole is made dependent upon the integrity of each correlative. The forces are active; the others passive.

Changes in the modes of force and extension necessitate changes in modes of experience. Also changes in modes of experience equally necessitate corresponding modifications of force and extension. Sentience or felt energy, energy conscious of itself, may be conditioned with a few or with many of the physical changes of the atom. It may be of a low order of sensation and instinct, or of a high order of perception and intelligent purpose. The only possible experiences of some living atoms may be changing, simple wants and sensations; but there is need only to add greater and greater variety and scope of experiences, in mathematical relation with the multiplying modes of force and extension, to reach at length an introspective self-consciousness; with a volition dominant enough to control the allied forces of the entire organism by a conscious initiation of the requisite modifications.

We arrive thus at a conception broad enough to include every grade of conditioned life. Every complete living organism may have its indwelling *sentient unit of being*, dominant in its own way and to a definite extent over the modes of all the allied units, but dominated by them also in turn—according to the established conditions of the alliance. The humbler compound structures may enfold and incorporate multitudes of a more limited grade of sentient atoms, each with its own individual experiences as completely its own as its forces and extensions are its own. The four phases of its one existence are conditioned together; they are all modified together; but they are modified in coöperation also with the entire associated organism.

The living unit, like the lifeless unit, is endowed with forms of extension and with measurable and interchangeable modes of force; these modes being measured and interchanged in neighborhood coöperation with all the other units of its organism and through them with the outside world. There can be no reason why, through its physical conditions, it should not ally itself to other adapted atoms and form the true physical molecule, of a type proper to itself. Judging from analogy, there can be no reason for supposing that such a molecule, if it exist, need be necessarily destroyed with the dissolution of the organism through which it becomes to us visibly incarnated. Many organic molecules are known to pass through a multitude of organic and inorganic processes and yet so intimately are the atoms associated, that they remain together as a little complete system, having its own special internal economy, which is not destroyed by any of the wider coöperations in which it participates.

An organism is notably heterogeneous, while most inorganic compounds are homogeneous—the one being composed of many classes of unlike molecules while the other is made up of a large constituency of exactly similar elements. A living atom, closely associated with a compound group of material atoms, whose allied energies are nicely adapted to all of its sentient needs, would be quite in accordance with all the known facts of organic structure. It might preëxist and become the central germ of its organism; and that it would, in that case, survive the destruction of the organism, is, reasoning from all known parallel facts, an almost assured certainty. Many so called *elements* are probably compounds.

Also, as very few substances exist in Nature permanently in an elementary condition, the presumption is that each living unit, of whatever grade, has already allied itself in some adapted compound unit which is immeasurably more permanent than its temporary organic relations. A molecule of salt is much less easily decomposed than a crystal of salt.

A rock may be ground to powder and yet its constituent molecules will all remain intact; mechanical force is totally inadequate to overcome the mutual attraction between these adapted atoms; it requires some stronger counter attraction, or some more subtle and energetic motion, like heat or electricity, to effect molecular decomposition.

The ordinary elements of vegetable tissues undergo processes of digestion and of assimilation into the tissue of animals, and the process is again repeated in the economy of the still higher organism; yet the organic molecule may be presumed often to remain intact throughout the process. It may pass through round after round of organic changes.

There is one peculiarity which attaches to all living tissue. None of its vital processes are so balanced that there is fixed, regular, pendulum-like vibration of particles which remain, as with inorganic solids, permanently within their own little orbits of motion. Each organic cell is a little independent circuit of changes which involve, not simply *change of motions between particles*, but *change of the particles themselves* as well. One particle is continually brought in and another is thrust out—this being an essential feature of all vital processes. All organisms are said to be in a *moving equilibrium*. But by this very instability and extreme mobility of substance, the sentient or living force is enabled, by controlling its atomic physical forces, to work through the organism which is mechanically adapted to all of its many sentient needs. Its physical properties are akin to all physical properties.

This is the theory of the conditioned nature of sentient with insentient phases of being. *They are conditioned to exist together in the unit and to work together in all of the many processes peculiar to either.* Now can this theory be sustained by plain, undoubted facts? Can it be shown to be even possible? Is there evidence enough in its support to make it presumably a true theory? It must be understood that everything which has been predicated of matter must apply with equal force to the mental atom; since *the living unit possesses all material attributes and functions* and all material methods and processes of activity, and *in addition*, is conditioned also by another and wholly unlike class of purely sentient processes which are both active and receptive.

It is not probable that either the mental atom or its compound molecule, if such molecule exists, can ever become directly visible to us through the bodily senses. Many gases are invisible; yet they possess most positive physical characters. The sky-ether is invisible, yet its physical properties are more like those of true solids than of fluids or gases. So mighty is it in elastic force that Prof. Jevons expressively characterizes it to be "adamantine." All living atoms evidence great and truly adamantine physical properties which manifest themselves through the tangible organism; but the intellect must trace backward through these lines of coöperative vital processes, to discover the nature and the action of the great living mainspring which coöperates with and directs or regulates the whole.

Prof. Tyndall has said: "I hardly imagine there exists a profound scientific thinker, who has reflected upon the subject, unwilling to admit the extreme probability of the hypothesis that, for every fact of consciousness, whether in the domain of sense, of thought, or of emotion, a definite molecular condition of motion or structure is set up in the brain; or who will be disposed even to deny that if the motion or structure be induced by internal causes instead of external, the effect on consciousness will be the same. Let any nerve, for example, be thrown by morbid action into the precise state of motion which would be communicated to it by the pulses of a heated body, surely that nerve will declare itself hot—the mind will accept the subjective intimation exactly as if it were objective. The retina may be excited by purely mechanical means. A blow on the eye causes a luminous flash, and the mere pressure of the finger on the external ball produces a star of light, which Newton compared to the circles on a peacock's tail. Disease makes people see visions and dream dreams; but in all such cases, could we examine the organs implicated, we should, on philosophical grounds, expect to find them in that precise molecular condition which the real object, if present, would superinduce." *

Thus in effect, Prof. Tyndall explicitly declares

* Fragments of Science, p. 118–119.

that in his view, which is common to all scientific thinkers, the facts of consciousness are all conditioned with definite corresponding facts of "motion and structure"—that is, of force and extension. His *internal causes*, though within the organism, are on our theory as much *external to the mental unit*, as are any causes outside of the organism. The mind-atom, having coöperated to build up about it an adapted organism, through which it can both act and be acted upon in a definite and characteristic manner, any somewhat disordered action of the machinery must produce results very similar to its entirely normal action.

In all sensation, the initiative comes from without. Any thing which can excite in the optic nerve the kind of motion which gives rise to the sensation of color, must excite the sensation of color. But in a quiet state of the nervous system, the blow gives rise to merely the sensation of color, not of colored forms. The stars and colored circles are only spreading waves of light-motion. But if the optic nerve is in the highly excited or reverberating state which is favorable to the passage to and fro upon it, not only of the direct, but of the reflected pulses of light-motion, then one may continue to see an object long after the bodily eye has ceased to communicate with it directly. I remember once looking at a piece of white lace with round open meshes; then, closing the eyes, I could distinctly see the outline of every separate mesh for a number of moments. The meshes grew steadily larger and every separate thread grew thinner, the whole gradually widening out and vanishing by becoming more and more dim, precisely as light does when many times reflected. The vibrations were visibly pulsating backwards and forwards along the nerves of vision.

Every one must remember to have seen the letters of a printed page reverberating in this way in the chambers of his brain; probably shimmering together in great confusion, but a few letters sometimes plainly visible in the shifting kaleidoscope of mechanical vision. From this echoing process to the visions of distinct forms, in a fevered state of the brain, is but a step, and that not wholly unlike in kind. Imagination becomes the initiative and in its turn produces the physical vibrations. It is not even necessary to believe the vision to be a reality. Like the fancies of a child, it is real yet not real.

A grave theological Professor, whose name is well known to fame, affirms that he has repeatedly seen cats, distinct and perfectly visible, imaginary cats, playing about his room ; and even while he was looking at them he knew and said to himself that they were only illusions. Yet they looked entirely real and tangible. This only shows that when the mind-unit is working through a disordered machinery, there must be corresponding disorder in the accompanying consciousness. If sentient experience is conditioned with modes of force and extension, these results must be inevitable. They are required by the hypothesis ; and the truthfulness of consciousness is not invalidated by it ! It has never been claimed that this class of subjective experiences is *like* its producing object.

"Given the state of the brain, the corresponding thought or feeling might be inferred." Given all the producing causes, and it cannot be doubted that every *effect*, as well as every *conditioned result*, could be absolutely predicted. The conscious unit, like every other unit of being, is at once simple and manifold in its nature. It is one in all persisting, structural facts, many in their related modifications; one in substance, a multitude in phenomena. In its association with all other units, it is also at once independent and dependent—independent as to its existence, dependent in all its modes of existing; independent in the quality and quantity of its being; but absolutely dependent as to the time and the amount of its physical activity and also of its psychical evolution.

Its very existence is conditioned, but here the conditions are constitutional, beyond the reach of all interfering causes; but in coöperative energies, it is compelled to work in alliance with the universal law of equal mechanical action and reaction. Its continuity of action is assured; its modes of activity must be endlessly varied by outside coördinations. Nothing can be added to or subtracted from its innate capabilities; but every line of possible development may be stimulated, repressed, or grievously distorted and thrown out of proportion with other qualities of sentient experience. The immutable within it is intact; but every variable phase of being, modes of force, forms of extension, qualities of living energy, must be largely at the mercy of external influences with which all these are necessarily coöperative.

But *how* does consciousness infuse itself into this eternal round of shifting process? In Prof. Tyndall's view: "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable." He says: "Granted that a definite thought, and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning, from the one to the other."

But are we thus completely limited as to all intellectual possibility of ever relating these two phases of being? That which has not yet been thought, is not necessarily unthinkable. I hold that whatever is, must be knowable, thinkable, to any mind which is able to perceive the fact. The relation is there; the passage from the state of the *physical brain* to the *physical part* of the mind-atom, coöperative with the brain, is as plain and simple as the passage of acting and reacting energy between any other two material atoms. Is it then impossible to conceive of a unit of substance, possessing several mutually limiting phases of being, each of which is conditioned with and made dependent upon all of the others? This is not, surely not, impossible. A necessary constitutional dependence of this nature is entirely thinkable. There are different qualities of experience; there are degrees in all these qualities.

Let us endeavor to comprehend that there is but one substance, yet that it has four distinct phases of modifications. Neither can ever be merged into either of the others. They all exist together; they are all variable, each in its own kind; and they are so jointly conditioned that when either changes in its mode, they must all change, each after its own kind of change, in exact mathematical correlation. Admitting these conditions, the state of the brain acting upon the physical structure of the atom and modifying it, would necessitate corresponding modifications in consciousness. Mind has one passive phase.

Thus when the optic nerve is thrown into vibration from whatever cause, this being adapted to communicate with the mind-atom and to convey to it the same class of vibrations, and that class of vibrations being conditioned with sensations of color, the sensations arise of necessity. But the sensations are no more akin to the mechanical vibrations, than modes of extension are akin to modes of force. None of them are like in kind; neither is nor can be merged into the others; they are simply dependent each on the others. The being, so conditioned, is not altogether a free agent. He must accept the structural limitations inwrought in his nature. They are laws of his being; he must work under them and with them; yet he is not altogether passive and helpless, since force is intrinsically active; and, accepting its limitations, intelligent force can learn largely to control its allies and to direct its own interests.

There *is* no passage from structure and vibrations in the brain or elsewhere, to sensations or to any other states of consciousness, in the sense that vibrations become living energies, become felt and self-appreciative experiences. The distinction between the two kinds of modification, (sentient and unsentient) is absolute. Neither can become the product of the other, yet neither does arise without the other as matter of fact, and if conditioned together, as we suppose, neither could arise without its coördinate. Quality is not quantity; intension is not extension.

But we are not compelled to make these inferences wholly in the dark. We can comprehend something of the nature of the relation between sentient and unsentient modifications; between conscious and unconscious forces. Both of the latter become energies, but of the one class we ask how much? how fast? how far? in what direction? and similar questions which imply action as estimated in terms of time, space and quantity. Of the other we ask what kind of action? thought, feeling, or volition? What kind of thought? perception, outlook toward facts perceived? or conception, construction; as reasoning, imagining, fancying? What kind of feeling? sensations or emotions? And again of each of these, are they pleasurable or painful?

intense or otherwise? and which one of the ten thousand possible kinds and gradations in quality of feeling? We speak also of the quality of the volition—measuring it by its strength or intensity, as impelled by motives which are weak or powerful or otherwise qualitative. *Intensions* are to *qualities* what *extensions* are to *quantities*.

In brief, there are two worlds—the one manifesting itself through extended forms and measurable processes; the other through states of varying intensiveness and of unlike kinds of experiences. We belong to both. We are part and parcel of both. At every turn we find the one conditioning the other and becoming to it a direct and compulsory limitation. We see and feel that each is always dependent upon the other, not merely that modification of the one arises simultaneously with modification of the other, but that each conditions and necessitates the other as a true correlative. We see that kinds and degrees of experience in our psychical natures, are bound together; as forces and extensions are conditioned together in the physical world—that extensive or quantitative energies also do actually condition the intensive or qualitative forces which pertain to consciousness. Together they make up one immutable complete constitution.

We can see this fact; it is difficult to put it into words, since language has been so framed that it is well nigh inadequate to express the perception. But a large amount of physical action occasions in us corresponding intensity in every adapted state of consciousness. Also intensity of feeling, strength of volition, perspicacity of thought, each invariably eventuates in a large measure of adapted physical activity. We decide to strike a heavy blow, and we strike it—at least we do if the coöperative organism is in good condition. Or we choose to tap with but the little finger; and that prolonged, extensive instrument, the adapted muscle, is *obedient* to the will. We *know* that this *will-power is conditioned with mechanical force* and that *both are constituent elements of our essential being.*

But we do *not* find in consciousness the slightest evidence that a unit of motion, of mechanical force, ever is or ever can be transmuted into a state of consciousness. Every physical process is complete in itself. Every psychical process is complete in itself. They are simply conditioned together as two dependent phases of one activity. They are never alike; but they work together. We must turn to their modes of coöperation.

CO-ÖPERATION; PHYSICAL AND PSYCHICAL.

Sound vibrations conditioned by extension.—A musical instrument as conditioned.—Consciousness, how related to physical action.—Its active moods may control physical states.—Passive moods controlled by physical states.—Adaptations.—Sound as related to sensation.—Sunbeams and their action.—Relations of motion to growth, etc. Motion not sensation.—The mind-atom as coöperative with its organism.—Heredity.—A disturbed organism.—Succession of sentient states. They are not quantitatively exchanged.—In what sense they are convertible.—Thought.—Conscience and will.—Physical and psychical activities conditioned to work together.

A MUSICAL note is produced by a definite number of vibrations in a second; the more rapid the vibrations the higher is the pitch of the sound. But rapidity of vibration is determined by the weight, the structure, and the form of the vibrating substance. Length, thickness, density, and tension of the strings are all made to assist in regulating the concord of sounds in every stringed instrument.

All sound is vibration of something which produces or which conveys the sound. The process is vibration throughout, vibration of the sonorous substance, of the atmosphere which is thrown into alternate pulses of motion, of the solid medium which conveys the sound, of the nerves of the ear and brain, and, finally, of the physical extension of the mind which hears the sound. But the sensation of hearing is not vibration. *This* pulses back as vibration and is spread throughout the organism. The physical motion remains motion forever; but the sensation which is conditioned with each class of vibrations, is yet totally unlike it in kind. They have not one trait or feature in common.

The rate of vibration in all stringed instruments is inversely proportional to the diameter of the string; it is inversely proportional to the length of the string; it is inversely proportional to the square root of the density of the string; and it is directly proportional to the square root of the tension of the string. Size, weight, length, and the amount of stretching to which the string is subjected—properties of extension all of them—by their adaptations are made to condition the number of vibrations as to time.

By a method which is closely analogous to that which constitutes the structure of an atom or a molecule in nature, the manufacturer conditions the musical machine. It may be fittingly likened to a vast molecule put together by art, by exquisite human forecast, based upon observation of laws which operate throughout nature. In natural compounds, the adapted attractions of the atoms bind them into a coöperative system. Such attractions operate in the strings, the wood, the ivory; and by adjusting all these each to each, human prevision produces a machine which can give us a magnificent unity of harmonious effects.

It may be made to produce a thousand melodies as it is played upon from without; but it can do this only according to the laws of perfect action and reaction. It is action and reaction between atom and atom in the same molecule, whether organic or inorganic; whether it be the mental atom or a simply material one. There is action and reaction between the fingers and the keys; between the keys and the strings: between the strings and the sounding board; between the sounding board and the atmosphere; between the atmosphere and the nerves of the ear; and finally between ear and brain, which being the most direct visible organ of mind, may stand as its physical representative; and again between brain and general organism. The conscious force does not enter into this cycle. It is conditioned with it—not a part of it.

Nothing has lost force or has gained force by the whole operation, except as it has lost or gained in substance also. A series of exchanged energies have gone round in a circle—a portion of the energy, as in nearly all forms of activity, being dissipated; carried outward in the usual broadening waves of communicated motion. A trifling wear and disintegration of substance, organic and inorganic, must have resulted from this musical process. It attends the activity of all destructible systems of force, but the matter is somewhere; there is simply change of form and mode arising in exact correlation. Every atom in the musical instrument has taken part in many widely unlike processes which were in simultaneous progress; but all coöperation with outside energies is but reaction against some form of external motion.

Vibration, shared in common by associated units, must involve change of atomic positions, and all such change must be socially effected. The sentient *will* decides and initiates the musical process. The extremely mobile organism being adapted to all sentient moods, every conscious, self-determined change, must of necessity call into action the physical energies conditioned with such moods. But the will does not enter into the physical process. This is complete in itself and is confined to material changes. Physiologists have discovered that use of any part of the organic system is accompanied by a definite amount of waste in the system itself; and the kind of physical action may be very nearly determined simply by the class of substances which are thus eliminated.

The mind changes its mood; this must inaugurate that physical change in brain, nerves and muscles which is adapted to the psychical change. The will directs the fingers simply by causing its own change of mood; the fingers press upon and move the keys, the motion is carried forward to the strings, the strings change the rate and direction of the motion, their vibrations are taken up by the surrounding surfaces and passed on and outwards in all directions, till a part reacts on the physical extension of the originating mind.

A given amount of pressure produces through one string a high rapid sound, through another a slow bass note—the character of the sound being determined by the vibrating extensions which condition the acting force. The number of vibrations decides the question whether or not a response shall be awakened in the nerves of the ear and excite in the mind the sensation of hearing. When the number of vibrations is less than sixteen in a second, they are not blended together in the human ear; they are heard only as so many separate shocks. But when the number exceeds 38,000 in a second, the consciousness of sound is not produced at all.

The human ear is not adapted to take up and transmit these extremely rapid vibrations. Indeed some ears can respond only to a much narrower range of sounds, the low and the high notes failing to make themselves heard; though the best ears, listening at the time, catch the wide range of vibrations, covering about eleven octaves. The sensation of hearing is evidently conditioned by rate of vibration, and rate of vibration by extension. When the vibration is communicated to the structure of the mind, the sensation arises; and the sensation varies as the vibrations vary. A larger amount of force exerted by the fingers, increases the amount or amplitude—not the rate—of the vibrations in any given string of the instrument. The nerves respond; the sensation increases in intension. A large amount of sound must produce a responsive amount of sensation. So far mind is passive. *It must hear when the conditions of hearing are all fulfilled.*

But when a mind is otherwise absorbed, the sensation is not excited even though all the remaining conditions are present. The nervous system conveys the sound, but the mind may be presumed to have assumed a control so supreme over its physical states that the vibration is rejected by it. It is reflected or turned back as light is reflected from a non-receptive surface. One may receive wounds and other grievous hurts, yet be quite unconscious of pain in any state of mental pre-occupation. A parallel rejection of motion by other bodies when their physical state is not adapted to receive it, makes the inference that the motion is for the time effectually resisted, entirely legitimate as derived from the premise; psychical and physical modifications must vary together. It is not that the sensation arises but is not noticed; the sensation does not arise, because its adapted vibration is not produced.

At other times the sensation is comparatively feeble and partial. It may be supposed that the motion was then but partially resisted. Our oft repeated experience tells us that the mental state at the time does control the sensation, that entire absorption in some opposed quality of consciousness can wholly prevent the appropriate sensation from arising under any and every form of objective stimulation. Martyrs who have burned at the stake in a triumphant exaltation of happiness, have thus effectually resisted the pain of burning. The pain was not felt, it was not there.

Many a commander on a battle field has been wounded unto death without knowing it. There was not even the voluntary effort to resist suffering because there was no suffering to resist. The active and resolute mind effectually shut out the possibility, for the time being, of receiving those vibrations which are allied with pain. Every one must remember many things akin to this in his own experience. Words are uttered and we do not hear them, yet, after a time, they come to us like an echo; they are an echo, a reflected vibration which comes to us as soon as the mental absorption is somewhat relaxed.

A little experiment in this direction must convince any one that he can greatly modify and perhaps completely control his sensations in the presence of very powerful objective stimuli. We infer from these and similar well known facts that whenever the mind is attending, is in a receptive state, that it must then accept the sensation which is conditioned with the vibration received from without; but that the mind is so far dominant over its material phases that it can, by the appropriate mental action, exert much control over and often completely negative the physical states which must otherwise arise.

It does this involuntarily by the exercise of those mental moods which are adapted to resist the reception of the incoming physical waves of motion; but it may produce the same results intelligently and voluntarily. We can certainly take ourselves away from sight or sound by the exercise of will; we can turn from a thought or feeling; can refuse attention to any topic. But not one of these things can be accomplished except by the active use of counter energies. One cannot passively resist any form of sensation or other objective solicitation. He must act or consent to be acted upon; he must either control the physical modification with which the psychical mood is conditioned, or he is in his turn controlled by it, for the two states must vary together. They are but associated phases of one substance, of one personality. They are both modifications of his very self.

The mental experience is totally unlike its associated physical properties. It can be no more possible to change a sensation or an active perception into a vibration of extended substance, or the reverse, than to change the strings of a piano which condition sound into the sound itself. On the contrary, the conditioning principle never is, and never can be, akin to the principle which it conditions. It must be so far unlike it in kind that each can hold the other—that is, can condition it, can bind it in necessary dependence upon itself. In the nature of things the two cannot be interchangeable. Each is an inherent limitation of the other—a true constitutional limitation which involves modification together, but each of necessity after its own class of variation.

If a conditioned existence means anything definable and permanent, it must involve permanent unlikeness in the conditioning elements. Otherwise we use words without meaning. We are variable in all the several phases of our being; but we are so constituted that they all necessarily change together, and either phase of our richly endowed natures may take the initiative in effecting these several sided changes. The passive or receptive states must accept the change. Physical force can but react as it is acted upon; but conscious self-recognizing force can learn to so control the organism which has been adapted to its needs, that it can initiate changes voluntarily and for its own ends. By accepting all of its limitations it can overcome them all. The voluntary motion of every limb is a tangible proof of this position.

Adaptation reigns everywhere in Nature. Our mind-unit comes into an organism which has been fitted to its uses originally by no power consciously exercised by itself. It must take all of its allies as it finds them, and learn to do the best it can under the circumstances. It is greatly the inferior of many lower organizations in many important respects. Many forces have wrought together in its behalf and the result is not wholly satisfactory. Nature is teeming with countless myriads of the most admirable and delicate adjustments, and our senses are adapted to respond to but very few of her countless energies. Even of these few we are restricted in our conscious coöperation within extremely narrow limits.

The vision of certain birds and beasts is found to be vastly more penetrating and far reaching than our own. The hearing of some dumb animals is extremely acute in comparison with ours. Others have a sense of smell adapted to an incomparably smaller amount or division of odorous particles than we have. The scavengers of Nature, beasts, birds, and insects, can discover a breakfast by odors which float outwards upon the air miles away. The keen scented hound can distinguish any number of persons by the peculiarities of personal odor alone, and as a capable detective, can recognize an article which has been in the possession of a man though days or even weeks have intervened. He can readily follow the scent dropped from hasty footsteps hours or days before; showing that no one can plant his foot upon the earth, however lightly, without leaving there some remnant of discarded tissue which was once part of his living organism.

Science has discovered incidentally the strangely suggestive fact that on either side of each sense, and of every known energy, there is a vastly broader range of coöperations in ceaseless progress, in which we have no direct conscious share; and yet upon the sustained integrity of their action our happiness is utterly dependent. Can we ever attain to a direct participation with them in these many operations?

The question is a fitting one and it may have many practical bearings. No one at the present day can afford to wholly overlook its possible significance.

Objectively, sound of every pitch is nothing but vibration more or less rapid of some material substance. May we conclude that the converse of this must be true—that all vibration of material substance might awaken the sensation of sound through ears adapted to re-echo its oscillations? The hum of an insect's wing enables the mathematician to calculate how many vibrations it makes in every second. Extensions everywhere condition and modify vibrations. When atomic attractions build up a molecule or a larger mass, the effect must be like that of increasing the vibrating substance; it must change densities, tensions, diameters, length of vibration; it must definitely modify motions of every class.

Every crystal which has built itself up in an enduring symmetrical structure, must be in a very literal sense a harp of many strings which is played upon ceaselessly by the varying forces of nature. Every substance is in constant vibration, and each substance is structurally adapted to rates and extent of motions peculiar to itself. The softer and more pliant bodies must be nothing behind the others in this respect. The posthumous works of Dr. Robert Hook, who died as early as the beginning of the last century, recorded this remarkable speculation which was destined to the fullest subsequent verification.

He says: "There may also be a possibility of discovering the internal motions and actions of bodies by the sound they make. Who knows but that, as in a watch, we may hear the beating of the balance, and the running of the wheels, and the striking of the hammers and the grating of the teeth, and multitudes of other noises; who knows, I say, but that it may be possible to discover the motion of the internal parts of bodies, whether animal, vegetable, or mineral, by the sound they make; that one may discover the works performed in the several offices and shops of a man's body, and thereby discover what instrument or engine is out of order, what works are going on at several times, and lie still at others, and the like; that in plants and vegetables one might discover by the noise the pumps for raising the juice, the valves for stopping it, and the rushing of it out of one passage into another, and the like? I could proceed further, but methinks I can hardly forbear to blush, when I consider how the most part of men will look upon this; but, yet again, I have this encouragement not to think all these things utterly impossible, though never so much derided by the generality of men, and never so seemingly mad, foolish, and phantastic, that, as the thinking them impossible cannot much improve my knowledge, so the believing them possible may perhaps be an occasion of taking notice of such things as another would pass by without regard as useless."

Since this was written, two hundred years ago, by a progressive series of discoveries, and by the invention of the stethoscope, which accumulates and conducts sounds from the internal organs to the listener's ear, the science and art of distinguishing the states of health and disease by the study of sounds, has reached such perfection it is said to have "enabled the physician to see into the chest almost with as much clearness as if its walls were transparent." The sounds of the different organs are found to vary greatly in health and in disease. The skillful listener can hear what part is out of order in the human system as the trained musician hears which note is out of tune in a piano.

It remains to invent some instrument which can so retard the too rapid vibrations of molecules as to bring them within the time adapted to human ears; then we might comfortably hear plant movements carrying on the many processes of growth, and possibly we might catch the crystal music of atoms vibrating in unison with the sunbeams. Sound can be refracted by passing it through a lens which retards its motion. Such an improvement upon the stethoscope would reveal phenomena but little more marvellous than those already offered us by telescope and microscope. A better but possibly a slower process might add to the responsive capacity of the organic ear. The mind must respond to all the vibrations which its organism can transmit.

What are the revolutions of the planets about the sun but true musical vibrations? What requisite is lacking for the composition of a grand symphony to any ear which could be attuned to this stupendous "music of the spheres." The solar system is but a great type of every molecule; the sun, with its internal restless throbs of heat motion, the central atom, with the planets forever vibrating about it at unequal distances, all under the influence of their coöperative attractions and repulsions. They exchange energies—not forces.

Bnt music-like, regular vibrations are not always addressed to the human ear. The wave theory of light and heat supposes that the sun particles, in the vigorous agitation which arises from their red hot condition, communicate motion to the ether; the ether carries forward the motion in waves, in little gusts of action and reaction—as the atmosphere passes on the slower waves of sound. When these successive pulses of motion reach the earth, they are either taken up by the bodies upon which they fall—when these bodies vibrate in unison with the received vibrations—or the motion is suffered to pass on its way directly through substances which are then said to be transparent to such vibrations; or, under a third set of conditions, the vibrations are turned back, are reflected by the body upon which they had fallen. It is these reflected rays which directed upon our eyes, communicate adapted vibrations to the optic nerve and the brain, and awaken in us corresponding sensations which we distinguish as color of various hues and tints.

Exactly as the pitch of a note in music depends upon the number of vibrations in a given time, so the shade of color depends also upon the number of vibrations in a given interval. The red rays are the slowest in their oscillations and the violet the most rapid, with intermediate grades between. On the outer side of the red rays are non-luminous heat vibrations, and on the outer side of the violet, non-luminous chemical rays; the scale of colors adapted to the eye being much more limited than the scale of sounds for the ear. It covers but a single octave, but the vibrations are immensely more rapid than in sound. All the substances on the earth respond to them, each accepting those motions adapted to itself and rejecting all the others. Hence the endless variety of colors which make the world so passingly beautiful.

If there were organisms delicate enough to respond to every motion in the sunbeam, can any reason be assigned why every ray should not utter through them its note of endless harmony? The ultra violet and red vibrations intensify the lesson which mankind are steadily learning—the lesson which tells us of many wondrous adaptations, each producing its own definite yet widely unlike results.

Every leaf and bud responds to the sunbeam by adding particle to particle in the growth of new structure; every prepared brick, as it were, wheeling into its place under the action of each directive vibration. We discover the important fact not by direct vision but by an intellectual insight. Growth involves motion; sunshine is motion. Vegetation can receive nothing from the sun for which it does not return a full and fair equivalent. Action and reaction are balanced in that process as in all others. The ether particles are but so many "middle men" through which is effected a continual exchange of the energy of heat-motion from the sun for the energy of resistance to heat-motion, sent up in reacting pulses by every receptive atom on the earth.

We are often told that all energy, all working force, is derived from the sun. In one sense, yes;

in a much more important sense, no. Without sun shine, physical action and conscious life, as we know them must both cease; but so they must if any important link in the chain of adaptations were to be suddenly destroyed. With no ether, there could be no sunshine; but with no innate active force in every atom, the ether would be equally powerless to mediate between earth and sun. Annihilate oxygen or hydrogen; destroy the most uninfluential element of matter—the entire universe must be thrown back for ages into hopeless confusion.

For the sun, it is losing heat; but it cannot lose force. The gases and cinders evolved from burnt coal are left in no state for a new burning; but all their subtle and powerful forces are still intact and inseparable from their own extensions. Our little inch of line has not yet fathomed all the mysteries which lie at the bottom of the universal system of the transmutation of physical energies. But we do know that Nature exacts equivalent for equivalent.

Does any substance derive its power to reject certain portions of the sun's rays directly or indirectly from the sun? Does it receive its energy of gravitation, its chemical affinities, its cohesive forces from the sun? Phrases are of little moment, but we must accept one theory or the other. Force, energy, is either a shifting principle which can be imported totally from the sun, or it is a persisting principle which must remain where its substance remains; exchanging its modes of action, to be transported to a distance by Nature's adapted vehicles. Surely no scientist, with a positive belief in the existence of matter or mind as any thing more than force, can deliberately maintain that essential energy is sent racing over the universe, wholly astray as to a permanent abiding place!—that any world or any atom can have now more and now less of actual inherent force!

But there is no middle ground. If force is inseparable from extension, then each least division of force is inseparable from its division of extension. It must react as it is acted upon, according to its position, arising from its present relations with coöperative forces. It is but a unit constrained by a vast system of universal adaptations. Thus the sun supplies the needed impulse towards the promotion of vegetable growth; yet it can supply neither the extensions nor the proper building forces by which all vegetable tissues are organized, added to, and maintained.

Sunshine is adapted to promote the formation of vegetable tissues; electricity is adapted to promote chemical composition at one time, and at another to promote chemical decomposition; heat of a certain temperature forwards the growth of animal tissues; at a much higher temperature, heat destroys animal tissues. How these various results are produced, we cannot tell exactly; but motion of a definite kind, is in each case, taken up by the substances acted upon. Motion is transformed under one set of adaptations into vital processes, under another into chemical action. At another time, motion of the white sunbeam is shivered into a thousand shades of color; and gives rise in our consciousness to a thousand definite sensations.

All of these parallel results are equally mysterious, and to about the same extent they are subject to explanation. Motion changes the housewife's cream into butter and buttermilk; but the original forces and extensions of the cream are all there; changed in mode and form, unchanged in amount. When the motion which initiated these changes is produced at the expense of muscular tissue, the tissue is destroyed in form and function, but the elements of which it was composed, though remanded again to the inorganic state, can have lost no inherent properties. It is but the running down of a weight raised by organic processes originally. The consciousness, the felt need, either instinctively or voluntarily exercised, impels the physical energies both to the raising and to the lowering of the weight. The work is done mechanically.

By some combination of mechanical adaptations, the sun's forces are raised to intense heat; they also are running down to a lowered condition, but the *change* is wrought by a fair *exchange* of equal but unlike energies.

A little added impulse from the weight of a clock, keeps the clock pendulum vibrating; a little added motion "just at the nick of time" can be made to transform an apparently structureless fluid mass into a community of well defined crystals, each with form and angles as positive and characteristic of its kind as the properties of any chemical compound or any organic tissue. Almost every boy and girl must have looked on open-eyed while one small finger acted as fairy wand to bring out a score of shining jewels in a bowl of water which had stood undisturbed through a winter night. The marvel was wrought by a little simple stirring of the water. The child has created a firmament of stars each as shining and as perfect as the stars in heaven. *But the moulding forces were in the water*, not in the child's finger.

In all these illustrations there is only transformation of some mode of motion into other correlated modes. The gas in the burner and the coal in the grate must both be lighted before they can begin to burn. A sunbeam is nothing but a beautiful cluster of vibrations; is it more marvellous that it can promote growth in a leaf, by helping the right particle into the right place, than that it can give to everything animate and inanimate "a complexion" which is characteristically its own? Both are mechanical processes.

One eye is blind where another sees; one ear is deaf when another hears; one organism responds to a particle of odorous matter which produces no vibration in systems otherwise more highly organized. These vibrations are *conditioned with sensations.* But responsive vibrations arise in inorganic bodies, in which no accompanying sentient life can be presumed to exist; as when a wave of motion sweeps down the room and one chord of a musical instrument responds though all the rest are silent. The response or non-response is in all cases dependent upon purely mechanical adaptations. Sensation is something over and above these; conditioned with them, but not of them.

A wave of rapid heat-vibrations beats on the face of a leaf and on the face of a child; in the leaf there arises chemical action, and growth; the child feels heated, but in his system sunshine cannot impel inorganic matter into organism. But by the storing up of balanced motion in vegetation, which the child can appropriate by definite processes, he, too, grows by sunshine. But not as a pauper. He pays for all he receives. Every physical change arises under the universal system of adapted equal action and reaction. The sensation is a new creation; it is clear gain.

All motion is one, as all force is one, as all extension is one. The motion indicates and measures the amount and the mode of the force with its adapted extensions. When a personal consciousness is conditioned in and through the physical conditions of any unit of being, then, *with* the physical vibration, arises the associated sentient experience. Thus the right motion must originate its own given state of consciousness. The converse is equally true; consciousness must occasion physical motion. The same motion, objectively considered, may excite in one mind the sense of sound; but in some other differently responsive organism, the sensation may be that of light. There is no generic difference between objective light and objective sound. They are both modes of motion. So are heat, electricity, chemical action and all vital processes.

To the eye which could respond to all the myriads of unlike modes of motion, the whole universe would be self-luminous. There could be nothing opaque, nothing dark; everything would present itself in an endless series of admirable coöperative adjustments. Every vibration, judging it as we must judge those motions which are adapted to our senses, might be a condition of light, and warmth, and music to any sentient nature large enough to respond to them all simultaneously. This is not theory, but legitimate deduction.

But these mechanical vibrations may not be confounded with the sensations which they everywhere condition, nor with the volitions by which they are themselves conditioned. The arm is but a pendulum adapted to move to and fro in all directions. The extremities of all animals, legs in walking, wings in flying, the tail of the fish, and indeed the whole body of the fish in swimming, are thrown into pendulum-like vibrations.* All these movements are simply mechanical; the same laws govern natural and artificial progression. No body, acting alone, can move itself. The ground, the air, the water, act as fulcra to the limbs which are true levers; they rotate in their sockets; the laws of gravity coöperate, and

* Animal Locomotion, by J. Bell Pettigrew, M. D., F. R. S., etc. etc.

the living muscles supply the motive power. The mind can only excite the adapted muscles.

The organized animal system is an intricate machine which is adapted to move its several parts; and adapted to locomotion as a whole. All motion, whether voluntary or involuntary, must be achieved at the expense of organized tissue. All vital processes, muscular action, nerve action, digestion, circulation, tissue formation and tissue disintegration—every form of cerebration, whether consciousness enters into the process or otherwise, must be regarded as pertaining solely to physical structures; as modified by their many coöperative higher forms of energy. The body is a true machine, an instrument.

We regard all vital processes as strictly quantitative; measurable, in as absolute a sense as the simplest visible motion is measurable; though from the exceeding complexity of the vital process it may not be possible to be as accurate in measurements in one case as in the other. Every coöperative system, whether it be a molecule of gas, an inorganic solid, or a living organism, must effect all of its appreciable changes by borrowing coöperative motion, in exchange for resistance to motion, from without the system. To this law there can be no exception.

Hence, bodies become visible to us, not by their internal operations, but by their outside coöperation with the vibrations of light. A projectile, also, is thrown against another solid body, not by its chemical or combining forces, not by its energies of cohesion; not by any mode of internal vibration; but solely by the energy of visible motion which it has received from without. On the same principle is the living body moved, but with this difference; vibrations of light and projectile energy, are both motions simply; are but *modes* of force acting; the receiving body exchanges its former mode for the new one, and its force acts accordingly. But the organism incorporates new substance with its inhering force; it transfers this substance, particle by particle, to the place where it is needed—so coöperating with it step by step through its whole progress, that when finally in its place, it is available for exactly the work which it is to perform.

But that work performed, the particle drifts again out of the organism. A new particle comes in its place and repeats the process. This endless round of change, involving both substance and force, is the one distinguishing characteristic of the living organism. Organic compounds are brought together in the laboratory by chemical affinity. A living organism has never yet been proved to originate without the intervention of a prior living organism; and if it ever does so originate, it must be because all the conditions have been fulfilled which can enable a living atom to establish itself as the nucleus of an unresting series of adapted organic processes. Sentient force is the only organic mainspring.

What physical part must the living atom be supposed to take in all the manifold modified organic operations? Evidently, it must act and be acted upon on the uniform mechanical basis of measure for measure, exactly as every simply material atom does. All of its physical properties are quantitative; nothing more and nothing different. When, therefore, it is thrown into vibration of any kind by one set of energies, it must either react and return the vibration to the channel whence it came, or else it must pass it on to some other adapted part of the organism, precisely like every other material unit. So far as the purely physical results are concerned, its operations must all take place on the quantitative plane. But its sentient needs originate the self-winding process of perpetual organic renewal in both substance and force.

It may be in a very different position from any other atom in the organism; the root of every molecule, especially of every large organic molecule, is on vantage ground and must have a commanding influence by virtue of its position. So much we may freely concede, therefore, to the living unit as a purely physical prerogative. If moreover, it is allied to a molecule which is more permanent than its temporary organism; which as we have seen must be conceded to be highly probable, judging from a wide range of accepted analogies; then it must be considered as fully equipped and provided for by sustaining physical allies, adapted to coöperate with it in every possible emergency. This is not in itself a trifling consideration.

Let us recall again the group of essential oils, including the extracts from lavender, turpentine and pepper. Let it be remembered that the same chemical elements enter into each of these and many other widely unlike substances; their different properties being necessarily accounted for by a different bringing together of their unlike poles—by a different way in each compound of literally compounding their several vibrations, and thus, indirectly, of modifying their action upon such external tissues as the nerves of taste and smell.

This aromatic group affects us particularly; being marvellously unlike in properties to our sensations, as the colors of the solar spectrum are unlike to our sensations: but, in fact, there is probably but a very inconsiderable difference in their several rates and arcs of vibration; this being communicated to the proper nerves produces in them characteristic vibrations. The several modes of vibration being conditioned with our sensations, the sensations must arise with the vibrations as necessarily as when enlarging the third side of a triangle, we must correspondingly enlarge its opposite angle, though the line and the angle are totally unlike properties. So the internal vibrations of lavender and turpentine occasion in us unlike sensations, though vibrations and sensations are generically distinct.

But if the way in which the same small number of atoms work together can give rise to such marked differences in the result, how much must depend upon the associate atoms which co-work with our central living unit? It might be regarded as sufficient to produce the whole difference, both in physical form and in mental development, between man and any one of the lower animals down even to the lowest mollusk. But there is little reason for supposing that the essential atoms, man and mollusk, are identical, as viewed from the stand-point even of many evolutionists. Variety at the basis of the two worlds of associated intensions and extensions, is not improbable, nor out of keeping with any known facts past or present.

But the many curious facts pertaining to inheritance of qualities, physical and psychical, from one's more immediate ancestors, receive a large amount of explanation from a consideration of the influence which the associated organism, in its earlier stages, particularly, must exert upon the coöperative mind.

Any peculiarity of structure, with its corresponding modification of energies, would tend inevitably to perpetuate itself and to correspondingly influence the sentient development. If a child had but one parent, he should, according to all the known principles and facts of nature, grow as nearly into the parental image as one molecule of water becomes like another molecule of water, or as all carbon is like all other carbon.

The reaction against external forces would work corresponding changes. There might be several types, as charcoal and diamond, or unlike states, as ice and steam; but growth, like all facts arising from identical conditions, would produce correspondingly identical results. Two parents greatly complicate the problem. Each must transmit the physical adaptations and dominant tendencies peculiar to himself; the new organism must arise as a resultant of these combined influences.

This is not the connection in which to enter upon a detailed discussion of the facts of heredity. But granting the hypothesis that every mind is inseparably conditioned with a physical side of its being, in inseparable alliance; and that the two states are made variable together, and the many complicated facts of inheritance, physical and psychical, become so intelligible that he who runs may read.

The child is but the resultant of inherited physical tendencies, modified by external conditions, up to the stage of development in which sentience, often involuntarily, and the Will, instinctively or designedly, begin more and more to assume control and direction. The persistent development of special tendencies in any direction, to the exclusion of opposed mental states, must work corresponding changes in mind and body. Sentient moods and physical modes must vary together. This law is verified in every stage of our existence.

Whenever we wait to be passively acted upon through either of our senses; both the quality and the degree of the answering consciousness is then predetermined. A heavy blow must hurt us, a jangle of harsh discords must be disagreeable, the sky must look blue and the grass green, familiar phrases must call up familiar thoughts, a pitiable tale must appeal to the sensibility, and a noble example, once apprehended, must excite admiration if not emulation. So we are constituted. We must be unmade before it can be otherwise. Every external stimulant, if accepted, must give rise to the state of consciousness which has been inseparably conditioned with it. The physical vibration and the consciousness are the two inseparable phases of the one fact.

As the organism is but the adapted mechanism through which we are acted upon and also through which we react, when the machine is out of order, the normal results do not follow. But why? Because the appropriate physical vibration is not, in that case, communicated to the mind-atom. The right vibrations from the green leaf fall upon the eye; but in a state of fevered nerves, these vibrations may be so interfered with and modified within the organism, that by the time they reach the mind-atom they may excite the sensations of a blood red blotch, of a black horror, or of any other externally baseless chimera.

The string of a musical instrument out of tune, if it sounds with other strings, can give nothing but discord. If we are dependent upon an adapted organism for all communication with the outside world, a failure at any point of the many combined adaptations must produce corresponding failure in the related consciousness—regarded in the light of a response to the external activity.

The consciousness is one, is individualized; but the possible simultaneous states of this consciousness are many. In abnormal states of the body, these several modes may become apparently incongruous or even contradictory. Instances have been given of what appeared to be a divided or double consciousness; the person living, as it were, two lives in his different states of mind. There are cases where there is apparent loss of a clear and continuous sense of personal identity—loss of a recognized unity of the consciousness as a whole.

The explanation is obvious. The mind cannot command its own moods sufficiently to coördinate them in one self-consciousness, simply because its physical correlations, impelled by abnormal outward influences, are perpetually forcing upon it irrelevant and disturbing modes of sentience, in such rapid succession, or so incongruously brought together, that the result is a necessary confusion of jumbled experiences. The mind has lost present self-control.

Just as we must feel warm when heat-vibrations awaken their adapted sensations, or as we must perceive a confused medley of the seven colors of the rainbow, if we look into a revolving prism, so a feverish brain can thrust vagaries upon the coöperating consciousness. Since the modes are all conditioned, a perceived unity in these wild experiences may be impossible at any time when the physical dominates over the sentient states; but the sense of a distinct personality is not lost, except in some unusual and greatly disturbed condition of the nervous system.

The same explanation would apply to dreams with all their vagaries; to all unregulated fancies, and to all forms of involuntary cerebration. In some states of excitement we cannot stop thinking by a simple act of will. The reflex action of the awakened nerves force upon us continual repetitions and variations of the same thoughts. Or we find it impossible to control some feeling, which wears on and on with reiterated pertinacity. In such cases, the only possible way to regain self-control is to quiet the nerves by diverting their action into some new channel.

Self-control is an acquirement which must be promoted and regulated by means as purely physical and manageable as are those which are used in cultivating a garden or in chopping down a tree in the forest. Educators must understand that mind has a physical basis, through which it must secure all even of its own proper mental development.

In dreams and reveries, when certain modes of sentient action are equilibriated or at rest in active present consciousness, the others run riot as influenced by external causes, or as stimulated by the excited and related nerves, or by both acting together. These results not only may occur, but they must occur. Self-control can guide its mental states at will; but loss of it leaves the mind to be played upon by an inexorable series of measurable physical forces. It is through such forces, with their unyielding extensions, that consciousness is related to external nature, as well as to every other consciousness like or unlike its own.

That mind is thus necessarily, definitely conditioned with matter, is a theory which should be able to offer in its support the most positive proof of which the nature of the subject will admit. The facts are largely within the domain of experimental tests. The purely physical facts are measurable, and through the organism we can indirectly measure their corresponding sensations, perceptions, emotions, and volitions. But all mental states are more than quantitative. Here we must call in the aid of consciousness itself to help us. But the laws of thought are comprehensive; they can relate all the phases of life in one unity. They can, perhaps, prove that laws of thought, of legitimate thought, are in necessary correlation with laws of things; that the whole Universe is but a unity of unities.

One mode of consciousness merges into another as one mode of motion is transformed into other modes of motion, or as one form of an object is changed into some other form; but changes in the states of consciousness are not quantitative. A sweet flavor can never be measured as greater or less than the acid flavor of a moment previous. It is not the former sensation transformed in mode. Every thing which is measurable in either arises in and with the physical conditions. Consciousness has no direct space relations; but it has many pure qualities and many degrees in each quality. It can normally produce any state of consciousness at will; but it must do this through its control of the adapted physical conditions. Would it enjoy a fine landscape, it must put itself into communication with such a landscape; then its enjoyment is something which is not in the landscape, but which is yet necessarily conditioned with it. Memory may afterwards reproduce the enjoyment; but it can do this only by recalling again the same nervous vibrations which were originally set in motion by the actual scene.

Perception is Consciousness initiating a mood which sets in operation the physical mechanism through which the consciousness is related to the object perceived. Sensation generally merges into perception of the object which excited the sensation. Will, is consciousness deciding to relate itself to any desired end through the appropriate agencies which have become known to it by past experience. Habit establishes its adapted lines of effective action; and hence, purely or partially reflex action can accomplish many things without volition which formerly required active volition, aided by repeated and toilsome experience, to effect.

Thought is a voluntary, sometimes an involuntary, train of past perceptions or of conceptions related either capriciously or according to the necessary laws of legitimate thinking. Prepossessions, will, fancy, careless methods of noting or of combining facts, must arrive at conclusions which will correspond to the method by which they were obtained. Precisely as a disordered nervous action may thrust vagaries into the consciousness, so the mind, desiring to revel in vagaries, may call them up by a voluntary use of the appropriate agencies. Every step is conditioned by its adapted physical state; but as the master's hand can compel his violin to utter any strain, however whimsical or discordant, so the mind can compel its physical allies to aid in the furtherance of any discordant or fantastic moods of consciousness. Experience tells us that this can be done: our theory explains the *how* of its accomplishment.

"We think in relations;" * but each step in the chain of relations must be grounded in a physical change, from which, as from a point of rest, it changes to each new mood. The thought does not relation its successor by direct action; the act of thinking produces the needful physical state, which is conditioned with it through no agency of its own, and from this state it can go forward into the new mood. We stand often in amazement at the thoughts which arise most unexpectedly to ourselves; they have a certain sequence which we may or may not be able to discover; but the effect is almost as though another had thrust the conception upon us.

In some sense the responsibility of thinking does not rest with ourselves; we have not conditioned it with our physical states; we have not voluntarily organized that most complex, sensitive, and unstable prolongation and extension of the physical apparatus of thought, the brain; we are not altogether responsible either for its normal or for its abnormal working. When, therefore, the thought arises in sequence from a multitude of adapted physical contingencies,

* First Principles, by Herbert Spencer, p. 162.

it springs into consciousness like a new creation. It has no element of space or of quantity. In that sense it is not made of anything which preceded it.

Consciousness is individualized; it is the all-embracing sentient nature, within which arises every fresh experience, several moods of experience being often present at the same time. But the number of these sentient moods, is limited by physical non-adaptations to their exercise. Thus one mood negatives another, or one prepares the way for its successor. In this sense, thought merges into other thoughts or into feelings; and the sentient moods are convertible among themselves, but they are not convertible in the sense that so much of the one kind can be changed into so much of another. We must clearly realize the conception that sensation is not directly measurable by any relations of the extended, though conditioned by them; for distinctions like these will otherwise seem unmeaning.

Thinking without logical connection is from the nature of things as possible, according to our method of explanation, as is any other whimsical grouping of incongruities, discords, or non-adjustments of whatever class. But thinking according to the necessary laws of thought, like real perceptions, on which such thinking, if applied to the objective world, is always grounded, must be in true accord with external realities!

Moods of consciousness are as definitely related to the physical universe, are related through conditions which are as inherent and immutable as the parallel conditions which make force and extension the two phases of one material substance. As every atom must vibrate in response to the sun's vibrations, because their physical properties are in adaptation, so must consciousness respond to objective facts. A hundred contingencies may prevent direct coöperation between the physical atom and the related atoms in the sun; but when they are in relation they must coöperate. And when the mind is brought into a normal relationship with the objective world, it must act in response. It must see things as they are, not only through sensation, but also through the intellect.

Objective truth and subjective truth are one. The laws of things and the laws of thought are one.

Each can be made to verify the other; to interpret and explain the other. The laws of normally conditioned thinking can detect and correct all make-believe, illogical thinking. The mind itself knows that such thought is like the fancies of a child, a mere factitious seeming, some form of temporary illusion. And the mind can correct its own misapprehensions of external facts. But it must take the established means of relating itself to a wide range of vision, and whenever it can avail itself of these necessary adaptations, its vision, whether it be the vision of pure logical thought or a vision gained through sensation, its affirmations of consciousness must harmonize with the objective reality.

Emotions might be termed esthetic and moral sensations. They arise from an appreciation of adaptations which give rise to a sense of the beautiful and the good; to the apprehension that there is a vivid living consciousness in others, which is kindred with its own and subject to like conditions, with like enjoyments. Moral sentiments have their physical conditions. Conscience, like the Will, is conditioned by matter; and, like it also, through the proper use of its functions, it can control and overrule material limitations. They are both at once free and necessitated, but not in the same sense; and the necessity and the freedom exist in mutual dependence. They both arise in the conditioned nature of finite existence. In coöperation with Nature's laws, all things are possible; since the active consciousness is inherent force.

The receptive or passive consciousness, which we have called intension, intensiveness, must be controlled by its intellectual and moral energies. The physical organism has been specially adapted to enable it to secure this intelligent and voluntary control. Every sentient want or need, every mental appetency; as hunger, thirst, the enjoyment of pleasant sensations and craving for every variety of satisfactory mental experience, is the natural motive power which, acting instinctively, continually brings new substance and force into the system; which uses and rejects the right adapted tissues; and which thus creates and maintains a living organism as distinguished from an inorganic or non-living organism.

The consciousness must work with and through its own physical phases of being; they work through adapted nerves and muscles. The sun directly helps vegetable growth; indirectly aids the growth of animal tissues. It helps to wind up the energies in every physical system as literally as it raises the vapor of water into the air to become clouds, to condense and fall again to the earth.

We must, if we would learn to become the true sovereigns of the states of consciousness, as well as of material nature, begin to attach a "rigid mechanical signification" to all the joint activities of the mind-unit and its body. Between the *lifting force* of the sunbeam working with its many physical allies, and all physical activity, there are definite, necessary, measurable interactions. Heat and light, Nature's great lifting powers, are related to the every-day welfare of human beings in many ways which we have been much too little accustomed to consider.

Every sunbeam is an active lever, and in almost every molecule it can find both its fulcrum and the weight to be lifted. Without its continuous help, directly or indirectly given, to elevate or wind up the forces with their extensions, in every part of every organic structure, no vegetable growth would be possible, no chick could mature in the egg or begin to run about; no arm could move, and no brain could promote thought. Mental power is represented physically by the structure and size of the brain and nervous system, as also by the size and structure of the entire organism, as really as the gravitative force in a cannon ball is represented by its weight and the height to which it has been elevated.

Mind must work through its organism; it must accept and use the conditions imposed upon it by the material side of its nature. Its physical and its psychical activities must work together; for they are but the jointly conditioned phases of one indivisible, individualized existence.

CONCLUSION.

Universality of the atomic relations.—The body a true physical machine.—Position of Prof. Bain.—Of Prof. Fiske.—The material and the mental equally permanent.—Organic and inorganic allies.—Variability of mental with material states illustrated by geometrical units.—The argument from consciousness.—Extended consciousness.—Sleep ; its possible relations to mind and organism.—Organic substances not organisms.—Gauging thought by waste in brain tissue.—Organic matter receives no increase of essential force.—Various phases of mechanical action.—Memory.—Possible organism within the organism.—Various analogies.—Conclusion that life has a physical basis and is immortal.—Quotation from Pascal.

THE majority of readers undoubtedly prefer to have the bearing of the alleged facts distinctly indicated, while to others this must be quite superfluous. The golden mean is, therefore, but a shifting point, varying as all eye-glasses must vary, to suit the need of different eyes. It seems best to freely repeat such thoughts as are most needed in connection with remaining suggestions, to give, in summing up, a fairly complete outline of the argument, which attempts to show that a conscious immortality for each mind must be an abiding constitutional fact. The interests at stake would justify even unneeded iteration.

We claim that each ultimate atom,—whether conditioned by physical properties only; as unquestionably all simply material units may be, so far as anything is now known to the contrary, though we may not have evidence enough to determine this point from sufficient data; or whether conditioned by both physical and psychical properties, as all atoms must be when they possess the capacity to live, to be thrilled by any kind of felt experience, whether of a low or of a high order,—we claim that every atom in the universe, without exception, is, to itself, the axis or centre of the entire universe, in such a sense that it can and does coöperate with all other units in all directions, radiating its influence outward like a true central star; giving and receiving various *modes of activity* on all sides, and exchanging with its neighbors always on the rigid mathematical basis of equivalent for equivalent of working energy.

In proof of this position, we appeal directly to well known and admitted facts. Whoever is still doubtful as to the value of the evidence already offered on this point, must take up the subject for himself. He can surely determine in his own mind *how* any centre of force is able to co-work with other centres of force. With the attention concentrated on any one simple point of departure, if our theory is tenable, all the remaining units of the cosmos will be ranged about it as the sheaves of Joseph's brethren were around about Joseph's sheaf, bowing down before it; they all vibrate in response to its vibrations. But it responds to them all with equal courtesy; for in the great commercial mart of material nature there are no privileged traders enriching themselves at the expense of their fellows.

If we can satisfy ourselves that substances exchange, not innate forces, but modes or ways of working, that they exchange motive tendencies, opposed in direction, in rate or circuit of vibration, or in some occult trait of motion, which can enable them to share equitably in the results, we shall then find no difficulty in comprehending that we ourselves may be each a true material unit; taking unconsciously a full and fair continuous share in the manifold operations of the body and of its environment. The body is certainly worked, like any other machine, according to the established laws of material nature.

Is consciousness, then, conditioned with the material *me;* dependent upon it, limited by it, and its conscious states necessitated to change with every coördinated change of the physical side of its being? Experience *must* answer, it is. "From the ingress of a sensation, to the outgoing responses in action, the mental succession is not for an instant dissevered from a physical succession." * We can test this simultaneousness of the mental and material modifications in a multitude of ways. The most skeptical may convince himself of the fact that they necessarily occur together; conditioning each other *in time.*

But the physical succession is complete in itself. The mental succession is also complete and distinct in its kind. I cannot do better than to make another pertinent selection from Prof. Bain; whose position, as Professor of Logic and Mental Philosophy in the University of Aberdeen; the author of a number of able works treating of this question, and the leading

**Appendix* to Conservation of Energy; by Alexander Bain, p. 211.

influence in projecting the new Quarterly called "*Mind;*" to be devoted to a consideration of the relations of Mind and Body; must give weight to his conclusions.

"Walking in the country in spring, our mind is occupied with the foliage, the bloom, and the grassy meads, all purely objective things; we are suddenly and strangely arrested by the odor of the May-blossom; we give way for a moment to the sensation of sweetness; for that moment the objective regards cease; we think of nothing extended; we are in a state where extension has no footing; there is, to us, place no longer. Such states are of short duration, mere fits, glimpses; they are constantly shifted and alternated with object states, but while they last and have their full power we are in a different world; the material world is blotted out, eclipsed, for the instant unthinkable. These subject moments are studied to advantage in bursts of intense pleasure, or intense pain, in fits of engrossed reflection, especially reflection upon mental facts; but they are seldom sustained in purity beyond a very short interval; we are constantly returning to the object side of things—to the world where extension and place have their being."

Prof. Bain does not attempt to indicate *what* the connection is between mind and body. He accepts the alliance as a fact, and leaves it there; but he forcibly insists that "mental states and bodily states are utterly contrasted; they cannot be compared, they have nothing in common except the most general of all attributes, degree, and order in time." *

In the March number of the *Atlantic Monthly*, (another indication of the drift of current thought,) Prof. John Fiske, writing on the Unseen World, takes the position that a "world consisting of purely psychical or spiritual phenomena would be demarcated by an absolute gulf from what we call the material universe, but would not necessarily be discontinuous with the psychical phenomena which we find manifested in connection with the world of matter."

How fresh experience could be gained in the new state is "utterly and hopelessly inconceivable *because* it is without foundation in experience;" but, he

* The Relations of Mind and Body.

argues, "the entire absence of testimony does not raise *a negative presumption except in cases where testimony is inaccessible*." Prof. Fiske is disposed to think, with Berkeley, that consciousness is the reality, and material nature an orderly product of consciousness; presently to be cast off as an unneeded garment.

The often proposed suggestions, on one side that material nature is but an appearance, a phantasmagoria, to be presently abolished: and on the other, that consciousness, arising as a temporary manifestation of underlying causes, is to disappear with a new combination of the unknown realities, are both wofully unsatisfactory; if not equally abhorrent to every instinct of our natures. A negative belief, a belief based upon nothing except the bare fact that it is "necessary to one's comfort" has no more solidity than a girl's fancy that her doll is enjoying a delicious breakfast. It is a pleasant coveted illusion—that is all.

To know that a great hope cannot be positively disproved on the testimony of Nature, is certainly not valueless. But as we can assuredly gain a clear conception of a necessary mutual dependence between the physical and the psychical phases of being which can give to both an underlying reality, and an immutability which shall guaranty the eternal conservation of both.

Consciousness works through brain, nerves, and general organism; but it can be shown that *there is vastly "more reason for supposing that consciousness survives the dissolution of the brain, than for supposing that the pungent flavor of table-salt survives its decomposition into metallic sodium and gaseous chlorine."* My consciousness is working now through the pen held in my hand, and through the drop of ink flowing from the point of the pen; it controls the energies in this solid machine and in this fluid drop as undoubtedly as it controls the hand or the brain. Why should it not survive the destruction of the coöperative organism as easily as it may survive the destruction of its inorganic co-workers?

A mind, as a unit conditioned and modified by the dependent interaction of the several coöperative phases of its being, must find in an adapted organism a means of sentient development and an aid in conscious energizing, as it must find in it also the physical forces which supplement its own. But I find the same aids in this pen and ink! My views of the nature and the amount of evidence in proof that each one of us *must* accept the boon of a personal immortality, have been greatly enlarged through the attempt to express them in words, with the mechanical assistance of writing materials. Pen and paper are a prodigious means of human development.

The changing body is as purely mechanical as this pen. It is not a part of consciousness. If an atom of sodium can survive the destruction of the molecule salt, of the crystal of salt, of the bowl of water which holds it in solution, of the bread into which it enters as a constituent, of the organic processes of digestion, circulation, etc., in which it takes its share of work with the rest of the organism, then why should not the mind-unit equally survive its incarnation? its manifold organic coöperations? The difficulty is no greater in the one case than in the other. The sodium does survive all these and endless other changes; we know that; science accepts the fact that it exists still, the identical sodium that it was in the beginning, with all of its properties perfectly intact. Science must yet admit the constitutional indestructibility of every mind.

The organic processes are generically unlike the inorganic only because they are more directly adapted to the psychical changes. A touch upon any part of the body is immediately recognized by the mind; but when the pen is held in my hand, the touch of its point upon the paper is also recognized in the mind. A continuous chain of communication arises between the paper and the mind. If consciousness has not gone out into the pen's point, and its physical extension been put into actual contact with the paper, yet it is as undoubtedly interacting with the paper, as pen and paper are coöperating. It directs their coöperation.

The mind and the paper are interacting in several distinct lines of exchanged vibrations; in that which passes along the pen; in another which passes through the fingers that rest upon the paper beneath the pen; in another through the other arm and hand, and in still others passing through the nerves of vision and the intervening air. Consciousness is directly cognizant of all these simultaneous connections between the mind and the paper.

But undoubtedly there must be what might be termed, *a solid bundle of exchanged physical vibrations*, radiating from every point in the paper; received and returned unconsciously from every point of the organism. The purely physical character of these coöperative energies cannot be generically different, whether consciousness does or does not take part in the process. If the mind, though a unit, is yet a real physical structure, possessing its definite unlike poles, each radically conditioned with special sensations, then, whenever these physical poles are thrown into vibration, the special sensations must accompany the vibrations, but not otherwise.

Chemists find that all the material units with which they have made acquaintance in the laboratory, do possess definite special poles; each having its own determinate functions, which remain always the same under like conditions. Physicists, find a similar class of facts in their department of research. All atoms ally themselves in larger and larger systems, by lines of extended coöperations in which they take an active part; and in all of these many lines there is simple and equal exchange of physical motion. Why should not the mind take its physical share in all this; like other physical atoms? Why may it not have form, extension, and measurable force? Why not have definite physical poles which relate it to nerves of sound, of vision, of taste, smell, and touch? Sensations which *might be* thus produced, we doubtless have. Perceptions we have. They all come through the physical nature!

Does this reduce mind to the material level? Assuredly not. Consciousness works in and with its physical properties; it indifferently accepts and confers atomic modifications; but sentience, living experience, is totally distinct in kind from all possible physical operations. *It* gives all true value to existence.

Then is a mind, constituted at once by qualities and intensions, varying modes of an ever-living individual consciousness; and by quantitative states of unsentient force and extension reacting in compelled response to every impulse from without, yet conditioned with and varying with the conscious moods

—is such a mind a "thinkable" possibility? It is, if we can realize the conception in thought. We must turn once more to our geometrical units, though the illustration now, as indicating the complicated atomic structure adapted to changing human experience, must be so halting and inadequate, that I may well hesitate about bringing it forward; yet a tangible illustration, however faulty, has many advantages. Let us suppose that substance in the form of a triangle, is endowed with a consciousness, is alive. So far the proposition is entirely thinkable. We can suppose that this consciousness, *as a whole*, is a unit; so that whenever any new mood of experience arises, it must come in as a part of the general sentient condition. Let us further suppose that the form of the triangle can be so acted upon as to change it into either of the three triangular types, equilateral, isosceles, or scalene. Is it, then, impossible to think that a different quality of experience may be conditioned with each of the three types; and that whenever the triangle is varying from one to the other, there may be degrees of intension; in exact mathematical adjustment to the varying form of the triangle? Properties so coördinated would condition each other exactly as our mental and material states are supposed to do.

So far from finding trouble in supposing that the physical and psychical characters might be made thus to modify each other in a triangle or in any more complicated geometrical unit, if it was a substantial unit and gifted with consciousness, all mathematical dependence of parts would be meaningless or superficial if sentient moods and physical modes were not made mutually dependent in all their possible variations. Otherwise, the consciousness could be but an outside affair—not an integral part of the mathematical unit.

Now let the angles of our triangle represent chemical poles, possessing attractions which could ally the triangle to other geometrical units, like or unlike itself; with every variation of form, there must still be variation in conscious experience; the living triangle might find itself allied to a million of other geometrical units, yet it must still work under the laws of its own constitution; it might survive a thousand alliances; its own nature would remain an indestructible unit in the midst of all possible changes. It is structurally conditioned by dependent, unlike phases of related change.

It would appear, then, that wholly *dissimilar phases of being might be so conditioned together that change in either must imply allied change in all.* Such *might be* the constitutional limitations of each ultimate atom. To effect this coördination, there must be at least two unlike phases, which could mutually define and give characteristics to each other; there might be several such differentiated classes of dependent modifications.

We are here brought back again to existing facts. Are we conditioned by several phases of being, each dependent upon all of the others; yet not exchangeable with any of them? I have already stated many facts, all tending to answer this question in the affirmative; but happily, evidence in this direction is unlimited and easily tested by each one of us for himself. What doubt can exist that sensation and perception are related to the object-side of Nature by an inherent connection which is as necessary as the relation of inside to outside, or any other similar, double phased, mutually dependent fact? Early June foliage excites the lively sensation of fresh verdure; and charcoal, with its greedy capacity to absorb light and heat, looks to us black. Why? Because the essential *me*, having both a physical and a psychical side in its essential individuality, can literally take up and echo these various outside vibrations; and with each such echoing of an outward motion, springs forth the living consciousness—which feels each change because the change is a part of its complete self.

Philosophers like Prof. Fiske and M. Papillon, suggest that although consciousness is now conditioned by physical properties, it may yet be separated from them in the future. It can not and yet remain our personal consciousness! Prof. Bain's expression, "the extended consciousness," must represent an abiding fact. We ourselves have extension, have positive physical force, which consciousness accepts as its true physical possession: through which it allies itself to the external world. We each have a real position in space, and that position is *not* an unextended point; there is right and left, up and down, in even the innermost sensation, if we attempt to relate it to our complete selfhood. Our physical properties are not objective to our consciousness; *they are perceived in consciousness* as determining its sentient moods and as controllable in turn by its volitions. No fact seems more certain to me than that we all do positively and necessarily recognize ourselves to be units, possessing both physical and psychical attributes, which are so constitutionally indivisible that to separate them would be to separate necessary correlations—which of course would be to destroy utterly both terms of the one relationship.

For example: I have a sensation in my hand or foot; this sensation cannot pertain to the physical member; the mind's sensation, then, must relate the consciousness in place, in various divisions of space. Now whether the mind does or does not occupy every part of its organism, it recognizes its sensations as allied to and as conditioned by bodies extended in space. It is "an extended consciousness"; a better phrase may be, it is the consciousness of an extended unit, co-working with other extensions.

It is utterly impossible to think of ourselves without space relations; we can think of conscious states, one phase of ourselves, without space relations; but the completed me is conditioned in space, in time, in quantity, and in quality of being; and each phase of its modifications must determine every other phase—all varying together each in its own kind. Consciousness, as a whole, is a containing recognition of the many-sided fact.

But the moods of consciousness come and go. Several of them may coëxist; but any greatly absorbing mood negatives or partially negatives all the others. One listening to music with which he is greatly delighted, cannot at the same time be thinking intently. His nature is not large enough for this; or his physical aids are inadequate. Definite hard work, mental or physical, persevered in, must draw off the mind from any great grief; from any foreign interest. Thus habit becomes a moulding influence. It is the great educator which can carry down the lesson even to the next generation. So it is that our "fine spun theorizing" may become the most practical of all practical truths; the corner-stone of daily routine.

Any theory which attempts to ground itself in the permanent constitution of the most ultimate unit of being must ramify in all directions; but a prolonged discussion even of the testimony of consciousness as to its various interdependent states, would be out of place in a popular treatise. Elsewhere I have considered more at length many of the relations and consequences which must arise from the conditioned action of the physical and mental natures.* Each reader must now accept for himself the responsibility of deciding whether or not his nature embraces both mind and matter, "mind-body" in one unity.

If it does he can relate himself to all phenomena, for he is a part of all. If it does, his conscious immortality and the immortality of his true physical self are both assured facts. Nothing which he justly prizes need be lost in his future life.

But we do not forget that consciousness is suspended for some hours daily in natural sleep; that digestion, assimilation of food, the entire process of tissue building, and many involuntary movements of the body are conducted mainly, if not entirely, without

* Studies in General Science.

the intervention of conscious states. These purely physical processes are not more mysterious than those which build up the inorganic crystal, through the self-acting coöperation of adapted energies. Consciousness, with its felt appetencies, can do nothing more in the earlier stages of organic growth, than instinctively, with every recurring want, to relate its physical states to the adjusted sources of organic supply; they must carry on the process accordingly, step by step, to the upbuilding of the mature body with all of its differentiated organs and functions. All visible bodily activities are physical—not mental.

Then can mind rest while its organism is physically active—supposing the organism to be, in effect, but a prolongation of its own extension? The telescope, in a similar sense, is a prolongation of the optic nerve; but we use it, or lay it aside at pleasure. Until we know more of the internal economy of our bodies, we cannot know that the mind might not suffer its body to renew its energies undisturbed, as is done in sleep, while it retires within itself and closes the channels of communication between them.

But there are facts which indicate that even in a dreamless sleep some faculty of the mind is still alert. Dr. Brown-Séquard has pointed out the watchfulness of a power which is always alert to ward off danger. We fall asleep bidding ourselves awake at a certain hour; and we awake. Some state of the living unit must have been playing sentinel. Attention is now being strongly directed to the solving of these mysteries of the inner life. Doubtless we shall yet reach explanations which are fully satisfactory.

As motion seems equivalent to rest when mechanical forces hold each other in equilibrium, so consciousness may possibly become, as it were, *latently active*, under parallel conditions. Revery and absent-mindedness seem to be conscious phenomena which are much akin to sleep. A similar state can be produced by anæsthetics, or by an injury to the brain. The conditioned physical and mental states must change together in mutual dependence within the mind-atom; but between it and its organic adaptations there is no necessary connection. A cessation of interaction between them may be complete or partial, temporary or final. Their coöperation arises from an atomic adjustment of energies;

and any radical change in the mode of energizing might drive them asunder, as a magnet can attract a substance at one moment and yet repel it at the next.

The chemist, by a skillful manipulation of elements when the multitude of accessories are in conjunction, can create a great number of organic compounds. They are truly organic compounds, but they are not organisms; they have no adapted organs able to carry forward their own vital processes through continuous integration and disintegration of working material. The sentient appetencies of a living unit with recurring needs and instincts, on our theory, is indispensable to the beginning and to the continuity of this phase of vital process; but the process being purely physical, might go forward for a time after the withdrawal of the initiative influence. Its changing moods do nothing more than modify its own physical states; these set in action the adapted machinery, which thus builds up and operates itself through its own coördinated atomic energies.

Dr. Hammond thinks it quite feasible to gauge the kind and amount of thought, by an analysis of the waste in brain tissue. Modern physiology is coming more and more fully to indorse this sanguine expectation; whatever difficulties lie in the way must be of a practical class; such as the difficulty of taking into account all of the factors. Each given mood of mind should require an identical or at least an equivalent grouping of physical allies to further its action. A machinist may condition the chords of a musical instrument in several ways, and yet obtain the same essential results; but these different methods must be true equivalents.

An organism can possess no more force when in the full tide of vital activity, than when it lies a crushed and shapeless mass at the wayside; or than the aggregate of its particles would have if they all returned again to inorganic elements. The identical atomic forces, changed in nothing except in their modes of action, and changed in these only because now they are acting and reacting in a wholly unlike series of operations,—the identical atomic forces, at one time hold the little molecule to its proper action and right position among its fellows in the receiver filled with unlike gaseous vapors; at another, they co-work to build up a rigid symmetrical structure of enduring stone; at another they mould themselves into "protoplasm" and finally build up their ever-docile extensions into living tissue and help to forward the vast cycle of vitalized activities.

When we begin with the simpler combinations, the more complex become greatly more intelligible. Atomic forces and extensions being conditioned together and adjusted to unlike action of the several parts of the same atom, and being also conditioned to react as acted upon from without, every new combination must produce determinate but unlike results; the greater the number of units and the more varied the several classes coöperating in any perpetually movable system, like every organism, the more apparently marvellous, although equally mechanical and predetermined, must be the result. It is simple action and reaction throughout. The marvel lies in the structure of the atom; in the wonderful system of ever-widening adaptations; in the great plan thus substantially effected.

We can comprehend the mechanical action. We know how force is modified in its action by extensions; we know that the same kind and amount of energy communicated to a light body and to a heavy one, sends the light one forward rapidly, the heavy one slowly. The weight of each multiplied into its velocity, gives the same total of acting energy. Or, when they are fixed bodies and made to vibrate, the vibrations, as with vibrating strings, are conditioned by their allied extensions. These principles, applied to all compound and complex bodies, inorganic and organic alike, can be made to definitely, mathematically, explain the action of every system, living or lifeless. Consciousness directs the activity; it is not of it, but conditioned with it. The living experience is an ever new creation!

When there is repetition of any mood of feeling, we are accustomed to speak of it as *like* the former mood; but when the repetition is a thought, we call it *the same* thought, and the reproduction of it is assigned to memory. But if thought and feeling arise with material vibrations which condition them, renewal of either must depend on renewal of the appropriate vibrations. The mood of consciousness is new, as the vibration is new; the one being quantitative is made out of preceding quantities; the other, as qualitative needs no substantial predecessor; it arises as a fresh acquisition of the ever-living consciousness; as a fresh action of the ever active conscious energies. It is not something arising from nothing; but something arising with physical changes by which it is conditioned; it is living personal force in the exercise of its true prerogative; acquiring new stores of experience.

Thus is life a perpetual gain. Thus can immortality become a perpetual good—a growth of ever freshly acquired states of the living, all-embracing, consciousness. But these states are dependent on physical changes. The thought or feeling, out of consciousness, can only be recalled at will through a properly adapted organism. The mind must relate itself to the external world through some organ adapted to receive the modes of vibration which belong to the objective. Growth of experience is dependent on adapted extensions.

A train of associations will often bring back with it many mental states previously associated. Habit, repetition, can make the task an easy one; but often we beat about gropingly, till the right line is set in motion at last, and the desired mood arises with it. To be of value, therefore, immortality of experience must ally itself to an immortality of adapted physical coöperations. It will need—not literally a spiritual body—but a truly material one through which it can communicate with universal matter and with the universe of minds also. It should need growing facilities.

But all known analogies point to the strong probability that, as the visible body enlarges and is brought under the control of the mind, the "mind-body" is able to ally itself to adapted atoms, material also, but of a more ethereal character, like itself; with these it may enter into its future life, not maimed and helpless, but fully equipped for its new destiny.

All matter is not visible matter. No physicist can dispense with the interstellar ether and yet explain a fraction of the phenomena of universal Nature. If several vapors can occupy adapted portions of a given space without interference; if waves of ether called light and heat, can penetrate, pass through, work with, and give most various shades of color to solids, fluids and gases; if we must call in the action of a refined class or classes of matter to explain the transmission of all the more rapid and subtle forms of energy, as electricity, and gravity, then the supposition that every mind may have a more permanent ethereal body which mediates between it and its grosser organism, cannot involve a shadow of scientific absurdity. It even becomes highly probable.

Since the luminiferous ether can exist with and work with ordinary matter, now rarely found in an elementary state; and especially as it must have several distinct functions, like the transmitting of light and gravity, we can hardly regard it as one simple, homogeneous substance; all other matter, with no exception in the entire realm of known elements, tends perpetually to intimate molecular association, generally with substances adapted to supplement while yet unlike itself. This is Nature's invariable method of evolution. She carries on all her processes through an ever growing heterogeneity of compounds and of coöperations.

The mind, if material in any sense, must be regarded as more akin and therefore as likely to form more intimate and more permanent alliances with the less ponderable forms of matter than with the grosser visible organism. Circumstances apparently favor its continuous adaptation to an enlarging ethereal organism; analogy must point towards a probable increase of the inner and the outer bodies simultaneously; use, exercise of any function tending always to build it up, to perpetually strengthen and enlarge its capabilities. This would be but another illustration of the general plan which builds up system within system throughout material nature, and especially in every department of organic nature. The ordinary physical brain, it is well known, is steadily enlarged, and added to in convolutions, with the growth of the intellect; it changes in form with change in the character of the habitual mental activity; as with men savage or civilized, and with the differing nationalities.

There is, moreover, considerable and various reliable evidence that the mind is not necessarily wholly dependent on the normal action of the visible brain. One in feeble health can often control the mind with a power which seems superior to any thing properly pertaining to the shattered body; the strangely luminous state which often precedes death would seem to be of this order. That there are psychological states of mental activity with bodily torpor is certain. In old age, too, when the stiffened members move so wearily that the mind seems falling into dotage, at times it can arouse itself to an accurate memory of the past, and to eager and rapid action. The drowning man and one falling from a great height often find the mental powers become preternaturally active. Such facts make our hypothesis seem the more probable. They are not proof.

Chemists find, as a rule, that organic substances have very many more atoms in the molecule than inorganic. The beautiful dye stuffs, which they rival Nature, or rather imitate Nature, in manufacturing, are often very complex in molecular structure. Turn to Prof. Cooke's theory and explanation of the structure and action of nitro-glycerine—in "The New Chemistry;" we shall come to the conclusion that available energy must be allied with delicately adjusted, structural adaptations; and that, in every process of change, the atomic attractions of matter universally, since always seeking, will gradually find the higher and broader alliances adapted to them and that finding these satisfactorily, the relation is of a very permanent nature.

Granite is durable, a metal is to us indestructible; the great worlds which shine out nightly in space are slow to break asunder; every organism is tenacious of its continuous maintenance. Is the mind-unit likely to be the only exception to this physical instinct, to the innate attraction, which is always seeking for a permanent alliance? What more probable than that, co-acting with its ever changing organism it is able to steadily provide itself with allies which shall outlast the perishable form with which it is temporarily associated.

Still this is but tracing possible analogies. It all very possibly, very probably, may be; we cannot say positively that it actually is. But we can, as I think, assume without a shadow of doubt, from sufficient evidence of an affirmative character, that there is an indestructible atomic identity for every ultimate atom;

that in minds, physical and mental properties inhere together in mutual dependence. In what way consciousness will associate itself with coöperative energies in the future, where and in what state we have been in the past, must, at present, be matter of surmise. But that life, in all orders of being, has a physical basis through which it can ally itself to a willingly coöperative universe, is not left to any contingency.

Does an atom infinitesimally small seem too minute to be the eternal abiding place of a living consciousness? We have no knowledge of the size of the ether units; none of mind-units. But mere dimensions are valueless. In the language of Pascal, —"Let man investigate the smallest things of all he knows; let this dot of an insect, for instance, exhibit to him in its diminutive body parts incomparably more diminutive, jointed limbs, veins in those limbs, blood in those veins, in that blood humors, and drops within those humors—let him, still subdividing these finest points, exhaust his power of conception, and let the minutest object his fancy can shape be that one of which we are now speaking—he may, perhaps, suppose that to be the extreme of minuteness in Nature. I will make him discover yet a new abyss within it. I will draw for him not merely the visible universe but all besides that his imagination can grasp, the immensity of Nature, within the confines of that imperceptible atom."

I would gladly prove to him that this least existence is indestructible; that it is destined to relate itself continually more intimately to the all; learning steadily to apprehend alike the deepest mysteries and the broadest truths, as itself a living part and parcel of every process; I would show him that in this merest speck of life is embodied a scheme of thought, a scheme of delicate nicest adaptations, perfect in every least division; part fitted to part; each hanging upon the other; the least here allied to the greatest there, in so complete a unity that if either dropped out from the infinite plan, the most exact order would become but hopeless confusion; I would show him that every smallest change, every possible mode of variation, is so fully wrought out in the scheme that it must spread like a subtle wave of resistless influence, as action and as passion, as giving, as receiving—responsive through every phase of the many-sided whole; I would single out the self-conscious mind, enabled steadily to acquire wisdom, to grow in happiness, to gain in power; learning to guide its own destinies, yet leading always by the hand the weak and the erring towards a better eminence; I would convince him that this vast delicate incarnation of beneficent purpose, of manifested thought, of embodied adaptation, must hang but as a fringe upon the garment of the Infinite Thinker. There must be a Maker of the conditioned universe, himself unconditioned. To Him we may reasonably look for a continuation of the existing order of Nature, with the furtherance of all the interests which are bound up within it as part of its eternal process.

THE END.