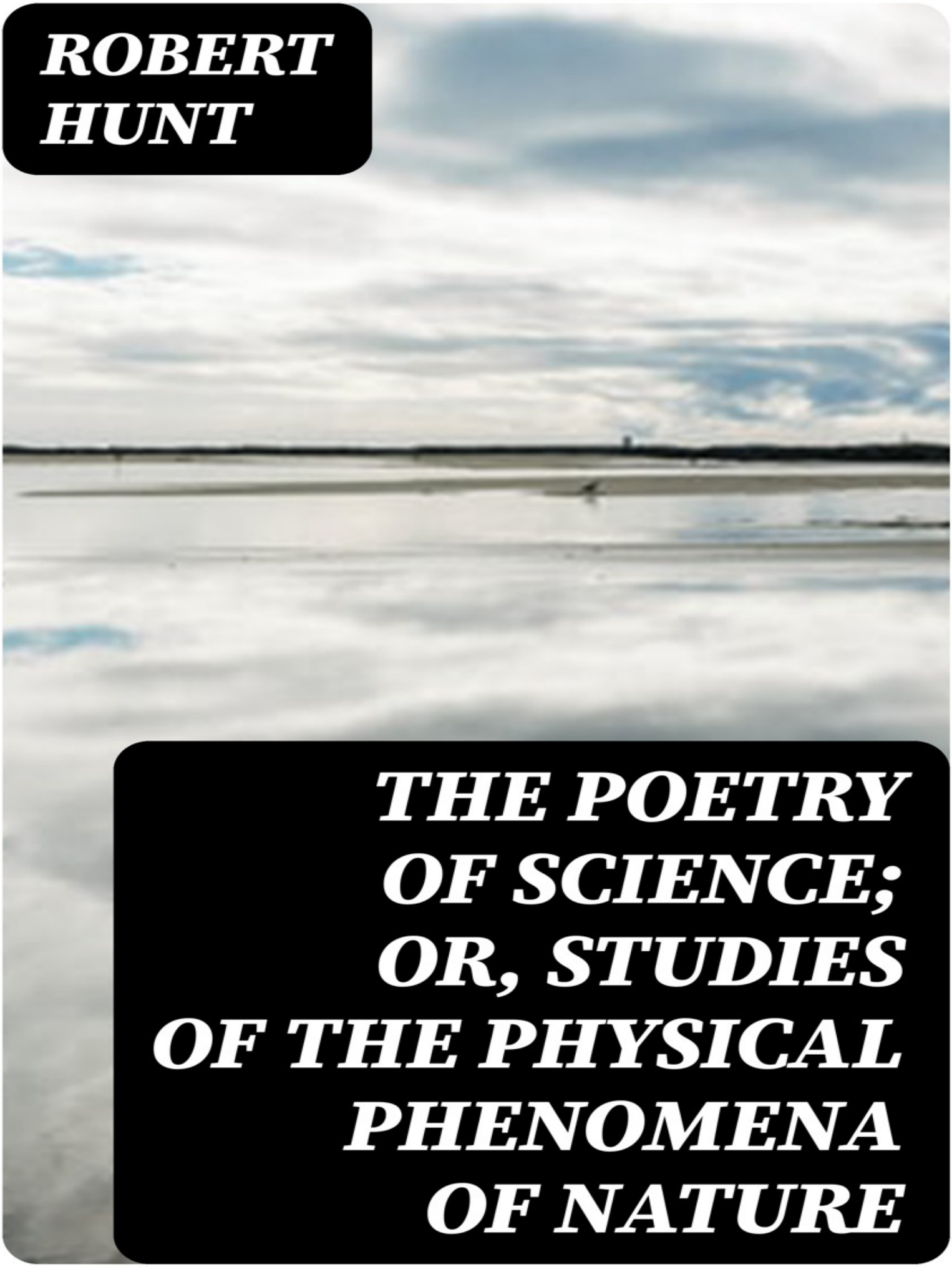

ROBERT HUNT

THE POETRY OF SCIENCE; OR, STUDIES OF THE PHYSICAL PHENOMENA OF NATURE

Robert Hunt

The Poetry of Science; or, Studies of the Physical Phenomena of Nature

EAN 8596547223009

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PREFACE.

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Since 1848, when the “Poetry of Science” was first submitted to the public, two editions have been exhausted. This, were proofs required, would of itself show that there is a large circle of readers to whom the deductions of science have an unfailing interest. Beyond this, it conveys an assurance that every truth, however abstract it may appear, has a large popular value if studied in its relations to those generalities which embrace great natural phenomena. With this persuasion the third edition of the “Poetry of Science” has been extended so as to include all the important discoveries which have been made in Natural Philosophy to the end of the year 1853. It is now presented to the world in a new and cheaper form, in the hope, that, with the extension of its circulation, there may be awakened, in still larger circles, a deep and healthful interest in the sciences of which the volume treats.

R. H.

Edinburgh, March 7, 1854.

INTRODUCTION.

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The True is the Beautiful. Whenever this becomes evident to our senses, its influences are of a soul-elevating character. The beautiful, whether it is perceived in the

external forms of matter, associated in the harmonies of light and colour, appreciated in the modulations of sweet sounds, or mingled with those influences which are, as the inner life of creation, ever appealing to the soul through the vesture which covers all things, is the natural theme of the poet, and the chosen study of the philosopher.

But, it will be asked, where is the relation between the stern labours of science and the ethereal system which constitutes poetry? The fumes of the laboratory, its alkalies and acids, the mechanical appliances of the observatory, its specula and its lenses, do not appear fitted for a place in the painted bowers of the Muses. But, from the labours of the chemist in his cell,—from the multitudinous observations of the astronomer on his tower,—spring truths which the philosopher employs to interpret nature’s mysteries, and which give to the soul of the poet those realities to which he aspires in his high imaginings.

Science solicits from the material world, by the persuasion of inductive search, a development of its elementary principles, and of the laws which these obey. Philosophy strives to apply the discovered facts to the great phenomena of being,—to deduce large generalities from the fragmentary discoveries of severe induction,—and thus to ascend from matter and its properties up to those impulses which stir the whole, floating, as it were, on the confines of sense, and indicating, though dimly, those superior powers which, more nearly related to infinity, mysteriously manifest themselves in the phenomena of mind. Poetry seizes the facts of the one and the theories of the other; unites them by a pleasing thought, which appeals for truth to the most

unthinking soul, and leads the reflective intellect to higher and higher exercises; it connects common phenomena with exalted ideas; and, applying its holiest powers, it invests the human mind with the sovereign strength of the True.

Truth is the soul of the poet's thought;—truth is the reward of the philosopher's toil; and their works, bearing this stamp, live among men through all time. Science at present rejoices in her ministry to the requirements of advancing civilization, and is content to receive the reward given to applications which increase the comforts of life, or add to its luxuries. Every improvement in the arts or manufactures, beyond encreasing utilities for society, has a tendency to elevate the race. Science is ever useful in the working days of our week, but it is not to be neglected on our Sabbath,—when, resting from our labours, it becomes agreeable to contemplate the few truths permitted to our knowledge, and thus enter into communion as closely as is allowed to finite beings, with those influences which involve and interpenetrate the earth, giving to all things Life, Beauty, and Divinity.

The human mind naturally delights in the discovery of truth; and even when perverted by the constant operations of prevailing errors, a glimpse of the Real comes upon it like the smile of daylight to the sorrowing captive of some dark prison. The Psychean labours to try man's soul, and exalt it, are the search for truth beneath the mysteries which surround creation,—to gather amaranths, shining with the hues of heaven, from plains upon which hang, dark and heavy, the mists of earth. The poet may pay the debt of nature,—the philosopher may return to the bosom of our

common mother,—even their names fade in the passage of time, like planets blotted out of heaven but the truths they have revealed to man burn on for ever with unextinguishable brightness. Truth cannot die; it passes from mind to mind, imparting light in its progress, and constantly renewing its own brightness during its diffusion. The True is the Beautiful; and the truths revealed to the mind render us capable of perceiving new beauties on the earth. The gladness of truth is like the ringing voice of a joyous child, and the most remote recesses echo with the cheerful sound. To be for ever true is the Science of Poetry, —the revelation of truth is the Poetry of Science.

Man, a creation endued with mighty faculties, but a mystery to himself, stands in the midst of a wonderful world, and an infinite variety of phenomena arise around him in strange form and magical disposition, like the phantasma of a restless night.

The solid rock obeys a power which brings its congeries of atoms into a thousand shapes, each one geometrically perfect. Its vegetable covering, in obedience to some external excitation, developes itself in a curious diversity of forms, from the exquisitely graceful to the singularly grotesque, and exhibits properties still more varied and opposed. The animal organism quickened by higher impulses,—powers working within, and modifying the influence of the external forces,—presents, from the Monad to the Mammoth, and through every phase of being up to Man, a yet more wonderful series of combinations, and features still more strangely contrasted.

Lifting our searching gaze into the measureless space beyond our earth, we find planet bound to planet, and system chained to system, all impelled by a universal force to roll in regularity and order around a common centre. The pendulations of the remotest star are communicated through the unseen bond; and our rocking world obeys the mysterious impulse throughout all those forces which regulate the inorganic combinations of this earth, and unto which its organic creation is irresistibly compelled to bow.

The glorious sun by day, and the moon and stars in the silence and the mystery of night, are felt to influence all material nature, holding the great Earth bound in a many-stranded cord which cannot be broken. The tidal flow of the vast ocean, with its variety of animal and vegetable life, the atmosphere, bright with light, obscured by the storm-cloud, spanned by the rainbow, or rent with the explosions of electric fire,—attest to the might of these elementary bonds.

These are but a few of the great phenomena which play their part around this globe of ours, exciting men to wonder, or shaking them with terror.

The mind of man, in its progress towards its higher destiny, is tasked with the physical earth as a problem, which, within the limits of a life, it must struggle to solve. The intellectual spirit is capable of embracing all finite things. Man is gifted with powers for studying the entire circle of visible creation; and he is equal, under proper training, to the task of examining much of the secret machinery which stirs the whole.

In dim outshadowing, earth’s first poets, from the loveliness of external nature, evoked beautiful

spiritualizations. To them the shady forests teemed with aërial beings,—the gushing springs rejoiced in fantastic sprites,—the leaping cataracts gleamed with translucent shades,—the cavernous hills were the abodes of genii,—and the earth-girdling ocean was guarded by mysterious forms. Such were the creations of the far-searching mind in its early consciousness of the existence of unseen powers. The philosopher picked out his way through the dark and labyrinthine path, between effects and causes, and slowly approaching towards the light, he gathered semblances of the great Reality, like a mirage, beautiful and truthful, although still but a cloud-reflection of the vast Unseen.

It is thus that the human mind advances from the Ideal to the Real, and that the poet becomes the philosopher, and the philosopher rises into the poet; but at the same time as we progress from fable to fact, much of the soul-sentiment which made the romantic holy, and gave a noble tone to every aspiration, is too frequently merged in a cheerless philosophy which clings to the earth, and reduces the mind to a mechanical condition, delighting in the accumulation of facts, regardless of the great laws by which these are regulated, and the harmony of all Telluric combinations secured. In science we find the elements of the most exalted poetry; and in the mysterious workings of the physical forces we discover connections with the illimitable world of thought,—in which mighty minds delight to try their powers,—as strangely complicated, and as marvellously ordered, as in the psychological phenomena which have, almost exclusively, been the objects of their studies.

In the aspect of visible nature, with its wonderful diversity of form and its charm of colour, we find the Beautiful; and in the operations of these principles, which are ever active in producing and maintaining the existing conditions of matter, we discover the Sublime.

The form and colour of a flower may excite our admiration; but when we come to examine all the phenomena which combine to produce that piece of symmetry and that lovely hue,—to learn the physiological arrangement of its structural parts,—the chemical actions by which its woody fibre and its juices are produced,—and to investigate those laws by which is regulated the power to throw back the white sunbeam from its surface in coloured rays,—our admiration passes to the higher feeling of deep astonishment at the perfection of the processes, and of reverence for their great Designer. There are, indeed, “tongues in trees;” but science alone can interpret their mysterious whispers, and in this consists its poetry.

To rest content with the bare enunciation of a truth, is to perform but one half of a task. As each atom of matter is involved in an atmosphere of properties and powers, which unites it to every mass of the universe, so each truth, however common it may be, is surrounded by impulses which, being awakened, pass from soul to soul like musical undulations, and which will be repeated through the echoes of space, and prolonged for all eternity.

The poetry which springs from the contemplation of the agencies which are actively employed in producing the transformation of matter, and which is founded upon the truths developed by the aids of science, should be in no

respect inferior to that which has been inspired by the beauty of the individual forms of matter, and the pleasing character of their combinations.

The imaginative view of man and his world—the creations of the romantic mind—have been, and ever will be, dwelt on with a soul-absorbing passion. The mystery of our being, and the mystery of our ceasing to be, acting upon intelligences which are for ever striving to comprehend the enigma of themselves, leads by a natural process to a love for the Ideal. The discovery of those truths which advance the human mind towards that point of knowledge to which all its secret longings tend, should excite a higher feeling than any mere creation of the fancy, how beautiful soever it may be. The phenomena of Reality are more startling than the phantoms of the Ideal. Truth is stranger than fiction. Surely many of the discoveries of science which relate to the combinations of matter, and exhibit results which we could not by any previous efforts of reasoning dare to reckon on, results which show the admirable balance of the forces of nature, and the might of their uncontrolled power, exhibit to our senses subjects for contemplation truly poetic in their character.

We tremble when the thunder-cloud bursts in fury above our heads. The poet seizes on the terrors of the storm to add to the interest of his verse. Fancy paints a storm-king, and the genius of romance clothes his demons in lightnings, and they are heralded by thunders. These wild imaginings have been the delight of mankind; there is subject for wonder in them: but is there anything less wonderful in the well-authenticated fact, the dew-drop which glistens on the

flower, that the tear which trembles on the eye-lid, holds locked in its transparent cells an amount of electric fire equal to that which is discharged during a storm from a thunder-cloud?

In these studies of the effects which are continually presenting themselves to the observing eye, and of the phenomena of causes, as far as they are revealed by Science in its search of the physical earth, it will be shown that beneath the beautiful vesture of the external world there exists, like its quickening soul, a pervading power, assuming the most varied aspects, giving to the whole its life and loveliness, and linking every portion of this material mass in a common bond with some great universal principle beyond our knowledge. Whether by the improvement of the powers of the human mind, man will ever be enabled to embrace within his knowledge the laws which regulate these remote principles, we are not sufficiently advanced in intelligence to determine. But if admitted even to a clear perception of the theoretical Power which we regard as regulating the known forces, we must still see an unknown agency beyond us, which can only be referred to the Creator’s will.

THE POETRY OF SCIENCE.

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CHAPTER I.

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GENERAL CONDITIONS OF MATTER.

Its varied Characters, and constant change of external Form—The Grain of Dust, its Properties and Powers—Combinations in inorganic Masses and in organized Creations—Our knowledge of Matter—Theory of Ultimate Atoms—The Physical Forces acting on the Composition of Masses—The certainty of the exercise of subtile principles, which are beyond the reach of experimental Science.

The Physical Earth presents to us, in every form of organic and inorganic matter, an infinite variety of phenomena. If we select specimens of rocks, either crystalline or stratified,—of metals in any of their various combinations with oxygen, sulphur, and other bodies,—of gems glistening with light and glowing with colour,—if we examine the varied forms and hues of the vegetable world, or the more mysterious animal creations, we must inevitably come to the conclusion, long since proclaimed, and admit that dust they are, and to dust must they return. Whatever permanency may be given to matter, it is certain that its form is ever in a state of change. The surface of the “Eternal Hills” is worn away by the soft rains which fall to fertilize, and from their wrecks, borne by the waters to the ocean, new continents are forming. The mutations of the old earth may be read upon her rocks and

> mountains, and these records of former changes tell us the infallible truth, that as the present passes into the future, so will the form of Earth undergo an important alteration. The same forces which lifted the Andes and the Himalayas are still at work, and from the particles of matter carried from the present lands by the rivers into the sea, where they subside in stratified masses, there will, in the great future, be raised new worlds, upon which the work of life will go forward, and over which will be spread a vast Intelligence.

If we regard the conditions of the beautiful and varied organic covering of the Earth, the certainty, the constancy, of change is ever before us. Vegetable life passes into the animal form, and both perish to feed the future plant. Man, moving to-day the monarch of a mighty people, in a few years passes back to his primitive clod, and that combination of elementary atoms, which is dignified with the circle of sovereignty and the robe of purple, after a period may be sought for in the herbage of the fields, or in the humble flowers of the valley.

We have, then, this certain truth,—all things visible around us are but aggregations of atoms. From particles of dust, which under the microscope could scarcely be distinguished one from the other, are all the varied forms of nature created. This grain of dust, this particle of sand, has strange properties and powers. Science has discovered some truths, but still more are hidden within this irregular molecule of matter which we now survey, than have yet been shadowed in the dreams of our philosophy. How

strangely it obeys the impulses of heat—mysterious are the influences of light upon it—electricity wonderfully excites it—and still more curious is the manner in which it obeys the magic of chemical force. These are phenomena which we have seen; we know them, and we can reproduce them at our pleasure. We have advanced a little way into the secrets of nature, and from the spot we have gained, we look forward with a vision somewhat brightened by our task; but we discover so much to be yet unknown, that we learn another truth,—our vast ignorance of many things relating to this grain of dust.

It gathers around it other particles; they cling together, and each acting upon every other one, and all of them arranging themselves around the little centre according to some law, a beautiful crystal results, the geometric perfection of its form being a source of admiration.

It exerts some other powers, and atom cohering to atom, obeying the influences of many external radiant forces, undergoes inexplicable changes, and the same dust which we find forming the diamond, aggregates into the lordly tree,—blends to produce the graceful, scented, and richly painted flower,—and combines to yield the luxury of fruit.

It quickens with yet undiscovered energies; it moves with life: dust is stirred by the mysterious excitement of vital force; and blood and bone, nerve and muscle, are the results. Forces, which we cannot by the utmost refinements of our philosophy detect, direct the whole, and from the same dust which formed the rock and grew in the tree, is produced a living and a breathing thing, capable of

receiving a Divine illumination, of bearing in its new state the gladness and the glory of a Soul.

These considerations lead us to reflect on the amount of our knowledge. We are led to ask ourselves, what do we know? We know that the world with all its variety is composed of certain material atoms, which, although presented to us in a great variety of forms, do not in all probability differ very essentially from each other.

We know that those atoms obey certain conditions which appear to be dependent upon the influences of motion, gravitation, heat, light, electricity, and chemical force. These powers are only known to us by their effects; we only detect their action by their operations upon matter; and although we regard the several phenomena which we have discovered, as the manifestations of different principles, it is possible they may be but modifications of some one universal power, of which these are but a few of its modes of action.

In examining, therefore, the truths which science has revealed to us, it is advantageous, for the purpose of fixing the mind to the subject, that we assume certain conditions as true. These may be stated in a few sentences, and then, without wasting a thought upon those metaphysical subtleties which have from time to time perplexed science, and served to impede the progress of truth, we shall proceed to examine our knowledge of the phenomena which constantly occur around us.

Every form, whether inorganic or organic, which we can discover within the limits of human search, is composed of atoms, which are capable of assuming, under the influence

of certain physical forces, conditions essential to the physical state of that body of which they constitute a part. [1] The known forces, active in producing these conditions, are modes of motion; gravitation and aggregation, heat, light; and associated with these, actinism or chemical radiation; electricity, under all its conditions, whether static or dynamic; and chemical affinity, regarded as the result of a separate elementary principle.

These forces must be considered as powers capable of acting in perfect independence of each other. They are possibly modifications of one principle; but this view being an hypothesis, which, as yet, is only supported by loose analogies, cannot, without danger, be received in any explanation which attempts to deal only with the truths of science.

We cannot examine the varied phenomena of nature, without feeling that there must be other and most active principles of a higher order than any detected by science, to which belong the important operations of vitality, whether manifested in the plant or the animal. In treating of these, although speculation cannot be entirely avoided, it will be employed only so far as it gives any assistance in linking phenomena together.

We have to deal with the active agencies which give form and feature to nature—which regulate the harmony and beauty and vigour of life—and upon which depend those grand changes in the conditions of matter, which must convince us that death is but the commencement of a new state of being.

FOOTNOTES:

[1] Sir Isaac Newton supposed matter to consist of hard, impenetrable, perfectly inelastic atoms.

Boscovich regarded the constitution of matter differently. The ultimate atom was with him a point surrounded by powers of infinite elasticity. (See *Dr. Robisons Mechanical Philosophy*, for a full explanation of the theory of Boscovich.)

The view entertained by Dr. Faraday, which will be comprehended from one or two short extracts from his valuable and suggestive paper, claims attention:—

“If the view of the constitution of matter already referred to be assumed to be correct—and I may be allowed to speak of the particles of matter, and the space between them (in water, or in the vapour of water, for instance), as two different things—the space must be taken as the only continuous part, for the particles are considered as separated by space from each other. Space will permeate all masses of matter in every direction like a net, except that in the place of meshes it will form cells, isolating each atom from its neighbours, and itself only being continuous.”

Examining the question of the conducting power of different bodies, and observing that as space is the only continuous part, so space, according to the received view of matter, must be at one time a conductor, at others a non-conductor, it is remarked:

“It would seem, therefore, that, in accepting the ordinary atomic theory, space may be proved to be a non-conductor in non-conducting bodies, and a conductor in conducting bodies; but the reasoning ends in this—a subversion of that theory altogether; for, if space be an insulator, it cannot exist in conducting bodies; and if it be a conductor, it cannot exist in insulating bodies.”—*A Speculation touching Electric Conduction, and the Nature of Matter*: by Michael Faraday, D.C.L., F.R.S., &c.: Philosophical Magazine, vol. xxiv. Third Series.

See also Wollaston, *On the Finite Extent of the Atmosphere*.—Phil. Trans. 1822. Young, *On the Essential Properties of Matter*.—Lectures on Natural Philosophy. Mossotti, *On Molecular Action*.—Scientific Memoirs, vol. i. p. 448.

CHAPTER II.

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MOTION.

Are the Physical Forces modes of Motion?—Motion defined—Philosophical Views of Motion, and the Principles to which it has been referred—Motions of the Earth and of the Solar System—Visible Proofs of the Earth’s Motion on its Axis—Influence of the proper Motions of the Earth on the Conditions of Matter—Theory of the Conversion of Motion into Heat, &c.—The Physical Forces regarded as principles independent of Motion, although the Cause and often apparently the Effects of it.

> Many of the most eminent thinkers of the present time are disposed to regard all the active principles of nature as “modes of motion,”—to look upon light, heat, electricity, and even vital force, as phenomena resulting from “change of place” among the particles of matter; this change, disturbance, or motion, being dependent upon some undefined mover.[2]

The habit of leaving purely inductive examination for the delusive charms of hypothesis—of viewing the material world as a metaphysical bundle of essential properties, and nothing more—has led some eminent philosophers to struggle with the task of proving that all the wonderful manifestations of the great physical powers of the universe are but modifications of motion, without the evidence of any antecedent force.[3]

The views of metaphysicians regarding motion involve many subtle considerations which need not at present detain us. We can only consider motion as a change of place in a given mass of matter. Now matter cannot effect this of itself, no change of place being possible without a mover; and, consequently, motion cannot be a *property* of matter, in the strict sense in which that term should be accepted.[4]

Motion depends upon certain external disturbing and directing forces acting upon all matter; and, consequently, as every mode of action is determined by some excitement external to the body moved, motion cannot, philosophically, be regarded otherwise than as a peculiar affection of matter under determinable conditions. “We find,” says Sir Isaac Newton, “but little motion in the world, except what plainly flows from either the active principles of nature, or from the command of the willer.”[5]

Plato, Aristotle, and the Pythagoreans, supposed that throughout all nature an active principle was diffused, upon which depended all the properties exhibited by matter. This is the same as the “plastic nature” of Cudworth,[6] the “intellectual and artificial fire” of Bishop Berkeley;[7] and to these all modes of motion were referred. Sir Isaac Newton also regards the material universe and its phenomena as dependent upon “*active principles*”—for instance, the cause of gravity—whereby the planets and comets preserve their motions in their orbits, and all bodies acquire a degree of motion in falling; and the cause of fomentation—whereby the heart and blood of animals preserve a perpetual warmth and motion—the inner parts of the earth are kept constantly warmed—many bodies burn and shine—and the sun himself

burns and shines, and with his light warms and cheers all things.

The earth turns on its axis at the rate of more than 1,000 miles an hour, and passes around the sun with the speed of upwards of 68,000 miles in the same time.[8] The earth and the other planets of our system move in ellipses around a common centre: therefore their motion cannot have been originally communicated merely by the impressed force of projection. Two forces, at least, must have operated, one making the planets tend directly to the centre, and the other impelling them to fly off at a tangent to the curve described. Here we have a system of spheres, held by some power to a great central mass, around which they revolve with a fearful velocity. Nor is this all; the Solar System itself, bound by the same mystic chain to an undiscovered centre, moves towards a point in space at the rate of 33,550,000 geographical miles, whilst our earth performs one revolution around the sun.[9]

The evidence of the motion of the Earth around its axis, as afforded by the swinging of a pendulum or the rotation of a sphere, is too interesting to be omitted. In mechanical philosophy, we have two terms of the same general meaning—the conservation of the plane of vibration—and the conservation of the axis of rotation. For the non-scientific reader, these terms require explanation, and in endeavouring to simplify this as much as possible, we must ask the indulgence of the Mechanical Philosopher. Let us fix in the centre of a small round table an upright rod, having an arm extending from its top, to which we can suspend a tolerably heavy weight attached to a string. This is our piece

of apparatus: upon the table draw a chalk line, along which line we intend our pendulum to swing, and continuing this line upon the floor, or by a mark on the wall, our arrangements are complete. Raise steadily the bob of our pendulum, and set it free, so that its plane of vibration is along the line which has been marked. As the pendulum is swinging firmly along this line, slowly and steadily turn the table round. It will then be seen that the pendulum will still vibrate in the direction of the line we have continued onward to the wall, but that the line on the table is gradually withdrawn from it. If we had no upright, we might turn the table entirely round, without in the slightest degree altering the line along which the pendulum performs its oscillations. Now, if from some elevated spot, say, from the centre of the dome of St. Paul’s, a long and heavy pendulum is suspended, and if on the floor we mark the line along which we set the pendulum free to vibrate, it will be seen, as in the experiment with the table, that the marked line moves away from under the pendulum. It continues to vibrate in the plane it first described, although the line on the earth’s surface continues to move forward by the diurnal rotation around the axis. Similar to this is the law of the conservation of the axis of rotation. If a common humming-top, the spindle of which is its axis of rotation, is set spinning obliquely, it will be seen that the axis will continue to point along the line it took at the commencement of motion. By placing a heavy sphere in a lathe, resting its projecting axial points on some moveable bearings, and then getting the sphere into extremely rapid motion, one of the bearings may be removed without the mass falling to the ground. The

rapidity of motion changes so constantly and quickly the position of the particles which have a tendency to fall, that we have motion balanced against the force of gravitation in a striking manner; and we learn, from this experiment, the explanation of the planetary and stellar masses revolving on their axis at a speed sufficient to maintain them without support in space. A mass of matter, a sphere or a disc, carefully balanced, is fixed in gymbals such as we employ for fixing our compass needles, and it is set by some mechanical contrivance in rapid rotation. The position of the axis of rotation remains unaltered, although the earth is moving; and thus, by this instrument,—called the gyroscope,—we can determine, as with the pendulum, the motion of the earth around its axis; and we learn why, during its movement around the sun, its axis is undeviatingly pointed towards one point in space, marked in our Heavens as the Polar Star.

In addition to these great rotations, the earth is subjected to other motions, as the precession of the equinoxes and the nutation of its axis. Rocking regularly upon a point round which it rapidly revolves, whilst it progresses onward in its orbit, like some huge top in tremulous gyration upon the deck of a vast aërial ship gliding rapidly through space, is the earth performing its part in the great law of motion.

The rapidity of these impulses, supposing the powers of the physical forces were for a moment suspended, would be sufficient to scatter the mass of our planet over space as a mere star-dust.

Limiting, as much as possible, the view which opens upon the mind as we contemplate the adjustments by which

this great machine, our system, is preserved in all its order and beauty, let us forget the great movement of the whole through space, and endeavour to consider the effect of those motions which are directly related to the earth, as a member of one small group of worlds.

We cannot for a moment doubt, although we have not any experimental proof of the fact, that the proper motions of the earth materially influence the conditions of the matter of which it is formed. Every pair of atoms is, like a balance, delicately suspended, under the constant struggle which arises from the tendency to fly asunder, induced by one order of forces—centrifugal force—and the efforts of others, gravitation and cohesion, to chain them together. The spring is brought to the highest state of tension—one tremor more, and it would be destroyed.

We cannot, by any comparison with the labours of the most skilful human artisan, convey an idea of the exquisite perfection of planetary mechanics, even so far as they have been discovered by the labours of science; and we must admit that our insight into the vast machinery has been very limited.

All we know is the fact that this planet moves in a certain order, and at a fixed rate, and that the speed is of itself sufficient to rend the hardest rocks; yet the delicate down which rests so lightly upon the flower is undisturbed. It is, therefore, evident that matter is endued with powers, by which mass is bound to mass, and atom to atom; these powers are not the results of any of the motions which we have examined, but, acting in antagonism to them, they sustain our globe in its present form.

Are there other motions to which these powers can be referred? We know of none. That absolute rest may not exist among the particles of matter is probable. Electrical action, chemical power, crystalline aggregation, the expansive force of heat, and many other known agencies, are in constant operation to prevent it. It must, however, be remembered, that each and every atom constituting a mass may be so suspended between the balanced forces, that it may be regarded as relatively at rest.

Theory imagines Motion as producing Force—a body is moved, and its mere mechanical change of place is regarded as generating heat; and hence the refinements of modern science have advanced to the conclusion that motion and heat are convertible. Admitting that the material atoms of which this world is formed are never in a state of quiescence, yet we cannot suppose any gross ponderable particle as capable of moving itself; but once set in motion, it may become the secondary cause of motion in other particles.[10] The difficulties of the case would appear to have been as follows:—Are heat, light, electricity, &c., material bodies? If they are material bodies—and heat, for example, is the cause of motion—must not the calorific matter move itself—or if it be not self-moving, by what is it moved? If heat is material, and the primary cause of motion, then matter must have an innate power of moving; it can convert itself into active force, or be at once a cause and an effect, which can scarcely be regarded as a logical deduction.

We move a particle of matter, and heat is manifested; the force being continued, light, electricity, and chemical

action result; all, as appears from a limited view of the phenomena, arising out of the mechanical force applied to the particle first moved.[11] This mechanical force, it must be remembered, is external to the body moved, and is, in all probability, set up by the movement of a muscle, acted upon by nerves, under the influence of a will.

The series of phenomena we have supposed to arise admit of an explanation free of the hypothesis of motion, and we avoid the dangerous ground of metaphysical speculation, and the subtleties of that logic which rests upon the immateriality of all creation. This explanation, it is freely admitted, is incomplete: we cannot distinctly correlate each feature of the phenomena, combine link to link, and thus form a perfect chain; but it is sufficiently clear to exhibit what we do know, and leave the unknown free for unbiassed investigation.

Each particle, each atom of that which conveys to our senses the only ideas we have of natural objects—ponderable matter—is involved in, or interpenetrated by, those principles which we call heat and electricity, with probably many others which are unknown to us; and although these principles or powers are, according to some law, bound in statical equilibrium to inert matter, they are freely developed by an external excitement, and the disturbance of any one of them, upsetting the equilibrium, leaves the other power equally free to be brought under the cognizance of human sense by their effects.

When we come to an examination of the influences exerted by these powers upon the physical earth, the position, that they must be regarded as the causes of

motion rather than the effects of it, will be further considered. At present it is only necessary to state thus generally the views we entertain of the conditions of matter in connection with the imponderable forces and mechanical powers. The conversion, as it has been called, of motion into heat, in the experiments of Count Rumford and Mr. Joule, [12] are only evidences that a certain uniformity exists between the mechanical force applied, and the amount of heat liberated. It does not appear that we have any proof of the conversion of motion into physical power.

It is necessary, to a satisfactory contemplation of the wonderful properties of matter, and of the forces regulating the forms of the entire creation, that we should be content with regarding the elementary bodies which chemistry instructs us form our globe, as tangible, ponderable atoms, having specific and distinguishing properties. That we should, as far as it is possible for finite minds to do so, endeavour to conceive the powers or forces—gravitation, molecular attraction, electricity, heat, light, and the principle which determines all chemical phenomena—as manifestations of agencies which hold a place between the most subtile form of matter and the hidden principles of vitality, which is still vastly inferior to the spiritual state, which reveals itself dimly in psychological phenomena, and arrives at its sublimity in the God of the universe.

FOOTNOTES:

[2] “Motion, therefore, is a change of rectilinear distance between two points. Allowing the accuracy of this definition, it appears that two points are necessary to constitute motion; that in all cases, when we are inquiring whether or no any

body or point is in motion, we must recur to some other point which we can compare with it; and that if a single atom existed alone in the universe, it could neither be said to be in motion nor at rest.

"The space which we call quiescent is in general the earth's surface; yet we well know, from astronomical considerations, that every point of the earth's surface is perpetually in motion, and that in very various directions: nor are any material objects accessible to our senses which we can consider as absolutely motionless, or even as motionless with regard to each other; since the continual variation of temperature to which all bodies are liable, and the minute agitations arising from the motion of other bodies with which they are connected, will always tend to produce some imperceptible changes in their distances."—*Lectures on Natural Philosophy, &c.*, by Thomas Young, M.D. Edited by the Rev. P. Kelland. 1845.

[3] "The position which I seek to establish in this essay is, that the various imponderable agencies, or the affections of matter which constitute the main objects of experimental physics, viz., heat, light, electricity, magnetism, chemical affinity, and motion, are all correlative, or have a reciprocal dependence;—that neither, taken abstractedly, can be said to be the essential or proximate cause of the others; but that either may, as a force, produce, or be convertible into, the other:—thus heat may mediately or immediately produce electricity, electricity may produce heat, and so of the rest.... Although strongly inclined to believe that the five other affections of matter, which I have above named, are, and will ultimately be, resolved into modes of motion, it would be going too far at present to assume their identity with it: I, therefore, use the term force, in reference to them, as meaning that active force inseparable from matter, which induces its various changes."—*On the Correlation of Physical Forces*, by W. R. Grove, Esq., M.A., F.R.S.

[4] When discussing the hypothesis of Hobbes—*that no body can possibly be moved but by a body contiguous and moved*—Boyle asks:—

"I demand how there comes to be local motion in the world? For either all the portions of matter that compose the universe have motion belonging to their natures, which the Epicureans affirmed for their atoms, or some parts of matter have this motive power, and some have not, or else none of them have it; but all of them are naturally devoid of motion. If it be granted that motion does naturally belong to all parts of matter, the dispute is at an end, the concession quite overthrowing the hypothesis.

"If Mr. Hobbes should reply that the motion is impressed upon any of the parts of matter by God, he will say that which I most readily grant to be true, but will not serve his turn, if he would speak congruously with his own hypothesis.

For I demand whether this Supreme Being that the assertion has recourse to, be a corporeal or an incorporeal substance? If it be the latter, and yet the efficient cause of motion in bodies, then it will not be universally true that whatever body is moved is so by a body contiguous and moved. For, in our supposition, the bodies that God moves, either immediately or by the intervention of any other immaterial being, are not moved by a body contiguous, but by an incorporeal spirit."—*Some Considerations about the Reconcileableness of Reason and Religion*: Boyle, vol. iii. p. 520.

[5] Boyle has some ingenious speculations on this point:—

"That there is local motion in many parts of matter is manifest to sense, but how matter came by this motion was of old, and is still, hotly disputed of: for the ancient Corpuscularian philosophers (whose doctrine in most other points, though not in all, we are the most inclinable to), not acknowledging an author of the universe, were thereby reduced to make motion congenite to matter, and consequently coeval with it. But since local motion, or an endeavour at it, is not included in the nature of matter, which is as much matter when it rests as when it moves; and since we see that the same portion of matter may from motion be reduced to rest, and after it hath continued at rest, so long as other bodies do not put it out of that state, may by external agents be set a moving again; I, who am not wont to think a man the worse naturalist for not being an atheist, shall not scruple to say with an eminent philosopher of old, whom I find to have proposed among the Greeks that opinion (for the main) that the excellent Des Cartes has revived amongst us, that the origin of motion in matter is from God; and not only so, but that thinking it very unfit to be believed, that matter barely put into motion, and then left to itself, should casually constitute this beautiful and orderly world; I think also further, that the wise Author of things did, by establishing the laws of motion among bodies, and by guiding the first motions of the small parts of matter, bring them to convene after the manner requisite to compose the world; and especially did contrive those curious and elaborate engines, the bodies of living creatures, endowing most of them with the power of propagating their species."—*Considerations and Experiments touching the Origin of Forms and Qualities*: Boyle's Works, vol. ii. p. 460. Edinburgh. 1744.

[6] Cudworth's *Intellectual System*.

[7] "According to the Pythagoreans and Platonists, there is a life infused throughout all things ... an intellectual and artificial fire—an inward principle, animal spirit, or natural life, producing or forming within, as art doth without—regulating, moderating, and reconciling the various motions, qualities, and parts of the mundane system. By virtue of this life, the great masses are held together in their ordinary courses, as well as the minutest particles governed in their